Annex 5

Report of the Working Group on Statistics, Assessments and Modelling
(Genoa, Italy, 27 June to 1 July 2016)

Contents

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Opening of the meeting

1.1 The 2016 meeting of WG-SAM was held in the Sala Lignea at the Biblioteca Berio (Berio Library), Genoa, Italy, from 27 June to 1 July 2016. The meeting Convener, Dr S. Parker (New Zealand), welcomed participants (Appendix A).

1.2 The Working Group was warmly welcomed by Dr M. Vacchi (Institute of Marine Sciences (ISMAR), National Research Council (CNR) and SC-CAMLR Representative) who also outlined local arrangements, Dr A. Meloni (President of the Italian Scientific Commission on Antarctic Research (CSNA), National Antarctic Research Program (PNRA)) who also outlined the history of the Italian Science Program in Antarctica, and Dr O. Leone (Promotion Manager of the Berio Library) who also invited participants to explore the library during the meeting.

Adoption of the agenda and organisation of the meeting

1.3 The meeting agenda was discussed and adopted with a small reorganisation required to facilitate the reporting of discussions (Appendix B).

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

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

1.6 The Working Group used the Secretariat's online meeting server to support its work and facilitate the preparation of the meeting report. The use of the meeting server is demonstrated in four training videos which were developed by the Secretariat and are available from the CCAMLR support forum (support.ccamlr.org).

1.7 The report was prepared by M. Belchier (UK), P. Burch and A. Constable (Australia), R. Currey (New Zealand), C. Darby and T. Earl (UK), L. Ghigliotti (Italy), T. Ichii (Japan), C. Jones and D. Kinzey (USA), K. Large (New Zealand), D. Ramm, K. Reid and L. Robinson (Secretariat), R. Sarralde (Spain), M. Söffker (UK), S. Somhlaba (South Africa), G. Watters (USA) and D. Welsford (Australia).

Methods for assessing stocks in established fisheries

Review of progress towards updated integrated assessments

2.1 WG-SAM-16/36 Rev. 1 described recent developments towards an integrated stock assessment for krill in Subarea 48.1. The model was fitted to a 40-year time series (1976 to 2015) of biomass indices and length-composition data from research surveys as well as to catches and length compositions from the krill fishery. A simulated population with parameters estimated from these data was projected 20 years into the future under various candidate levels of catch. The distribution of spawning biomass during the projection period for each level of catch was compared to nine alternative reference points (including the currently accepted reference point of the median unexploited spawning-stock biomass, SSB_0), and catches compatible with the two decision rules for krill were identified for each reference point.

2.2 The Working Group noted that, in its present implementation, too many parameters are likely being estimated within the krill assessment model. The parameter estimates may thus be unstable, particularly as new data are added. It was recommended that retrospective analyses and fits to simulated data be conducted to explore the properties of the estimated parameters. Plotting the marginal likelihoods of parameters that are likely to be confounded could also help identify which parameters are estimable from the available data and clarify model performance. The Working Group further noted that model stability might be enhanced by treating fishery catches as known, rather than estimated, quantities.

2.3 Dr S. Kasatkina (Russia) noted the following with respect to the assessment in WG-SAM-16/38:

(i) The krill model estimates the variability of krill recruitment in Subarea 48.1 assuming that future recruitment will be the same as it was during 1992–2011. It also significantly truncates datasets for forecasting the future distributions of krill spawning biomass in view of ongoing climate changes. This environmental variability impacts on sea-ice coverage that might affect krill productivity and krill larvae. She proposed to supplement recruitment data by those data from the last five years to estimate recruitment trends.

(ii) The krill model does not consider the krill movements into Subarea 48.1 by geostrophic flux that will significantly affect the dynamics and krill biomass located in Subarea 48.1 during fishing seasons and years. Moreover, the krill biomass estimates from local acoustic surveys undertaken for short time (about one month) have been used for modelling the ability of krill in Subarea 48.1 to support different levels of catch over the entire subarea during different reference periods. She indicated the need to have acoustic surveys accompanied by net surveys more regularly within a year rather than a single survey in a year.

(iii) With respect to the recommendations provided by WG-FSA-15 (SC-CAMLR-XXXIV, Annex 7, paragraph 4.122) to refine the integrated krill assessment model for Subarea 48.1, she highlighted the necessity to clarify how these recommendations were implemented. In particular, she noted that there were no model diagnostics on the prior and posterior distribution of model estimates including boundary values (SC-CAMLR-XXXIV, Annex 7, paragraph 4.122ii).

2.4 The Working Group determined that the model should not presently be used to provide advice. It was agreed that additional work is required to systematically document how all past recommendations made by WG-SAM, WG-FSA and WG-EMM have been considered and either used to revise the model or suitably rebutted. It was noted that the model had been reviewed by two independent referees whose findings largely paralleled those previously made by the three working groups and which were summarised in WG-SAM-16/37. Thus, documenting how the model had been changed (or not) to address the recommendations of the working groups would also help to document how the recommendations of the independent referees had been addressed, and vice versa. It was further suggested that it would be useful to complement this documentation with how similar recommendations are accommodated within the current approach used to provide management advice for the krill fishery in Area 48.

2.5 The Working Group referred WG-SAM-16/36 Rev. 1 to WG-EMM noting that WG-EMM may usefully consider the reference points and alternative decision rules. It noted that the estimate of variability in recruitment was large and that this parameter may be a reflection of the uncertainty in the model rather than a true estimate of variability. This would need to be explored further. It further noted that changing the harvest control rule would require a full management strategy evaluation (MSE).

2.6 The Working Group thanked the authors for their continued work on an integrated assessment for krill in Subarea 48.1. It noted that WG-EMM may wish to consider application of the population model in the integrated assessment to explore hypotheses of stock structure for krill more generally.

2.7 Mr N. Okazoe (Japan) presented WG-SAM-16/38, which included information on the survey design of the dedicated cetacean-sighting vessel-based krill (CSVK) survey undertaken by Japan in the east Antarctic to enable commentary by WG-SAM on the survey design for future seasons, in particular the trade-offs between the primary goal of gathering information on cetaceans versus the secondary goal of gathering information on krill and the ocean. It also presented some results of the first CSVK survey in the east Antarctic (115°−130°E) conducted during the 2015/16 austral summer. The survey was designed for the main purpose of obtaining systematic sighting data for whale abundance estimates. Along the sighting track lines, krill survey (based on echosounder and net sampling) and oceanographic survey (based on conductivity temperature depth probe (CTD)), as well as some feasibility studies on biopsy sampling and telemetry in Antarctic minke whales (*Balaenoptera bonaerensis*), and routine photo-id and biopsy sampling on large whales, were also conducted. Mr Okazoe noted that the survey is undertaken annually over 12 years and another type of survey, CCAMLR-type dedicated krill survey, will be undertaken twice during the 12 years. The plan of the first dedicated krill survey is under development with the intention to submit the plan to the appropriate working group next year.

2.8 The Working Group noted that the sampling for krill was not likely to be adequate for validating the composition of acoustic marks obtained by the echosounders. It was noted that the size of the net is likely to be too small and is not being used to target the acoustic marks, but to identify species existing at the stations. Also, the use of a light on the net may lead to biased estimation of what organisms are being detected by the acoustics. This is because some organisms will avoid the light, while others will be attracted to it. A further concern is that insufficient krill are being obtained to estimate the length frequency of krill detected by the acoustics; the estimation of krill abundance is very sensitive to the assumed length composition.

2.9 The Working Group also noted that it was difficult to evaluate the requirements for krill and oceanographic sampling without a clear description of the questions being addressed. For example, the sampling is likely to be insufficient to determine the relationship of whales to the densities of krill or physical ocean habitat. It recommended random sampling across the area to better estimate conditions of the habitat and the characteristics of the krill populations. In this case, the number of sampling locations may need to be increased to ensure the results have high statistical power in testing hypotheses being posed. It noted that power analyses would be important to determine an appropriate number of stations.

2.10 The Working Group recalled that detailed discussions had been had in the Scientific Committee in the 1990s with respect to the design of surveys to estimate the abundance of krill. The preference from that work was for parallel transects in an area rather than a zig-zag design. It did note, however, that sea-ice may present difficulties in adhering to a design of parallel transects and that geostatistics may now be able to better estimate biomass from zig-zag designs. Simulation work based on ocean models would help identify whether that would be suitable. While the design of the whale sighting survey is a matter for the Scientific Committee of the International Whaling Commission (IWC), the Working Group also noted that many aerial sighting surveys for cetaceans used parallel transects by choice.

2.11 WG-SAM-16/39 assessed the effective sample size of different strategies for observing the catch of the krill fishery for assessing the length composition of the catch. Catch at length is an important input into any stock assessment. Consequently, collecting length data from the catch is a task undertaken by all at-sea observers in CCAMLR fisheries. Although analyses in the past have looked to the optimal design of the observer program, in terms of levels of coverage of vessels and hauls, less attention has been focused on how many krill should be measured by observers in any given haul. Catch and effort (C1 data) and observer data from Subarea 48.1, collected between 2010 and 2015, were used to characterise how many krill are measured by observers, and for how many hauls. The impact of different haul-wise sample sizes on the ability to estimate mean length in a sample per small-scale management unit (SSMU) × month combination (effective sample size) was assessed using resampling procedures and simulations. The median number of krill measured per haul was around 200 (range 0–652). However, haul-wise sample sizes of down to 50 measurements did not substantially reduce the effective sample size, whereas increasing the number of hauls sampled did substantially increase the effective sample size. The authors recommended that observers collect smaller samples (50 length measurements) at the haul level, over a greater number of hauls to allow better estimates of catch at length in the krill fishery.

2.12 The Working Group found the paper to be very informative about the current performance of the observer program and thanked the authors for bringing this paper forward. It agreed that reducing the number of krill measured in a haul while increasing the number of hauls from which krill are measured will be very important to achieve estimates of the mean size of krill in the catch in different areas and at different times.

2.13 The Working Group suggested that other metrics that may be useful for evaluating observer requirements for measuring the size of krill, such as the multinomial nature of the length-frequency distribution, should also be considered by WG-EMM in providing advice on the implementation of observations in the krill fishery.

2.14 The Working Group agreed that further analyses would be valuable in determining the spatial and temporal arrangements of observations from the krill fishery needed to assess the

size of krill in different areas and times. This will be important for spreading the observations so that measurements are not concentrated where the fishery concentrates its activities in a given season. WG-SAM noted that the design of the observer program was different to the placement of hauls to obtain information on the krill population. In the case of the latter, consideration may need to be given on how to arrange some fishing operations in space and time for the purpose of addressing research questions on the characteristics of the krill stock.

2.15 WG-SAM-16/39 also presented an appendix on issues with the data extracted from the CCAMLR database.

2.16 Dr Ramm noted the data quality assurance (DQA) issues raised in the appendix and indicated that he would further discuss these issues with the authors and amend the data, where required, in the database. He also outlined the Secretariat's current multi-year work plan to redevelop the CCAMLR database. This included the development of a data warehouse with improved data integration and DQA. The progression of the transactional database to a data warehouse will address many DQA issues that are currently being encountered.

2.17 The Working Group noted that various issues, such DQA issues, are being encountered by different researchers and there needed to be a mechanism for recording these issues and having them resolved in order that future research does not have to go through the same data cleaning and validation exercises. WG-SAM agreed that such a mechanism may be implemented through the use of standard data extracts and accompanying documentation which described each data extract and outlined DQA issues and updates.

2.18 Dr Ramm indicated that the historical data will be screened as it is transferred into the data warehouse. For new data, scripts are being developed to better automate and screen the data as it is uploaded into the transactional database. He noted that the documentation on the transactional database is limited and needs to be updated to support the use of the existing database, including the development of scripts for data extraction, prior to the implementation of the new systems associated with the data warehouse. Improved documentation is being developed for the data warehouse, along with the development of scripts for data extraction.

