Annex 7

Report of the Working Group on Fish Stock Assessment
(Hobart, Australia, 7 to 18 October 2019)

Contents

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Opening of the meeting

1.1 The meeting of WG-FSA was held in Hobart, Australia, from 7 to 18 October 2019. The Convener, Dr D. Welsford (Australia), opened the meeting and welcomed participants to Hobart (Appendix A). He encouraged all participants to engage in discussion in the Working Group and urged participants to ensure that the discussions were based on science and where there were alternative views that these should be reflected as testable scientific hypotheses.

1.2 Dr D. Agnew (Executive Secretary) welcomed all participants to the CCAMLR Secretariat. He looked forward to the seeing the outcomes of the meeting being presented to the Scientific Committee and the Commission and hoped that everyone would also have an opportunity to enjoy the spring weather in Hobart.

1.3 The Working Group reviewed and adopted the agenda (Appendix B).

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

1.5 In this report, paragraphs dealing with advice to the Scientific Committee and other working groups have been highlighted. These paragraphs are listed under Item 9. In addition, the information used in developing assessments and other aspects of the Working Group's work is included in the Fishery Reports (www.ccamlr.org/node/75667).

1.6 The report was prepared by M. Belchier and C. Darby (UK), A. Dunn (New Zealand), T. Earl (UK), M. Eléaume (France), J. Fenaughty (New Zealand), I. Forster (Secretariat), N. Gasco (France), E. Grilly (Secretariat), P. Hollyman (UK), C. Jones (USA), D. Maschette (Australia), F. Massiot-Granier (France), T. Okuda (Japan), C. Péron (France), K. Reid (Secretariat), G. Robson (UK), M. Söffker (EU), S. Somhlaba (South Africa), S. Thanassekos (Secretariat), P. Tixier and P. Ziegler (Australia).

Review of data available

IUU fishing activity

2.1 CCAMLR-38/12 Rev. 1 presented a report on illegal, unreported and unregulated (IUU) fishing activity and trends in 2018/19. For the second consecutive year, no vessels included on the non-Contracting Party (NCP)-IUU Vessel List were reported as sighted by Members inside the Convention Area. The paper further presented a summary of reported instances of unidentified fishing gear in 2018/19.

2.2 The Working Group welcomed the lack of reported IUU fishing activity in the Convention Area in 2018/19, noting that without surveillance data it was difficult to provide effort-corrected trends of IUU activity.

2.3 The Working Group noted the importance of being able to identify the origins of abandoned, lost or otherwise discarded fishing gear (ALDFG) when recovered in the Convention Area and requested that the Secretariat review the current requirements for gear marking by CCAMLR vessels against the Food and Agriculture Organization (FAO) *Voluntary Guidelines on the Marking of Fishing Gear* (FAO, 2019) to advise on their consistency as well as the potential for clarifying and improving gear marking requirements in CCAMLR fisheries.

2.4 CCAMLR-38/BG/17 Rev. 1 presented draft technical guidelines to assist vessels which encounter unidentified fishing gear in the Convention Area. The work is summarised and the draft guidelines were published to the Unidentified fishing gear in the Convention Area e-group in 2019 (https://groups.ccamlr.org/group/60/stream). The Working Group welcomed this development and indicated that when the guidelines are finalised, they should be communicated to all Members that may encounter ALDFG.

Fishery notifications

2.5 CCAMLR-38/BG/07 Rev. 1 presented the exploratory fishery notifications for 2019/20. There was a total of 62 notifications across five exploratory toothfish fisheries submitted for 2019/20 and no new fishery notifications.

2.6 The Working Group welcomed the additional data on vessels and gear that are available via the hyperlinks included in CCAMLR-38/BG/07 Rev. 1 to the individual notifications on the CCAMLR website (https://www.ccamlr.org/fishery-notifications/notified). The Working Group requested that the details of gear type, including different configurations of different autoline gear, and a time-series of total notifications be included as a table in this background paper in the future. A summary of the gear type for vessels notified in 2019 is given in Table 1.

Reconciliation of CDS and monthly fine-scale catch and effort data

2.7 CCAMLR-38/BG/11 presented a data comparison between the Catch Documentation Scheme for *Dissostichus* spp. (CDS) and the fine-scale catch and effort data for the 2018 and 2019 fishing seasons. Overall, the comparison indicated that, in both seasons, the total toothfish catches reported from the Convention Area in the CDS and from catch data differed by less than 1%. Specific issues were identified in the accurate reporting of subarea and species in *Dissostichus* Catch Documents (DCDs) which the Secretariat are working with Members to resolve.

2.8 The Working Group welcomed this analysis and the overall high correlation between catch and effort data and verified landings data. The Working Group, however, highlighted the need to better understand discrepancies and their potential effects on assessments and the resulting advice. The Working Group further requested that the Secretariat extend this analysis to earlier fishing seasons.

2.9 The Working Group agreed that the process used by the Secretariat to identify where discrepancies arose between the CDS and fine-scale catch and effort data should continue to use a relative (10%) and an absolute (200 kg) threshold to trigger further investigation and correspondence with relevant Members to identify reasons for such a discrepancy.

2.10 The Working Group recognised the data quality improvements that have been achieved as part of the ongoing reconciliation of CDS and fine-scale catch and effort data, but advised the Scientific Committee that the current difference in the requirements to report landings from subareas or divisions in Conservation Measure (CM) 10-05, rather than the management areas specified in CM 41-09 (for Subarea 88.1 and small-scale research units (SSRUs) 882A–B), mean that it is currently not possible to