2.19 The Working Group encouraged all authors to provide appendices on data issues encountered during their research, as well as discuss DQA issues with the Data Manager. WG-SAM also suggested that the Secretariat develop an online archive of scripts for standard data extractions in order that these can be used to update extractions as the database evolves. It noted that, at present, there is no routine report to users of how the database has been changed from one year to another and how old records may have been modified or new records for past years been added.

2.20 The Working Group agreed that a data management group would be useful to provide a conduit between data users and the Secretariat in order to provide high-level input on the management and development of the CCAMLR database, standard data extracts and data tools.

Stock assessment methodologies

2.21 In 2013, WG-FSA produced a single table that included local biomass estimates and recommended research catch limits for exploratory fisheries for toothfish in Subareas 48.6 and 58.4 and in areas closed to fishing. This table also included relevant metrics used to assess the progress of such research fishing (see SC-CAMLR-XXXII, Annex 6, Table 13).

2.22 In response to the request from the Scientific Committee (SC-CAMLR-XXXIV, paragraph 3.232i), the Secretariat presented WG-SAM-16/18 Rev. 1 that provided an update to the summary table presented as SC-CAMLR-XXXII, Annex 6, Table 13, using the most recent data available and to detail the methods used for local biomass estimation.

2.23 The Working Group thanked the Secretariat for producing this important paper and noted that it had benefited from extensive intersessional discussion by Members via the WG-SAM e-group.

2.24 The Working Group recognised that changes in the criteria, metrics and application of methods used in setting research catch limits had resulted in some confusion in the application of methods in different research plans to WG-SAM-16.

2.25 Given the importance of this table to setting catch limits and research requirements in exploratory fisheries, there was a need to ensure clarity in the methods used to generate and update local biomass estimates. The Working Group agreed that following the confirmation of the detailed methods to be used to produce the biomass estimates (paragraph 2.28), the Secretariat be requested to produce the biomass estimates for all research blocks in Subareas 48.6 and 58.4 and to present these to WG-FSA-16.

2.26 The Working Group requested that estimates of the biomass for other proposed research blocks included in research proposals also be calculated by the Secretariat using the same methods. The Secretariat requested Members provide geographic coordinates for the extent of those research blocks in order to undertake this process.

2.27 The Working Group requested that, when producing these local biomass estimates for WG-FSA-16, the Secretariat provide the appropriate metadata on data extracted from the CCAMLR database, documentation of data cleaning processes, such as that provided in WG-FSA-13/56, and associated code for the analysis in order to ensure reproducibility of results. It was also noted that a summary of records removed or corrected due to data quality assurance processes in the database and as part of the analysis should be provided.

2.28 In reviewing the methods, the Working Group agreed the following methods for the estimation of local biomass using the catch-per-unit-effort (CPUE) by seabed area analogy and Chapman mark-recapture estimate:

CPUE by seabed area analogy method

$$B_x = \frac{I_x \times A_x \times B_r}{I_r \times A_r}$$

Where the subscripts x and r denote the parameter from the research block and reference area respectively and:

I is the median of the haul by haul CPUE where the total catch (kg) on a haul, including fish that are tagged and released (where the weight of released fish is estimated using the length–weight relationship for that area), divided by the length of line (km) reported for that set in the C2 data (paragraph 2.36).

A is seabed area (km^2) in the depth range 600–1 800 m using the GEBCO 2014 dataset (WG-SAM-15/01).

B_r is the current biomass (kg) from the most recent assessment in the reference area.

Chapman mark-recapture-based estimate of biomass

$$B_j = \frac{c_j\left(n_{j-1}+1\right)}{mx_j+1}$$

where n_{j-1} is the number of tagged fish available for recapture at the end of the season prior to season j, c_j is the catch in season j (as with CPUE the catch includes fish that are tagged and released, as these fish are scanned for tags upon capture) and mx_j is the number of tagged fish recaptured in season j (excluding within-season recaptures).

The number of tags available

$$n_j = \begin{Bmatrix} j=1, & r_j\left(1-t\right)e^{-\left(f+M\right)} - m_j \\ j>1, & n_{j-1}e^{-\left(f+M\right)} + r_j\left(1-t\right)e^{-\left(f+M\right)} - m_j \end{Bmatrix}$$

r_j is the total number of fish released in CCAMLR fishing season j

m_j is the total number of tagged fish recaptured in CCAMLR fishing season j

and n_{j-1} is the number of tagged fish available for recapture at the end of the season prior to season j

t is the post-tagging mortality rate of 0.1 (Agnew et al., 2006)

f is the annual tag loss rate which is 0.0084 (WG-SAM-11/18)

M is natural mortality where M = 0.13 for Antarctic toothfish (*Dissostichus mawsoni*) (WG-FSA-SAM-06/08) and 0.155 for Patagonian toothfish (*D. eleginoides*) (Candy et al., 2011).

2.29 The Working Group agreed that the CPUE should be estimated for *D. eleginoides* and *D. mawsoni* separately and that all hauls should be included and that the data used should not be limited to hauls with non-zero catches for that species.

2.30 The Working Group considered the choice of reference areas chosen for research blocks (WG-SAM-16/18 Rev. 1, Appendix 3, Table A3) and agreed that for *D. mawsoni* for research blocks in Subarea 48.6 and in Divisions 58.4.1 and 58.4.2, the Ross Sea region should be used as the reference area and that for research blocks in Divisions 58.4.3 and 58.4.4, the Heard Island and McDonald Islands (HIMI) region should be used as the reference area and for *D. eleginoides* in Subarea 48.6, the reference area would be Subarea 48.4 (N) (Table 1).

2.31 The Working Group requested that the Secretariat provide an analysis of effort (hooks set) and catch rate (number of fish and kg/hook) for the research blocks and reference areas, to evaluate the appropriateness of using the depth range of 600–1 800 m as the fishable area for these calculations.

2.32 In order to better understand the uncertainty in the estimate of local biomass in the research block, the Secretariat was requested to work with Members to present a bootstrap analysis to WG-FSA-16, drawing on distribution of CPUE data in the reference area and the research block and $B_{current}$ in the reference area, to provide a mean and variance estimate of B_r. The methods and results from this analysis would be presented in a paper to WG-FSA-16.

2.33 The Working Group noted that a bias in the number of tags available could be introduced by the movement of fish out of a research block and that, while such a bias may vary between habitat types, it was likely to occur on research blocks that contain seamounts as well as those adjacent to the Antarctic coast.

2.34 The Working Group noted that, based on the analysis of data from small-scale research unit (SSRU) 882H, movement-related bias would increase with time and, therefore, the Working Group agreed that for research fishing where movement has yet to be assessed only tagged fish released in the last three years should be considered to be available for recapture. The Working Group noted that when there was sufficient data to address this bias for a particular research block, then this would be reviewed and applied as appropriate.

Future developments

CPUE standardisation

2.35 The Working Group recognised that differences in CPUE by gear type were potentially important, however, differences between the gear used in reference areas (Ross Sea region and HIMI) and in the research blocks mean that it is not always possible to use CPUE for the same gear in the CPUE by seabed area analogy approach.

2.36 The Working Group recalled previous work on standardising CPUE, including analyses presented in WG-FSA-11/35 and WG-FSA-13/63, and recommended building on those studies to review approaches to standardising CPUE data for use in the CPUE by seabed area analogy approach, including the suitability of using the number of hooks and/or line length as a measure of effort.

2.37 Dr Kasatkina noted that the local biomass estimation method used in WG-SAM-16/18 Rev. 1 was accompanied with significant uncertainty. She also noted that the Chapman biomass estimates were obtained disregarding any assumptions in relation to tag-release mortality, the degree of spatial overlap between tagged fish and fishing efforts, possibility of migration of tagged fish across the boundary of research blocks including migration out of the fishing ground.

2.38 Dr Kasatkina indicated that the CPUE by seabed analogy method was applied without standardisation of CPUE between types of longlines and the median CPUE (kg/km) was estimated from all vessels and all longline gears (trotlines, Spanish and autoline). She noted that the estimate of CPUE was obtained as kg of catch per 1 km of longline regardless of variability in the number of hooks per 1 km between vessels and gears. She further noted that the CPUE data normalised to thousand hooks would be more suitable for use in the CPUE analogy method.

2.39 Dr Kasatkina noted that analysis of the longline fishery in the Ross Sea (e.g. SSRUs 881B, C and G, WG-SAM-16/26 Rev. 1) highlighted significant variability of CPUE between longline types as well as differences in CPUE (kg km^{-1}) and CPUE (kg/thousand hooks) for each longline type (trotlines, Spanish and autoline). She indicated that this variability might arise from different selectivity and different spatial coverage of fishing effort using different gear types and that the latter issue would usually be taken into account in stock assessment methods.

2.40 The Working Group noted that commercial CPUE is not used in the Ross Sea stock assessment.

Selection of local biomass estimates for use in setting catch limits

2.41 The Working Group noted that in 2014 WG-FSA outlined a process for how catch limits for research are derived and agreed that where there were multiple estimates of biomass that the lower estimate should be used (SC-CAMLR-XXXIII, Annex 7, paragraph 5.123i). This was the method that was followed in WG-SAM-16/18 Rev. 1.

2.42 Dr Ichii noted that WG-FSA-13 agreed that where alternate methods yielded conflicting estimates of local biomass, comparing expected versus observed recaptures may inform selection of the more plausible biomass estimate (SC-CAMLR-XXXII, Annex 6, paragraph 6.25). He indicated that this selection procedure is indispensable and provides justification of the selection of a biomass estimate used in setting catch limit.

2.43 In addition, Dr K. Taki (Japan) and Mr Somhlaba pointed out the significant difference of meaning between SC-CAMLR-XXXII, Annex 6, paragraph 6.26 and SC-CAMLR-XXXIII, Annex 7, paragraph 5.123. They considered that SC-CAMLR-XXXII, Annex 6, paragraph 6.26, means the catch limits which expect the more than 10 recaptures of tagged fish are allowable when those do not exceed the exploitation rate of 4%, because the more sample sizes lead to the more reliable stock assessment, while SC-CAMLR-XXXIII, Annex 7, paragraph 5.123, considers the 10 recaptures of tagged fish as the precautionary index, which is not based on the original sense, and the precautionary index should be restricted to the exploitation rate of 4%. Dr Taki and Mr Somhlaba requested WG-FSA to clarify the situation.

2.44 The Working Group agreed that, while it may be considered precautionary to use the lower local biomass estimate, it was important to understand the variance. Where two biomass estimates are available, there are a range of factors that could be included in the choice of which estimate to use in determining a catch limit.

2.45 The Working Group agreed that, while it had not yet developed further advice on the process for the decision of which biomass estimate to use in setting catch limits for research, there is an expectation that the variance in those estimates is likely to be used in such a decision process. Therefore, the Working Group agreed that developing measures of the uncertainty in the estimates of local biomass and how such measures are used in the decision of selecting the most appropriate biomass estimate to use should be a priority area of work in the coming intersessional period.

2.46 The Working Group recalled that the local biomass estimates should not be considered as a biomass estimate upon which to set long-term catch limits for a sustainable fishery but they are designed to facilitate research and, therefore, it was important to define the period of that research.

2.47 The Secretariat had identified that differences in the numbers of fish available for recapture could arise as a result of the selection of the data source of the tagging location data such that when all data collected on a set are georeferenced to the location of the start of the set, there can be small differences in location relative to the tagging location data provided by observers. The Working Group noted that there are operational reasons why the location for the release of a tagged fish could be some distance from the actual set location and agreed that the location provided by observers was more appropriate and agreed that any tags released within 5 km of the research block boundary should be included in the estimation of tags available for recapture for that research block.

2.48 The Working Group noted that the estimated biomass based on tag data will be sensitive to the values of parameters for tag loss or mortality of tagged fish. If possible, these need to be estimated directly for different areas, to take account of factors that may differ between vessels or between areas such as the potential for thermal shock. In the absence of such direct estimates, it is highly desirable to investigate whether tag recaptures are consistent with those from areas where the parameters governing tag survivorship were estimated, including through an extension of the 'case-control' method used for the Ross Sea region assessment as described in WG-SAM-13/34.

2.49 WG-SAM-16/13 described the development of an index to assess the potential bias in the difference in the spatial distribution of the release of tagged fish and the subsequent spatial coverage of fishing effort to recapture tagged fish.

2.50 The Working Group welcomed WG-SAM-16/13 and noted that the issues of the spatial structuring of toothfish fisheries in the paper were directly relevant to important topics identified by the Scientific Committee (SC-CAMLR-XXXIV, paragraph 3.83) and encouraged further work on the indices developed in the paper and, in particular, how these indices might be used in an absolute (rather than relative) context and also work to evaluate the impact of the movement of fish on the overlap metrics.

2.51 In considering the description of the data cleaning steps undertaken in the preparation of WG-SAM-16/18 Rev. 1, the Working Group agreed that confidence in the data quality assurance in the CCAMLR database was fundamental to the work of CCAMLR scientists. It further agreed that there is a need to ensure that differences in analyses do not arise as a result of differences in the data provided in data extracts and recommended that all data extracts contain clear documentation on the code used to extract the data from the database and details of all data quality assurance and data cleaning that had been applied to the data used in any analysis.

2.52 The Data Manager updated the Working Group on the work outlined in WG-SAM-15/33 on the redevelopment of the CCAMLR database, including the implementation of a data warehouse, and described how the work underway in the Secretariat had expanded to cover all elements of CCAMLR data. Migrating all of the data simultaneously is a much larger undertaking than was originally planned, hence the timeline on the delivery has been impacted significantly and, as a consequence, it was not possible to provide a definitive date for the completion of this work.

2.53 The Working Group thanked the Secretariat for the ongoing work to improve the DQA associated with the CCAMLR databases and noted that this work should be applied to the transaction database as well as the data warehouse. The Working Group requested that changes to the data that arise as a result of applying data quality checks that occur in the current transaction database, and those that will occur in moving data from the transaction database to the data warehouse, be recorded in a systematic way that allows users to review the potential for such changes to introduce differences from the results of historical analyses.

2.54 The Working Group requested the Secretariat provide a paper to the Scientific Committee on the milestones and timeline for developing the new data system. It will be important for Members to know these timelines in order to better plan their work and what DQA tasks may be required in the interim of the data warehouse being completed.

Review of research plans in Subareas 48.6 and 58.4

Review of research plans in Divisions 58.4.1 and 58.4.2

3.1 WG-SAM-16/28 presented results of the second year of the Korean research program in Division 58.4.1. Research was conducted across the research blocks in Division 58.4.1. The Working Group noted that this program included the objective of characterising the food web in the region and that a paper on the stable isotope composition of *D. mawsoni* from the region had been submitted to WG-EMM-16 using samples collected during this program (WG-EMM-16/31).

3.2 WG-SAM-16/17 described the proposal to continue research in Divisions 58.4.1 and 58.4.2, continuing the design used to date, including sampling tissue and stomach contents of toothfish, otoliths, CTD casts and plankton sampling. The Working Group welcomed the collection of datasets which could provide additional context on the environment in Divisions 58.4.1 and 58.4.2. It also noted the recovery of a pop-up satellite archival tag (PSAT) released by the Republic of Korea in the previous year and welcomed a further analysis of the data to be submitted to WG-FSA-16.

3.3 WG-SAM-16/35 reported on the catch effort and biological data collected by Australia while undertaking its research plan in Division 58.4.1. Two research blocks in SSRU 5841E and the grid over the location of the Spanish depletion experiment in SSRU 5841G were fished. Catch was dominated by *D. mawsoni*, and by-catch by *Macrourus* spp. *Dissostichus eleginoides* were also encountered in small numbers in SSRU 5841E. By-catch was highest in sets conducted in depths shallower than 1 000 m and deeper than 1 800 m. Three tags were recaptured, however, two were within-season recaptures.

3.4 WG-SAM-16/34 reported on environmental and video data collected in Division 58.4.1. The Working Group noted that all video footage indicated the seafloor consisted of soft sediments or cobbles with low densities of vulnerable marine ecosystem (VME) indicator organisms in all 15 locations cameras were deployed. Motile fauna, including squids, fish and echinoderms were also recorded. CTD data was also collected from 33 locations. The Working Group welcomed this unique component of the Australian research, and encouraged other Members to consider adding cameras and other sensors to fishing gear to provide data to improve habitat and species distribution maps in the Convention Area.

3.5 WG-SAM-16/09 presented the plan for research fishing by Australia in Divisions 58.4.1 and 58.4.2 in 2016/17. The Working Group noted that the focus in the coming season would be returning to the research blocks fished in 2015/16, as well as targeting research block 5842_5 to attempt to discover younger *D. mawsoni* and assist with evaluating the current stock hypothesis for the region. Australian Antarctic Division scientists will also be developing an ageing program for *D. mawsoni* and methods for rapid analysis of video footage and CTD data.

3.6 WG-SAM-16/40 Rev. 1 presented a summary of results of the three years of depletion experiments conducted by Spain in Division 58.4.1. In two out of the three locations where depletion experiments had been initiated in 2015/16, depletion curves were not able to be consistently fitted, and tag recaptures were lower than expected. The Working Group recalled that there had also been mixed success with ad hoc depletion experiments in the past in the Convention Area, and that the Spanish results confirmed that planned depletion experiments were also difficult to interpret and convert into robust information on local biomass. It also noted that the data used for bootstrapping had outliers which appeared to be generating bias in the biomass distribution. It also noted that robust bootstrapping methods would be more appropriate to use with these datasets to reduce biases introduced by outliers.

3.7 WG-SAM-16/10 presented a proposal by Spain to conduct research fishing in Division 58.4.1 across existing research blocks as well as continuing to tag and recapture tagged fish in the three locations where depletion experiments have occurred over the last three seasons. The Working Group welcomed the information that Spain had initiated an ageing program using *D. mawsoni* otoliths collected from research catches. The Working Group requested that additional information be provided to WG-FSA-16 as to the rationale for establishing new research blocks around the three depletion experiment locations. It further noted that the Australian research in 2015/16 released tagged fish across a grid including the location of the depletion experiment in SSRU 5841G.

3.8 WG-SAM-16/04 and 16/05 presented proposals by Japan to conduct research fishing in Divisions 58.4.1 and 58.4.2 respectively. Japan was unable to conduct research fishing in this region in 2015/16, but proposed to undertake the same activities as outlined in its proposals last year (SC-CAMLR-XXXIV, Annex 5, paragraph 3.11).

3.9 WG-SAM-16/01 and 16/02 presented proposals by France to conduct research fishing in Divisions 58.4.1 and 58.4.2 respectively. France was unable to conduct research fishing in this region in 2015/16, and proposed to undertake the same activities as outlined in its proposals last year (SC-CAMLR-XXXIV, Annex 5, paragraph 3.16).

3.10 The Working Group noted that Japan had proposed to conduct research in this region for several years, but had not been able to commence research. It noted that the Scientific Committee had advised that Japan conduct research in Subarea 48.6 as a priority (SC-CAMLR-XXXIV, paragraph 3.233) and, therefore, the proposal should be modified to reflect what would be realistically possible in 2016/17 in Divisions 58.4.1 and 58.4.2.

3.11 The Working Group noted that during the previous three-year research plan, very little fishing effort in Division 58.4.2 had occurred due to the strong seasonal pattern of sea-ice and prioritisation of research and exploratory fishing in other areas during the summer when the research blocks were most likely to be open. However, it noted that the Republic of Korea had captured 11 tonnes of toothfish and released 82 tagged toothfish in research block 5842_1 during research in 2014/15.

General matters

3.12 The Working Group recalled the recommendation of the Scientific Committee (SC-CAMLR-XXXIV, paragraph 2.9) that there was a need to coordinate research across all of Subarea 58.4 to ensure that vessel effort was distributed to make the most effective use of the research and ensure rapid progress towards an assessment of the stock in these areas (SC-CAMLR-XXXIV, Annex 5, paragraph 3.17). It welcomed the undertaking that consolidated research plans be presented by the proponents of research in Divisions 58.4.1 and 58.4.2 to WG-FSA-16.

3.13 The Working Group requested the development of measurable research milestones that included both at-sea and onshore coordination of research activities, including analysis of samples and desktop studies to progress assessment of the toothfish stock in the area.

3.14 It was noted that activities in 2015/16 had been conducted using an initial research allocation as agreed between proponents in SC-CAMLR-XXXIV, Table 2, and that this mechanism had successfully avoided 'olympic research', as well as providing for circumstances where vessels were unable to participate. The Working Group noted that similar principles could be applied in other areas where multi-Member multi-vessel research plans were proposed or underway.

Review of research plans in Division 58.4.3a

3.15 WG-SAM-16/03 presented a research plan for the exploratory longline fishery for *Dissostichus* spp. in 2016/17 in Division 58.4.3a by France and Japan. The Working Group noted that research fishing has been conducted in the research block by two vessels using longlines. The proposal notified that France and Japan intend to continue their exploratory fisheries in Division 58.4.3a to contribute to the tagging program and to achieve a robust stock assessment.

3.16 A biomass of 398 tonnes was estimated during WG-FSA-15 using the geometric mean of Chapman biomass estimators. The Working Group noted that further developments of a CASAL integrated stock assessment model requires a stock biomass with reliable estimates of illegal, unreported and unregulated (IUU) removals, as well as a maturity key and parameters for the von Bertalanffy growth curve from age readings.

3.17 The Working Group noted that CPUE was described in different units (kg km^{-1} and kg/hooks) in different parts of WG-SAM-16/03 and recommended that it would be clearer to present these CPUEs in the same units throughout the paper. The Working Group further noted that only the size distribution of tagged fish was compared to the size distribution of the recaptures, and recommended that it would be useful to compare it with the length-frequency distribution of the entire catch.

3.18 The Working Group underscored the need to develop a procedure to estimate IUU removals in this division and to include this in the development of a robust stock assessment.

Review of research plans in Division 58.4.4b

3.19 WG-SAM-16/06 presented a research plan for the 2016/17 toothfish fishery in Division 58.4.4b (research blocks 5844b_1 and 5844b_2) by Japan and France using the updated CCAMLR C2 and observer data. The estimated median stock size in research blocks 5844b_1 and 5844b_2 was 380 and 483 tonnes respectively using the Chapman estimator, and 1 057 and 1 153 tonnes respectively using the CPUE analogy method (reference area: northern area of Subarea 48.4).

3.20 WG-SAM-16/06 suggested that predicted numbers of tag recaptures using a CPUE analogy method were generally closer to the observed ones for both blocks, and proposed to continue the current research operation for the next fishing season with the same survey design as recommend for 2015/16.

3.21 The Working Group noted that it would be useful to provide WG-FSA with a standardised CPUE series for this division (paragraph 2.36).

3.22 The Working Group recommended that it would be valuable to compare tag-recapture rates between the Japanese and French vessels in this division, and that a table of this comparison be provided to WG-FSA. It was further recommended that a figure of the location of planned and realised sets (mid-points) carried out in this division should be provided to WG-FSA-16.

Review of research plans in Subarea 48.6

3.23 The Working Group considered five papers relating to research plans and results of research conducted in Subarea 48.6, including a summary of results of four years of research fishing carried out by Japan and South Africa (WG-SAM-16/41 Rev. 1), an analysis of sea-ice concentration in the south of Subarea 48.6 (research blocks 486_4 and _5) (WG-SAM-16/42 Rev. 1), a proposal to extend the spatial extent of research block 486_2 (WG-SAM-16/08), an updated joint proposal to continue research fishing in Subarea 48.6 submitted by Japan and South Africa (WG-SAM-16/07) and a proposal for three years of planned research fishing by Uruguay (WG-SAM-16/12).

Review of Japanese and South African research plans

3.24 The Working Group welcomed the joint progress report on research fishing from South Africa and Japan (WG-SAM-16/41 Rev. 1) and noted that a preliminary integrated assessment for research block 486_2 had been attempted using data from 2009 onwards which included new estimates of growth parameters and age-at-maturity data derived from an otolith ageing program. The Working Group also welcomed the provision of research 'milestones' which included a summary of research progress to date and an overview of future research, including an indication of how various components of the research would be shared between the proponents (WG-SAM-16/41 Rev. 1, Table 11).

3.25 The report also contained an outline of a stock hypothesis for the region which suggests that the life history of *D. mawsoni* in Subarea 48.6 is similar to that seen in the Ross

Sea with juveniles inhabiting the continental shelf region with northward spawning and southward feeding movements. However, the Working Group noted that the stock area had not yet been resolved.

3.26 The Working Group noted that the research fishing was now into its fourth year and that over this period almost all fishing had taken place in research blocks 486_2–4. Research block 486_1 was fished in one year only and catches were dominated by *D. eleginoides*. Poor ice conditions meant that research block 486_5 was accessible in only one year in four. The Working Group noted that an inability of vessels to consistently return every year to a research block in order to deploy or catch tagged fish was a major constraint on the development of an assessment. Based on information from the Ross Sea, it is assumed that the change in availability of tagged fish resulting from movement of fish means that tagged fish are considered unavailable for recapture after three years at liberty. Therefore, if access to a region is restricted for more than two years in three, the recovery of tagged fish would not be predicted from that research block.

3.27 The Working Group noted that the lack of a robust stock hypothesis was impacting on the ability to develop an integrated stock assessment for Subarea 48.6. It noted that the further development of a stock hypothesis for *D. mawsoni* for Subarea 48.6 would benefit from data from the shelf region in research block 486_5 and this has been severely limited by access issues caused by sea-ice. The Working Group agreed that the current low levels of tag returns and only limited information on fish movement away from research blocks meant it was difficult to interpret the results obtained from different methods of estimating biomass and, therefore, evaluate which was likely to be the more reliable.

3.28 The Working Group agreed that the focus of research should be on efforts to resolve the movements of fish between research blocks and to improve the tag-recapture rate.

3.29 The Working Group agreed that the use of PSATs could provide a considerable amount of information on fish movement that could be used to further develop a stock hypothesis and noted that they could potentially be deployed in research block 486_5 (when ice conditions were good) without the need to return in subsequent years in order to obtain information on fish movement.

3.30 The Working Group noted that sea-ice could limit the utility of PSATs (as they must reach the surface to transmit data) but they could also provide useful and rapid information on movement of individuals if deployed in ice-free research blocks such as 486_2 and 486_3.

3.31 The Working Group welcomed the sea-ice analysis carried out by Japan (WG-SAM-16/42 Rev. 1) which examined accessibility of research blocks 486_4 and 486_5 in the southern region of Subarea 48.6 over the last four years using satellite-derived data.

3.32 The Working Group noted that such analyses are very useful in providing an indication of the inter- and intra-annual variability in the accessibility of research blocks to fishing vessels and could potentially be used to predict periods when access is most likely. However, it was noted that operational constraints on vessels mean there may not be a temporal overlap with optimum ice conditions and this may impact the ability to collect the necessary information. The Working Group encouraged Japan to continue these analyses using data spanning a greater number of years. This could be used to indicate regions of the continental shelf within fishable depths that may have more reliable and frequent access than research block 486_5.

3.33 The Working Group considered WG-SAM-16/08 by Japan which proposes an extension to the spatial extent of research block 486_2. The rationale for the extension to the research block is that it is adjacent to an area of higher *D. mawsoni* density within the existing research block which could increase the possibility of the catch limit for the research block being taken. There would be no increase in catch for this research block but it would come from the limit for the existing research block 486_2.

3.34 Dr Ichii noted that in the western part of research block 486_2 near Bouvet Island, both *D. mawsoni* and *D. eleginoides* will possibly be taken as by-catch, even though fishing tends to focus on *D. mawsoni*. He also considered that it is worthwhile shifting the block north-eastward where possibly only *D. mawsoni* are distributed, so that it can avoid by-catch of *D. eleginoides*. Japan will resubmit a proposal on this revision to WG-SAM-17.

3.35 The Working Group noted that such an approach was likely to dilute fishing effort across a larger area and, therefore, could reduce the ability of vessels to scan tagged fish and dilute tagging effort in the research block. It was suggested that moving the existing block whilst maintaining the same effort would have the same effect, but would result in the loss of some existing tagged fish that would then be outside the research block.

3.36 The Working Group considered the joint proposal by Japan and South Africa for continuing research in Subarea 48.6 for 2017 (WG-SAM-16/07). It noted that the proposal was largely unchanged from the existing plan, except for the proposal for extension of research block 486_2 (see paragraph 3.33).

Uruguayan proposal for research fishing in Subarea 48.6

3.37 The Working Group considered a three-year proposal by Uruguay to conduct a plan of research fishing in Subarea 48.6 (WG-SAM-16/12). The proposal is based on the joint Japanese/South African research with effort focussed on research blocks 486_1–4. The aims of the planned research fishing are to increase the number of fish tagged and scanned in the subarea. The vessel would use trotline fishing gear.

3.38 The Working Group noted that a greater number of Members involved in research in Subarea 48.6 may lead to an increased amount of work carried out and speed up the rate at which data are collected. However, the Working Group noted that the science objectives of the planned research were currently not clear and did not include a plan for analysis of collected samples, or for desktop analysis to contribute to the development of stock structure and other data inputs needed for stock assessment.

3.39 The Working Group also noted that Uruguay had not yet approached the proponents of the existing joint research plan in Subarea 48.6 (Japan and South Africa) in order to coordinate research activities. The Working Group recalled that this coordination should include both on-water activities and the subsequent analysis of samples and data and recommended that Uruguay collaborate with South Africa and Japan in any planned research fishing activities in Subarea 48.6.

Advice on research proposals in Subarea 48.6

3.40 The Working Group evaluated whether the current research plan was achieving its objective towards the development of an integrated stock assessment for Subarea 48.6. It noted that without data to test the stock hypothesis it was not clear how the transition from estimation of biomass within research blocks to an integrated assessment for the whole subarea would be achieved. In order to expedite the process of testing the stock hypothesis and increasing the likelihood of obtaining sufficient tags necessary for the development of an integrated stock assessment, the Working Group recommended that:

(i) research fishing in Subarea 48.6 should be targeted towards *D. mawsoni* as a greater amount of data derived from research fishing is available compared to *D. eleginoides*. Catches from research block 486_1 have been comprised solely of *D. eleginoides* and this block should be removed from research proposals

(ii) research blocks 486_2, _3 and _4 should be considered priority areas for research fishing as they are consistently free of sea-ice at the time of the research fishing and represent a diverse range of likely toothfish habitat

(iii) the use of PSATs is encouraged in the priority research blocks to provide data on fish movement within and outside these areas

(iv) the Working Group further recommended that the following analyses should be carried out and a report be submitted to WG-SAM-17:

(a) further analyses of sea-ice dynamics should be carried out over the whole of the continental shelf region to identify other regions of suitable toothfish habitat that may be more reliably ice-free in a given year and would enable the detection of tags with an assumed tag availability period of three years

(b) an analysis of all available tag data should be undertaken to better characterise fish movement within and between research blocks to assist with validation and development of the stock hypothesis.

3.41 The Working Group also agreed that a range of other research fishing and analytical activities analogous to those carried out in the Ross Sea should be considered in the longer term. This includes:

(i) winter surveys in ice-free northern areas to provide data on the spawning dynamics of *D. mawsoni* in the region

(ii) random stratified, effort-limited sub-adult surveys of the southern shelf region to provide data on recruitment

(iii) experimental work and desktop-based analyses of data from both fishery and other scientific fields to understand stock structure, life history, movement patterns and productivity.

Review of scientific research proposals for other areas (e.g. closed areas, areas with zero catch limits, Subareas 88.1 and 88.2)

Structurally changed or new research proposals intended to provide other advice

Research proposals in Subarea 88.1

4.1 WG-SAM-16/14 presented the results of the fifth CCAMLR-sponsored Ross Sea shelf survey to monitor abundance of sub-adult *D. mawsoni* in the southern Ross Sea. The survey included numerous objectives as outlined in WG-SAM-15/45, with two additional objectives relating to the deployment of PSATs to assess toothfish movements and baited cameras to observe fish and animals throughout the water column. The survey successfully completed 45 sets in the core survey strata and 10 sets in McMurdo Sound, detecting an increase in catch rates of sub-adult fish in the core strata consistent with a strong year class progressing through the surveyed population. The paper included the notification and survey station locations for the continuation of the survey in 2017. The Working Group recalled that continuing the survey in 2017 was recommended by the Scientific Committee and endorsed by the Commission (SC-CAMLR-XXXIV, paragraph 3.190; CCAMLR-XXXIV, paragraph 5.34).

4.2 The Working Group welcomed the paper, noting the new information presented on the prevalence of depredation by scavenging benthic amphipods (lice). It noted a high prevalence of lice in some areas, the potential for depredation to impact on CPUE and a weak correlation with soak time. It noted the recent Coalition of Legal Toothfish Operators (COLTO) symposium on depredation at which sperm whale and killer whale depredation were the key focus, but other forms of depredation (e.g. from lamprey, hagfish and squid) were also discussed. It noted a meta-analysis of lice prevalence would be useful, as would collection of lice prevalence data in other areas of the Ross Sea. It recalled the establishment of the depredation e-group and noted that it may be a useful forum for the discussion of all forms of depredation.

4.3 The Working Group noted that the survey estimates of CPUE were precise relative to other survey series. It noted that the precision of the estimates was a consequence of applying appropriate survey methodology (i.e. using standardised gear and applying a random stratified survey design) in an area with relatively stable catch rates. It noted the difference in size distribution between the catch in the survey strata and research fishing that was occurring through the sea-ice in McMurdo Sound, with predominantly larger older fish being found in the southern areas, highlighting the value of sampling in those areas.

4.4 Dr Parker provided an update on the CCAMLR-sponsored Ross Sea winter survey to investigate *D. mawsoni* spawning (WG-SAM-15/47) that is currently being conducted in the northern Ross Sea. The survey is being conducted with international collaboration from the Italian Antarctic Programme and ISMAR in Genoa. Five PSATs were deployed on the northern seamounts in collaboration with the USA. A report of the survey will be provided to WG-FSA.

Research proposals in Subarea 88.2 (north and south)

4.5 WG-SAM-16/26 Rev. 1 presented analysis of catch and fishing effort from *Dissostichus* spp., as proposed in SC-CAMLR-XXXIV, paragraphs 3.200 and 3.201 and

CCAMLR-XXXIV, paragraphs 5.38 to 5.41, in the exploratory fishery in the northern part of the Ross Sea (SSRUs 881B, C and G). Data from the autoline longline fishery for the period of 1997–2015 was used as example.

4.6 Dr Kasatkina recalled that in accordance with current practice used by WG-SAM and WG-FSA in the presence of questionable CPUE values (kg/thousand hooks or kg km^{-1}) it is recommended to analyse: (i) reconciliation of vessel monitoring system (VMS) data with reported catch location data; (ii) the relationship between hauling duration and CPUE; and (iii) the relationship between hauling speed and CPUE. She noted that it is necessary to clarify whether this approach to analyse longline fishery provides adequate information for decision-making.

4.7 Dr Kasatkina indicated that the analysis in WG-SAM-16/26 Rev. 1 shows the presence of a weak dependence between haul duration and CPUE and between haul speed and CPUE: the correlation coefficients were in the range 0.05–0.4. In some cases, a negative correlation or lack of dependence was observed. However, regardless of the relationship between CPUE and hauling duration (or speed), there is a possible presence of high CPUE, which are outside the upper limit of confidence interval of 95% CI as well as 99.7% CI. In her opinion, CPUE values outside the upper limit of 99.7% CI are statistically unreliable and questionably high with respect to the fishery data in the year under consideration.

4.8 Dr Kasatkina noted that it is obvious that the presence of high CPUE outside the 99.7% CI, as well as the lack of dependence between CPUE and hauling speed (hauling duration), may occur regardless of the reconciliation of VMS data with reported catch location data.

4.9 Dr Kasatkina highlighted that the current approach to analyse longline fishery data in the presence of questionable CPUE values does not allow revealing adequate information for decision-making. She proposed to add the following procedures into the above said analysis of longline fishery data:

(i) criteria for the assessment of CPUE variability from the duration and speed of hauling (for example, significance measure of the correlation values)

(ii) confidence interval (e.g. 99.7%) for the decision-making in relation to questionable CPUE values.

4.10 The Working Group thanked the authors for the analysis. It noted that the presentation included material that was not included in the paper and noted that the presentation was appended to the original paper and submitted as WG-SAM-16/26 Rev. 1. In reviewing the presented material, the Working Group noted that it is usual that some CPUE values will be above the confidence intervals. In the majority of CPUE analyses, the distribution of the CPUE values does not usually follow a normal distribution as was assumed in the analysis presented. The Working Group also noted that CPUE regression analysis could be improved by adding prediction intervals about the regression to highlight those data outside the specific interval. It noted, however, that the confidence intervals shown in the presentation reflected variation in only one dimension of one of the regressed parameters and, therefore, were not valid for the inferences made.

4.11 The Working Group noted that the survey data included in the analysis came from three Members' vessels and, therefore, represented independent CPUE samples with similar characteristics, exhibiting both high and low values of CPUE.

4.12 The Working Group acknowledged the offer of New Zealand and the UK to work with Russia to develop methods that could be used to assess the quality of fishery data and hoped that these methods could be presented to WG-FSA-16.

4.13 WG-SAM-16/16 Rev. 1 presented an analysis of catch and effort data in SSRUs 882A–B north from the 2015 fishing season, including comparisons with data from exploratory fisheries and closed areas (performed by New Zealand, Norway and the UK as indicated in SC-CAMLR-XXXIV, paragraphs 3.200 and 3.201). The authors concluded that the characteristics of the haul and catch metrics, and of the biological records taken from fish caught by the three independent vessels conducting the SSRUs 882A–B offshore survey, are consistent with those collected by other vessels fishing in comparable CCAMLR areas.

4.14 The Working Group thanked the authors for the analysis. It noted that it included all available data from exploratory fisheries and closed areas until 2015, but excluded quarantined data.

4.15 Dr Kasatkina noted that catch and effort data from the 18 longline sets undertaken during the 2015 survey in the northern region of SSRUs 882A–B were compared with those from a large number of longline sets conducted by exploratory fisheries in different areas of the Convention Area. She indicated that the results only showed that CPUE from the survey were within the range observed from all available data from exploratory fisheries and closed areas until 2015. She also emphasised that it has yet to be determined whether the high CPUE in the northern region of SSRUs 882A–B are the specific properties of this region or represent questionable data.

4.16 Dr Kasatkina also highlighted that the analysis does not provide methods for identifying any potentially questionable sources of the high CPUE observed in the northern region of SSRUs 882A–B. She noted that CPUE values of higher than 100 fish/thousand hooks constitute only a very small proportion of all available longline sets from exploratory fisheries and closed areas while they comprise 4 out of the 18 longline sets obtained during the 2015 survey in SSRUs 882A–B.

4.17 Dr Kasatkina emphasised the necessity to provide an analysis of the VMS data with reported haul locations and proposed to provide this to WG-FSA-16 that will accomplish the objectives stated in the Scientific Committee (SC-CAMLR-XXXIV, Annex 7, paragraph 4.104; SC-CAMLR-XXXIV, paragraph 3.200).

4.18 The Working Group noted that for any further analysis in this context, the objectives should be clearly stated, hypotheses identified, and that criteria to meet these objectives that are acceptable to all Members be stated.

4.19 The Working Group agreed on the importance of identifying a set of diagnostics and clear criteria to assess the likelihood that a vessel is operating as would be expected in normal research fishing activities, so that the Working Group could provide advice to the Scientific Committee. It noted that characterising research fishing activities and the operation of vessels would be helpful in developing diagnostics and criteria. The Working Group noted that those records identified as suspect should be flagged in the database.

4.20 The Working Group recommended that an e-group be established to develop objectives (paragraph 4.18) and to continue the analyses of CPUE identified above and to develop a common approach and outcomes. This would facilitate the participation of all Members to help continue the work and resolve any outstanding issues. All Members with an interest in these analyses and the results are encouraged to participate.

4.21 WG-SAM-16/15 presented the proposal for a second multi-Member longline survey of toothfish in the northern Ross Sea region (SSRUs 882A–B), to be conducted by Australia, New Zealand, Norway and the UK. The proponents noted the proposal had the same objectives as for the first year of the survey but that there had been minor modifications to the design, including: vessels recording depth and location every five minutes; vessels fishing in the same research blocks as in 2015; spreading samples spatially by applying a 25 tonne catch limit per research block while retaining a maximum of 17 250 hooks per cluster of five sets; adopting a data collection plan to ensure adequate data are collected and samples processed by Members; and agreeing that observers transmit summary data daily for scientific oversight by each Member conducting the research.

4.22 The Working Group noted the overall objective of the research was to provide the necessary information to enable the opening of closed SSRUs as part of the Ross Sea region toothfish fishery by identifying appropriate catch splits and obtaining movement data for a spatial population model (SPM) from tag recaptures. It noted that such research could be used as a template for CCAMLR-sponsored multi-Member, multi-sample surveys across the whole of the northern part of Subarea 88.1 and SSRUs 882A–B.

4.23 Dr Kasatkina recalled that analysis of the 2015 survey in the northern region of SSRUs 882A–B was uncompleted and this analysis does not meet the recommendation of the Scientific Committee (SC-CAMLR-XXXIV, Annex 7, paragraph 4.104; SC-CAMLR-XXXIV, paragraph 3.201). She cannot support the proposal for a second longline survey of toothfish in the northern Ross Sea region (SSRUs 882A–B).

4.24 Dr Kasatkina stated that the high CPUE from the 2015 survey in the northern region of SSRUs 882A–B should result in all of the data from this survey being placed into quarantine until a satisfactory analysis of the questionably high CPUE has been completed, as occurred when data from Subarea 48.5 showed questionable CPUE values and the data was subsequently placed under quarantine.

4.25 Some participants of the Working Group noted that the survey proponents had provided an analysis of the data in WG-SAM-16/16 Rev. 1, which contained both high and low catch rates. The initial analysis indicated that the data was consistent with fishing parameters estimated within other comparable areas, and the analysis will be continued and submitted to WG-FSA-16.

4.26 The Working Group noted that the data currently quarantined in Subarea 48.5 had been agreed to be quarantined by the Commission, including the Members submitting that data to CCAMLR (CCAMLR-XXXIII, paragraph 5.66; CCAMLR-XXXIV, paragraph 3.90), following analysis conducted at the Scientific Committee that showed it was inconsistent with what would be expected under normal research fishing activities (SC-CAMLR-XXXIII, paragraphs 3.230 to 3.234).

4.27 At the time of adoption, Dr Kasatkina stated that Russian data currently quarantined in Subarea 48.5 is the responsibility of the Standing Committee on Implementation and Compliance (SCIC) but not the responsibility of WG-SAM.

4.28 The Working Group recalled the discussion of the Scientific Committee (SC-CAMLR-XXXIV, paragraphs 3.200 and 3.201), noting that there were no Scientific Committee recommendations for further analysis, and the only outstanding analysis was that which Dr Kasatkina had indicated she would undertake. The Working Group agreed the analysis methods applied were appropriate and encouraged Members to work together to bring any further analysis to WG-FSA.

4.29 The Working Group requested the Secretariat provide an analysis to WG-FSA-16 comparing VMS data with reported catch location data for the most recent three years (as outlined in SC-CAMLR-XXXIV, Annex 7, paragraphs 3.30 to 3.32), consistent with the proposal of Dr Kasatkina (SC-CAMLR-XXXIV, paragraph 3.200), to verify if catch records correspond to VMS locations for all exploratory fisheries and closed areas within the CCAMLR area.

4.30 Dr Kasatkina presented WG-SAM-16/27 describing the Russian research program on resource potential and life cycle of *Dissostichus* species in SSRU 882A from 2016 to 2019. She noted that the proposed survey by Russia in the southern region of SSRU 882A includes sampling requirements that exceed the observer sampling requirements specified in Conservation Measure (CM) 41-01, Annex 41-01/A. Moreover, the Russian program sampling is consistent with the Ross Sea region fisheries data collection plan proposed by WG-FSA-15/40. She noted that the Russian program requirements include tagging (5 toothfish per tonne of catch), toothfish biological sampling (length, weight, sex, stomach weight and stomach contents, gonad state and gonad weight, muscle tissue and otoliths), as well as sampling for more detailed analysis (gonad histology, muscle tissue for stable isotope analysis, genetic analysis and parasitological analysis). She noted that the majority of these sampling requirements would also be undertaken for by-catch species.

4.31 Dr Kasatkina recalled the recommendation of the Scientific Committee that if the survey in the southern part of SSRU 882A was undertaken within the catch limit for the Ross Sea region, then to achieve the objectives of the research a catch limit of 100 tonnes would be appropriate (SC-CAMLR-XXXIII, paragraph 3.226). She noted that this catch limit would be used by the Russian research program.

4.32 Dr Kasatkina highlighted that a Ukrainian observer is planned to be on board the Russian vessel. A vessel from Member countries is invited to take part in the research program in the southern region of SSRU 882A.

4.33 The Working Group asked how the catch limit was derived. Dr Kasatkina informed the Working Group that the proposed catch limit was based on the original proposal for research undertaken by Russia in 2010–2012. The Working Group recalled that the Secretariat will compute biomass estimates for research blocks and research fisheries, including the proposal presented in WG-SAM-16/27 (paragraph 2.26), which will allow WG-FSA-16 to evaluate the proposed catch limit.

4.34 The Working Group requested more information regarding the partner vessel that is proposed to undertake research in the adjacent research block along with a table of proposed

milestones for the research. Dr Kasatkina informed the Working Group that a Member had been approached to provide a partner vessel to participate in this research proposal and that, should the Member accept this proposal, a joint-research proposal would be submitted to WG-FSA-16.

4.35 The Working Group noted that this research plan had the opportunity to collect information relevant for toothfish predators such as Weddell seals and encouraged the proponents to consider incorporating these objectives into the research proposal.

Research proposals in Subarea 88.3

Korean survey

4.36 WG-SAM-16/29 reported research fishing by the Republic of Korea in Subarea 88.3 from 8 February to 25 March 2016 with 41 of 47 days on the fishing grounds. Four of the five research blocks were visited. The total catch of *D. mawsoni* was 106 tonnes, comprising 5 227 individuals with an average CPUE of 0.19 kg/hook; 566 individuals of *D. mawsoni* were tagged. Length frequency of *D. mawsoni* showed peaks with both small and large individuals within the subarea, with a high proportion of individuals at maturity stages 1 and 2. Biological information was collected comprising otoliths, stomach contents, gonad and muscle samples. Temperature and salinity data were collected at nine CTD stations.

4.37 WG-SAM reviewed the results from the survey and the proposal for continuation of the research (WG-SAM-16/11). No issues were identified with the proposal that would require changes before submission to WG-FSA. The Working Group thanked Korea for the information provided.

Research proposals in Subarea 48.2

Ukrainian survey

4.38 WG-SAM-16/22 reported on the second year of research fishing and observations on *Dissostichus* spp. in Subarea 48.2. The design had been amended following discussions within WG-SAM, WG-FSA and SC-CCAMLR. After adjustment for the catch taken by Chile during the previous month (7 tonnes), the remaining catch limit available for the survey did not allow all planned stations to be completed, only those in the southern area. Biological information on age, length and maturity were presented. Catch rates were used to provide estimates of the local biomass which differed between the 2015 and 2016 surveys due to the relative contribution of the CPUE collected in the areas surveyed; only three of 18 planned stations were conducted in the northern area due to the catch limit restrictions.

4.39 The survey noted fragments of IUU gillnets at three stations in the southern area and a longline at a fourth. COMM CIRC 16/24 had been issued to inform Members of the details. Samples of the nets and marked hooks were retained and the hooks passed to Chile to establish whether they belonged to the vessel which conducted the survey before Ukraine. Depredation by giant squid had also occurred.

4.40 WG-SAM thanked Ukraine for the report and welcomed the progress to obtain information from this closed area.

4.41 WG-SAM recalled the request for the development of forms to record observations of interactions with IUU gear by station, including measurements of gillnet mesh and longline gear details (SC-CAMLR-XXXIV, Annex 7, paragraph 3.47). This would allow mapping of the distribution of IUU fishing at a finer scale and allow selection of the gillnets used to be estimated. Furthermore, evidence of gillnet activity, such as abrasion or scarring from gillnet interactions, should be reported through such a mechanism.

4.42 WG-SAM-16/23 presented the research plan for the third year of research fishing, which would visit the same research grid. Ukraine noted that tagging larger fish of lengths more than 160 cm, the quantity of which did not exceed 20% of the catch, presented difficulties in hauling that were likely to result in the fish having poor survivorship as a result of the hauling process and requested consideration of omitting these from the tagging program.

4.43 WG-SAM noted that omitting large fish from the tagging program would result in bias in the assessment process. Other Members had developed methods for handling large fish, and noted that they could provide Ukraine with the details before or during WG-FSA. Previous advice provided in the CCAMLR tagging protocol and CCAMLR tag training module, including working with large fish, was available from the Secretariat (www.ccamlr.org/node/76310).

4.44 The Working Group requested Ukraine to provide a paper for review to WG-FSA-16 outlining their concerns if they wish to progress this consideration.

4.45 The Working Group noted that this research is still within the prospecting phase of the CCAMLR research plan flowchart (SC-CAMLR-XXXII, Annex 6, Figure 10) and, as such, the blocks defined within the research plan in this closed area were defined by the survey proponents for the purposes of defining areas with similar species composition and catch rates. The nomenclature used for describing research blocks, survey blocks and other bounded areas is required to be clarified to enable transparency in the ongoing development of the data-poor assessments.

Chilean survey

4.46 WG-SAM-16/20 reported on the first year of research fishing and observations on *Dissostichus* spp. in Subarea 48.2 by Chile. The vessel had arrived late to the fishing grounds at the end of the time period agreed for the Chilean fishing and had, therefore, only fished for 11 days before leaving the area. Due to the short time available, only 11 of the 30 research sets were completed. Seven tonnes of toothfish were caught (183 fish) but only four fish were considered by the observer to be in a condition that was suitable for tagging. Biological data (length and maturity) were collected and reported along with by-catch composition and *Dissostichus* spp. spatial catch rates.

4.47 The survey recaptured one tagged fish that had been released in Subarea 48.6, research block 486_5 in 2011, a new record for the longest movement by a toothfish. The Working Group discussed the implications of this information and noted that to date the majority of

tagged toothfish movements had been of very restricted range but that occasional long-distance movements had also been noted. Consequently, the majority of toothfish distances travelled recorded so far were relatively short.

4.48 The Working Group highlighted the need for further genetic studies to help in the differentiation of the population structure of the toothfish within Area 48 (southern Atlantic). It also requested that the Secretariat update its previous meta-analysis of the long-distance movement of tagged fish throughout the CCAMLR area.

4.49 The Working Group noted that the time available for the survey had restricted the amount of data that could be collected. However, it was presented with no information to indicate why the condition of caught toothfish was considered too poor for tagging and requested that further information be provided to WG-FSA-16 to allow evaluation of the likelihood that the vessel would be able to provide toothfish in a condition suitable for tagging if the research were to proceed and to fulfil its research commitments successfully. The Working Group also considered that this inability to provide fish in a condition for tagging should be brought to the attention of the Scientific Committee.

4.50 Chile noted that the vessel conducting the research would be replaced in 2016/17.

4.51 The Working Group questioned whether the replacement vessel would be able to conduct tagging successfully, as without it, WG-FSA may be in a situation whereby it could not recommend that the current research program continues.

4.52 The Working Group also noted that the vessel had a substantial catch of grenadiers, considerably higher than the target species catch. This contrasted with the by-catch recorded by the Ukrainian research which had a very low grenadier by-catch. It requested that the spatial distribution of grenadier by-catch be presented to WG-FSA along with any information on species composition.

UK survey

4.53 WG-SAM-16/33 presented a proposal by the UK for a longline survey connecting the currently undertaken surveys in Subarea 48.2 with the established fishery in Subarea 48.4. The research objectives included determining population connectivity between these subareas, improving understanding of *Dissostichus* spp. population structures in this region, and improving available data on bathymetry and associated distributions of benthic by-catch species. The proposal included a three-year data collection and two-year data analysis plan towards the development of a stock hypothesis for the northern regions of Subarea 48.2 and southern regions of Subarea 48.4.

4.54 Dr Kasatkina noted that the UK survey is aimed at providing data on *Dissostichus* spp. population structure in Subarea 48.2 and UK survey data will be combined with those from surveys conducted by Chile and Ukraine. She also noted that to obtain accuracy in the survey data, all vessels should operate with the same type of longline; and so the UK should also use trotline, rather than autoline, gear in this survey.

4.55 The Working Group noted that the gear used was consistent with the gear type used in Subarea 48.4. Whilst different longline gear may have different CPUE for *Dissostichus* spp.,

CPUE differences are not an issue when collecting biological data and conducting tagging to provide information on population structure and, therefore, this was not an issue for this survey. The Working Group also requested that Dr Kasatkina provide a reference to papers which indicated that selectivity, rather than catchability, differed between gear types.

4.56 Dr Kasatkina noted that the UK survey area in Subarea 48.2 is adjacent to the Ukrainian survey area. However, the catch limit for research fishing in the neighbouring areas was estimated using different analogies: a reference area from Subarea 88.2 (Ukrainian survey) and a reference area from Subarea 48.4 (UK survey). She noted that above said requests additional consideration.

4.57 Dr Kasatkina also noted that the catch limit estimated for the UK survey in Subarea 48.2 was based first on the reference area of Subarea 48.4S exploratory fishery and then on the southern part of the Subarea 48.4S fishery, and using the stock size for *D. mawsoni* in Subarea 48.4. However, the UK survey in Subarea 48.2 will be undertaken for research fishing of two species of toothfish. This issue has to be clarified.

4.58 Dr Kasatkina noted it was necessary to indicate the source of the research catch limit in Subarea 48.4. She asked if the research catch limit should be part of the total catch limit established for the fishery in Subarea 48.4.

4.59 The Working Group noted that the proposed catch limits were provided on the basis of two comparative areas and information for both species in those areas. The catch limits were considered as indicative and would be reviewed at WG-FSA-16 in light of the standardised methodology estimates being prepared by the Secretariat (paragraph 2.26).

4.60 The Working Group recalled its advice that there was a need to coordinate research across all of Subarea 48.2 to ensure the most effective use of the research and ensure rapid progress towards an assessment of the stock in the area (SC-CAMLR-XXXIV, Annex 5, paragraph 3.17).

4.61 The UK noted that it was collaborating with Ukraine in the analysis of ageing information and the genetic analysis of tissue samples. This had been occurring since the first survey was conducted in 2014/15.

Chilean finfish survey

4.62 WG-SAM-16/19 reported on the first year of research fishing for finfish around the South Orkney Islands and Elephant Island (Subareas 48.2 and 48.1 respectively). Fishing had been conducted in a circuit around the two islands using a midwater and a bottom trawl. Observations on the finfish species caught, seabird and cetacean encounters and also acoustic data were collected on icefish and krill. A second year of research with an increase in the number of days, shorter haul times and, therefore, an increased number of hauls was envisaged for the second year.

4.63 The Working Group questioned why the survey objectives in the research report differed substantially from those agreed by WG-SAM-15, WG-FSA-15 and SC-CAMLR-XXXIV. The cruise track did not follow the original transect lines but appeared to have the

characteristics of a fishing exercise. In addition, a bottom trawl (two hauls) had been used in addition to a midwater trawl (30 hauls), whereas the research proposal, agreed in 2015, only specified the use of a midwater trawl.

4.64 The Working Group noted that the survey spent less time (10 days) than had been planned (1 month), but the abandonment of a clearly specified and agreed survey design for all of the survey area, rather than completing a partial survey incorporating the original objectives, was disappointing; the original over-arching objectives had not been adhered to or met.

4.65 The lack of a clearly designed random stratified survey trawl protocol in the revised program was noted by the Working Group. As such, acoustic and trawl data collected by the survey was directed and considered biased. It could, therefore, not be used as a basis for determining any structure within the resource – an overriding aim of the survey.

4.66 Combined bottom and midwater trawling methods had been investigated by the UK and Russia in the early 2000s (SC-CAMLR-XXI, Annex 5, paragraphs 5.103 to 5.105) and trawling and acoustic work on icefish had been conducted more recently (WG-EMM-16/23). The Working Group noted that the survey design used in Subareas 48.1 and 48.2 in 2016 was extremely unlikely to produce results that will meet the requirements of the revised objectives. Consequently, the revised survey objectives, presented in the research report WG-SAM-16/19, would, most likely, not have been supported by WG-SAM and WG-FSA without substantial revision.

4.67 The Working Group agreed that the departure of the survey from its agreed objectives and the introduction of new objectives should be raised at the Scientific Committee before the survey is considered for further exemption under CM 24-01.

Research proposals in Subarea 48.5

4.68 Dr Kasatkina presented WG-SAM-16/25 in which she indicated that in 2016/17 Russia is proposing to continue investigations in Subarea 48.5 according to the research program adopted by the Commission (WG-FSA-12/12; SC-CAMLR-XXXI, paragraphs 9.5 to 9.15; CCAMLR-XXXI, paragraphs 5.37 to 5.43). She presented the Russian research program in Subarea 48.5 (Weddell Sea) from 2016 to 2019 (WG-SAM-16/25).

4.69 Dr Kasatkina noted that the Russian survey in the eastern part of the Weddell Sea includes sampling requirements that exceed the observer sampling requirements specified in CM 41-01, Annex 41-01/A. She noted that the Russian program requirements include tagging (5 toothfish per tonne of catch), toothfish biological sampling (length, weight, sex, stomach weight and stomach contents, gonad state and gonad weight, muscle tissue and otoliths), as well as sampling for more detailed analysis (gonad histology, muscle tissue for stable isotope analysis, genetic analysis and parasitological analysis). She noted that the majority of these sampling requirements would also be undertaken for by-catch species.

4.70 Dr Kasatkina noted that the catch limit was calculated based on the CPUE analogy method using SSRU 882H as the analogy (CPUE – 0.202 tonnes km^{-1} – SC-CAMLR-XXX, Annex 5, Table 2). The catch limit of 60 tonnes for option 1 and 50 tonnes for option 2 would be taken under the Russian research program (SC-CAMLR-XXXI, paragraphs 9.5 to 9.15;

CCAMLR-XXXI, paragraphs 5.37 to 5.43). Dr Kasatkina highlighted that a Ukrainian observer is planned to be on board the Russian vessel. One or two vessels from Member countries are invited to take part in the research program in the Weddell Sea.

4.71 The Working Group noted that Russia had not, to date, provided an update on the analyses requested by the Scientific Committee on the catch rates in Subarea 48.5 to which WG-SAM-16/25 referred (SC-CAMLR-XXXIII, paragraph 3.232; SC-CAMLR-XXXIV, paragraphs 3.271 and 3.272), and which were due to be provided to WG-SAM-16 and SCIC in 2016. The Working Group requested a timeline of when the results of these analyses would be available. Dr Kasatkina confirmed that these results will be available before SC-CAMLR-XXXV.

4.72 At the time of adoption, Dr Kasatkina stated that the situation with the quarantined Russian data is the responsibility of SCIC, but not of WG-SAM.

4.73 The Working Group recalled that the situation with this survey proposal in Subarea 48.5 has not changed since 2014 (SC-CAMLR-XXXIII, paragraphs 3.230 to 3.233), and WG-SAM is thus still unable to evaluate the research proposal in its current or previous formats. The Working Group referred to the discussions at WG-SAM-15 (SC-CAMLR-XXXIV, Annex 5, paragraph 4.10) recommending that the data concerned remain quarantined until such time that a complete analysis has been undertaken and submitted for consideration by WG-SAM, WG-FSA and SC-CAMLR.

4.74 The Working Group recalled that, as in previous years, the submitted proposal was based on assumptions and results of previous work carried out by Russia in Subarea 48.5 in 2012–2014, and that data from these activities have been quarantined by CCAMLR since 2014 (SC-CAMLR-XXXIII, paragraph 3.232). Without further clarification of these data as requested from Russia (SC-CAMLR-XXXIII, paragraph 3.232; SC-CAMLR-XXXIV, paragraphs 3.271 and 3.272), the Working Group was not able to evaluate the approach and proposed research in WG-SAM-16/25.

4.75 The Working Group further noted that the ice maps contained in WG-SAM-16/25 showed varied and difficult sea-ice conditions in the proposed working areas and their access routes, questioning whether the research area can be revisited sufficiently regularly to conduct the proposed research program. The Working Group referred to similar observations made regarding research block 486_5, where it had encouraged sea-ice analyses using data over a longer temporal range (>4 years) to indicate ice conditions along the continental slope more suited to regular access (paragraph 3.26).

General matters

4.76 In view of the discussions concerning all research plans presented during WG-SAM-16, the Working Group encouraged all multi-Member, multi-vessel research plan proposals to identify a coordination manager or group for a given research area to facilitate coordination of research proposals, operations at sea and data analyses.

4.77 The Working Group requested that such multi-Member, multi-vessel research proposals include a coordination paper outlining milestones, operational contingency plans and progress made.

Other business

5.1 WG-SAM-16/24 presented proposals by Russia to standardise reporting of by-catch. The paper reported that there were discrepancies between the methods employed by different Members.

5.2 The Working Group agreed that by-catch estimation was important and noted that under CM 23-07 the responsibility for reporting by-catch rested with the Flag State. The Working Group noted that the *CCAMLR Scientific Observers Manual* does not include comprehensive details of the methods of by-catch recording to be employed. Further detail is provided in the electronic logbooks, which should be the method of reporting used by all Members. Some Members are currently using electronic monitoring to supplement observer coverage in fisheries outside the CCAMLR area, and the Working Group considered that this approach could be useful to help develop accurate and efficient mechanisms to monitor and quantify by-catch in longline fisheries.

5.3 The Working Group noted that the differences in approach referred to in the paper were not specified precisely and may relate to confusion between the protocols for by-catch accounting and for monitoring interactions with VME indicator taxa. The Working Group further noted that it would be helpful if the Russian observer manual referred to in the paper were provided to the Secretariat to better understand the processes used on Russian vessels.

5.4 The Working Group noted that the recommendation in the paper to develop species identification resources is already underway and a draft identification guide is currently being reviewed by the Scheme of Scientific Observation e-group (SC-CAMLR-XXXIV, Annex 7, paragraph 7.3).

5.5 WG-SAM-16/30 reported estimates of conversion factors used to estimate green weight from processed weight in the Korean longline fishery during 2015/16. There was generally a good overlap between estimates and measured samples. Conversion factors slightly decreased with weight of fish. The conversion factors reported by observers were higher than those reported by the vessel, which could lead to an underestimate of the actual catch green weight reported by the vessel.

5.6 The Working Group welcomed the response to previous recommendations (SC-CAMLR-XXXIV, paragraphs 3.93 and 3.94) to do further work on green weight conversion factors and noted the importance of these factors to accurately estimate catch. The Working Group noted that the difference in conversion factors between vessels and observers has the potential to introduce a bias into catch data used in assessments and management.

5.7 The Secretariat reported that trials are currently underway to investigate the differences in conversion factors using data collected by observers from South Africa. The Secretariat noted that this work will inform development of routine processes for reconciliation of catch and Catch Documentation Scheme for *Dissostichus* spp. (CDS) data that will be made available through the data warehouse which is currently under development (paragraph 6.8).

5.8 WG-SAM-16/31 presented details of 10 CCAMLR tags recaptured by Korean vessels from 2011 to 2013 within the southern Indian Ocean (Area 51).

5.9 The Working Group welcomed the reports of tagging data from outside the CAMLR Convention Area. The Working Group noted the collaboration with adjacent Regional Fishery Management Organisations (RFMOs), and agreed the importance of continuing these relationships; in particular, ensuring that CCAMLR's expertise in tagging programs is available to inform the design of such programs beyond the CAMLR Convention Area. Such collaboration is important for ensuring optimal data collection for stocks straddling the boundary of the CAMLR Convention Area.

5.10 WG-SAM-16/32 compared the depredation estimation method of Gasco (WG-FSA-14/10) with the method using CPUE difference currently used within the assessment for toothfish in Subarea 48.3. The analysis showed that the methods were comparable and consistent with each other. A verbal report on the recent depredation symposium organised by COLTO was also included in the presentation of this work (paragraph 4.2).

5.11 The Working Group welcomed the paper and noted that such work crosses the remit of several fora, including the Scientific Committee Symposium to be convened this year, and the Depredation e-group. The Working Group recommended that the Scientific Committee consider whether such work may need its own work program in future years.

5.12 The Working Group noted the variability in depredation rates between regions, and emphasised the importance of the continued monitoring of these rates, even in areas where they are low, to avoid missing potentially substantial mortality effects from the fishery.

5.13 The Working Group noted the importance of gaining understanding of the scale of depredation by scavenging benthic amphipods (sea lice) and the effect on catch estimation as part of the work on depredation.

Data

5.14 Although no paper was submitted on the subject, the Working Group considered the ongoing issue of quarantined data. The Working Group noted that originally it had been assumed that quarantine would be a temporary stage until issues with the data had been addressed, but it has become apparent that this is not the case. The Working Group noted that careful consideration will need to be given by the Secretariat to the inclusion of these data in extracts available from the data warehouse as these are developed, and to inclusion in the *CCAMLR Statistical Bulletin*.

5.15 The Working Group noted the importance of accurate and complete metadata to guide users during selection of data for analysis. This is being actively developed by the Secretariat as part of the development of the data warehouse and metadata has been made publicly available. The Secretariat also reported on efforts to make the *CCAMLR Statistical Bulletin* more easily available via a web interface and non-proprietary file types. The Working Group welcomed these efforts to make the work of CCAMLR more transparent to the public.

Future work

6.1 The Working Group agreed that its future work should be driven by the outcomes of the forthcoming Scientific Committee Symposium. The Symposium will develop priorities for future work from, inter alia, a table that lists the various issues currently considered, or planned for consideration, by all of its working groups. This table was circulated to Members as Appendix 2 of SC CIRC 16/36.

6.2 Due to an editorial error, SC CIRC 16/36 does not correctly reflect the Working Group's efforts to address depredation and assess risks to by-catch species. A correct version of the entries in Appendix 2 of SC CIRC 16/36 would be provided by the Convener of WG-SAM for consideration at the forthcoming Scientific Committee Symposium (SC CIRC 16/06 and SC CIRC 16/36).

6.3 The Working Group advised the Scientific Committee that, during its last few meetings, most of its work has focused on reviewing research plans of Members who notify to fish in data-poor exploratory fisheries or closed areas. This point is relevant to discussions about future work for at least three reasons:

(i) if business continues as usual, WG-SAM will likely be unable to address all the issues identified in SC CIRC 16/36 and paragraph 6.2

(ii) although WG-SAM's efforts to review Members' research plans have proven invaluable, the work of WG-SAM has largely evolved away from detailed consideration of quantitative methods and now overlaps substantially with that of WG-FSA

(iii) many research plans and their accompanying progress reports are Member-specific and uncoordinated but apply to the same statistical subarea or division; this lack of coordination has increased the complexity of the review process and caused discussion by WG-SAM to be repetitive.

6.4 The Working Group identified issues arising from the lack of coordination and communication among proponents of research plans. These issues include the additional time required to review multiple proposals and results, confusion generated by applying different analytical procedures to the same data describing the same area, and the lack of accountability for analysing samples and data collected by all proponents, and Members proposing to fish in a given area but ultimately not conducting the planned research.

6.5 The Working Group encouraged the development of performance milestones for all research plans, including proposals made under CM 24-01, and noted that project management and reviews of research would be enhanced if Gantt charts were used to identify specific measurable objectives of the research; the expected outputs associated with those objectives; the dates those outputs would be provided; and, in the case of multi-Member proposals, the Member(s) responsible for conducting the work.

6.6 It was suggested that all the issues facing WG-SAM, including review of research plans, might be most efficiently and thoroughly addressed as a series of focus topics that are sequentially considered over a scheduled period of years rather than annually considered as standing agenda items. The schedule might be established on the basis of statistical area, for

example with all research plans in Area 88 being reviewed one year and then progressing to Areas 48 and 58 in two subsequent years. It was noted that the detailed review of Members' plans to fish in Subarea 48.6 (paragraphs 3.23 to 3.41) had demonstrated the utility of such focused area-based discussion. It was suggested that if a rotation of detailed reviews by WG-SAM were to continue, then a coordinated review of research plans in Divisions 58.4.1 and 58.4.2 would be useful.

6.7 There would be several advantages to minimising the number of standing agenda items considered at future meetings and focusing future discussions on area-based issues. These include:

(i) providing Members with advance notice of what science will be needed and considered at any given meeting

(ii) reducing the number of papers which receive only cursory review

(iii) providing opportunity for more in-depth discussion on any given issue

(iv) increasing coordination among Members.

6.8 The Working Group recommended that the Scientific Committee consider establishing a data management group for the reasons outlined in paragraph 2.20. It drew the attention of the Scientific Committee to a number of database issues currently needing to be resolved or worked on (paragraphs 2.15 to 2.20, 2.51 to 2.54, 5.7, 5.14 and 5.15).

Advice to the Scientific Committee

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

(i) Development of the CCAMLR database and data quality assurance –

  (a) data management group (paragraph 2.20)
  (b) milestones and timeline (paragraph 2.54).

(ii) Development of assessment methods in data-poor areas –

  (a) estimation of local biomass (paragraphs 2.28 to 2.30, 2.34 and 2.46).

(iii) Review of research plans in Subareas 48.6 and 58.4 –

  (a) Subarea 48.6 (paragraph 3.40)
  (b) Division 58.4.3a (paragraph 3.18).

(iv) Review of scientific research proposals for other areas –

  (a) interactions with IUU fishing gear (paragraph 4.41)
  (b) Chilean surveys in Subareas 48.1 and 48.2 (paragraphs 4.49 and 4.67).

(v) Other business –

(a) depredation work program (paragraph 5.11).

(vi) Future work –

(a) WG-SAM work program (paragraph 6.3)
(b) data management (paragraph 6.8).

Adoption of the report and close of the meeting

8.1 The report of the meeting of WG-SAM was adopted.

8.2 In closing the meeting, Dr Parker thanked CNR for hosting the meeting, and Dr Vacchi and the local organising team and Berio Library staff for their kind hospitality and use of the library facilities and the Sala Lignea. He also thanked participants for their contributions to the work of WG-SAM and engaging in the discussions and preparation of the report.

8.3 Dr Reid, on behalf of WG-SAM, thanked Dr Parker for his leadership of WG-SAM and successful completion of the meeting.

References

Agnew, D.J., J. Moir Clark, P.A. McCarthy, M. Unwin, M. Ward, L. Jones, G. Breedt, S. Du Plessis, J. Van Heerdon and G. Moreno. 2006. A study of Patagonian toothfish (*Dissostichus eleginoides*) post-tagging survivorship in Subarea 48.3. *CCAMLR Science*, 13: 279–289.

Candy, S.G., D.C. Welsford, T. Lamb, J.J. Verdouw and J.J. Hutchins. 2011. Estimation of natural mortality for the Patagonian toothfish at Heard and McDonald Islands using catch-at-age and aged mark-recapture data from the main trawl ground. *CCAMLR Science*, 18: 29–45.

Table 1: Agreed reference areas for species and research blocks in Subareas 48.6 and 58.4. TOP – *Dissostichus eleginoides*; TOA – *D. mawsoni*; 48.4 N – Subarea 48.4 north; RSR – Ross Sea region; HIMI – Heard Island and McDonald Islands.

Research block	Species	Reference region for CPUE analogy method
486_1	TOP	48.4 N
486_2	TOP	48.4 N
486_2	TOA	RSR
486_3	TOA	RSR
486_4	TOA	RSR
486_5	TOA	RSR
5841_1	TOA	RSR
5841_2	TOA	RSR
5841_3	TOA	RSR
5841_4	TOA	RSR
5841_5	TOA	RSR
5842_1	TOA	RSR
5844b_1	TOP	HIMI
5844b_2	TOP	HIMI
5843a_1	TOP	HIMI

Appendix A

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(Genoa, Italy, 27 June to 1 July 2016)

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Appendix B

Agenda

Working Group on Statistics, Assessments and Modelling
(Genoa, Italy, 27 June to 1 July 2016)

1. Introduction

    1.1 Opening of the meeting
    1.2 Adoption of the agenda and organisation of the meeting

2. Methods for assessing stocks in established fisheries

    2.1 Review of progress towards updated integrated assessments
    2.2 Stock assessment methodologies

3. Review of research plans in Subareas 48.6 and 58.4

    3.1 Review of research plans in Subarea 58.4
        3.1.1 Review of research plans in Divisions 58.4.1 and 58.4.2
        3.1.2 Review of research plans in Division 58.4.3a
        3.1.3 Review of research plans in Division 58.4.4b

    3.2 Subarea 48.6 review

4. Review of scientific research proposals for other areas (e.g. closed areas, areas with zero catch limits, Subareas 88.1 and 88.2)

    4.1 Structurally changed or new research proposals intended to provide other advice
        4.1.1 Research proposals in Subarea 88.1
        4.1.2 Research proposals in Subarea 88.2 (north and south)
        4.1.3 Research proposals in Subarea 88.3
        4.1.4 Research proposals in Subareas 48.1, 48.2 and 48.4
        4.1.5 Research proposals in Subarea 48.5

5. Other business

6. Future work

7. Advice to the Scientific Committee

8. Adoption of report and close of meeting.

Appendix C

List of Documents

Working Group on Statistics, Assessments and Modelling
(Genoa, Italy, 27 June to 1 July 2016)

WG-SAM-16/01	Research plan for exploratory fishing for toothfish (*Dissostichus* spp.) in 2016/17 in Division 58.4.1 Delegation of France
WG-SAM-16/02	Research plan for exploratory fishing for toothfish (*Dissostichus* spp.) in 2016/17 in Division 58.4.2 Delegation of France
WG-SAM-16/03	Research plan for the exploratory longline fishery for *Dissostichus* spp. in 2016/17 in Division 58.4.3a Delegations of France and Japan
WG-SAM-16/04	Research plan for the 2016/17 exploratory longline fishery of *Dissostichus* spp. in Division 58.4.1 Delegation of Japan
WG-SAM-16/05	Research plan for the 2016/17 exploratory longline fishery of *Dissostichus* spp. in Division 58.4.2 Delegation of Japan
WG-SAM-16/06	Research plan for the 2016/17 toothfish fishery in Division 58.4.4b by Japan and France Delegations of Japan and France
WG-SAM-16/07	Research plan for the 2016/17 exploratory longline fishery of *Dissostichus* spp. in Subarea 48.6 by South Africa and Japan Delegations of Japan and South Africa
WG-SAM-16/08	Proposal of extension of research block 48.6_2 to complete planned research and examine the habitat model and the stock structure T. Namba, T. Ichii and K. Taki
WG-SAM-16/09	Proposal for continuation of Australia's research plan for exploratory fishing for toothfish (*Dissostichus* spp.) in East Antarctica (Divisions 58.4.1 and 58.4.2) Delegation of Australia
WG-SAM-16/10	Spanish research proposal for the 2016/17 season in Division 58.4.1 Delegation of Spain

WG-SAM-16/11	Korean research plan in Subarea 88.3 in 2016/17 Delegation of the Republic of Korea
WG-SAM-16/12	Proposal for research fishing in CCAMLR Subarea 48.6 during the three-year period 2016/17–2018/19 Delegation of Uruguay
WG-SAM-16/13	Performance metrics to index the spatial coverage of mark-recapture data C. Marsh, A. Dunn and S. Mormede
WG-SAM-16/14	Results of the fifth Ross Sea shelf survey to monitor abundance of sub-adult Antarctic toothfish in the southern Ross Sea, February 2016, and notification for continuation in 2017 A. Dunn, C. Jones, S. Mormede and S. Parker
WG-SAM-16/15	Proposal for a second longline survey of toothfish in the northern Ross Sea region (SSRUs 882A and B) S.J. Parker, R.J.C. Currey, M. Söffker, C. Darby, D. Welsford and O.R. Godø
WG-SAM-16/16 Rev. 1	Analysis of catch and effort data in SSRUs 882A–B North from the 2015 fishing season including comparisons with data from exploratory fisheries and closed areas K. Large, A. Dunn, S.J. Parker, T. Earl, C. Darby, M. Söffker and O.R. Godø
WG-SAM-16/17	Korean research plan in Divisions 58.4.1 and 58.4.2 in 2016/17 Delegation of the Republic of Korea
WG-SAM-16/18 Rev. 1	A description of current metrics and methods used in providing advice to the Scientific Committee on setting catch limits and assessing research plans in research blocks in exploratory fisheries and closed areas Secretariat
WG-SAM-16/19	Finfish distribution and abundance in Subareas 48.1 and 48.2, years 2016–2018 P.M. Arana, G. Plaza, J. Arata, N. Alegría and S. Viquerat
WG-SAM-16/20	Preliminary report on the survey for *Dissostichus* spp. in Subarea 48.2 (Phase one 2016) A. Zuleta, S. Hopf and P. Ruiz
WG-SAM-16/21	Research longline fishing proposal for *Dissostichus* spp. in Subarea 48.2 (Second season) Delegation of Chile

WG-SAM-16/22	The preliminary report on the survey in Subarea 48.2 in 2016 (the second year of the planned 3-year-old investigations) L. Pshenichnov, S. Ajiumerov and D. Marichev
WG-SAM-16/23	Plan of research program of the Ukraine in Subarea 48.2 in 2017 (third season) L. Pshenichnov, S. Ajiumerov and D. Marichev
WG-SAM-16/24	Proposals of the Russian Federation on by-catch reporting in the longline toothfish fishery in the CCAMLR Convention Area Delegation of the Russian Federation
WG-SAM-16/25	Plan of research program of the Russian Federation in Subarea 48.5 (Weddell Sea) in season 2016/17 Delegation of the Russian Federation
WG-SAM-16/26 Rev. 1	Analysis of the data at the international exploratory toothfish fishery in the northern part of the Ross Sea (SSRUs 881 B, C and G) Delegation of the Russian Federation
WG-SAM-16/27	Research program on resource potential and life cycle of *Dissostichus* species from the Subarea 88.2 A in 2016–2019 Delegation of the Russian Federation
WG-SAM-16/28	Progress report on the Korean exploratory longline fishery for *Dissostichus* spp. in Division 58.4.1 in 2015/16 Delegation of the Republic of Korea
WG-SAM-16/29	Progress report on the Korean research fishing by longline fishery for *Dissostichus* spp. in Subarea 88.3 in 2015/16 Delegation of the Republic of Korea
WG-SAM-16/30	Report on conversion factor of the Antarctic toothfish, *Dissostichus mawsoni*, by Korean longline vessels in 2015/16 Delegation of the Republic of Korea
WG-SAM-16/31	Recapture information by Korean longline fishery in Southern Indian Ocean Delegation of the Republic of Korea
WG-SAM-16/32	Validating the Gasco-method for depredation estimation in Subarea 48.3 M. Söffker and T. Earl
WG-SAM-16/33	Proposal for a longline survey to determine toothfish population connectivity between Subareas 48.2 and 48.4 Delegation of the United Kingdom

WG-SAM-16/34	Report on the collection of environmental data during exploratory fishing by Australia in Division 58.4.1 during the 2015/16 fishing season D. Maschette, T. Lamb, D. Welsford, P. Yates and P. Ziegler
WG-SAM-16/35	Report on exploratory fishing by Australia in Division 58.4.1 during the 2015/16 fishing season P. Yates, D. Welsford, P. Ziegler, D. Maschette and T. Lamb
WG-SAM-16/36 Rev. 1	The integrated krill assessment model for Subarea 48.1 with future catches meeting alternative decision rules D. Kinzey, G.M. Watters and C.S. Reiss
WG-SAM-16/37	Independent peer review of an integrated stock assessment model for Antarctic krill (*Euphausia superba*) conducted by the Center for Independent Experts J. Rusin, D. Kinzey and G. Watters
WG-SAM-16/38	Preliminary results of a dedicated cetacean sighting vessel-based krill survey in East Antarctica (115°–130°E) during the 2015/16 austral summer season K. Matsuoka, A. Wada, T. Isoda, T. Mogoe and L.A. Pastene
WG-SAM-16/39	Using effective sample sizes to evaluate the efficiency of length samples collected by at-sea observers in the krill fishery in Subarea 48.1 N. Kelly, S. Kawaguchi, P. Ziegler and D. Welsford
WG-SAM-16/40 Rev. 1	Preliminary results of the three season research surveys of the Spanish FV *Tronio* in Division 58.4.1 R. Sarralde, L.J. López-Abellán and S. Barreiro
WG-SAM-16/41 Rev. 1	Progress report for the fourth year of the research fishery for *Dissostichus* spp. in Subarea 48.6 being jointly undertaken by Japan and South Africa in the years 2013–2016 S. Somhlaba, R. Leslie, K. Taki, T. Ichii and T. Namba
WG-SAM-16/42 Rev. 1	Analysis of sea-ice concentration of 48.6_4 and _5 with remote sensing data during the latest four seasons T. Namba, K. Taki and T. Ichii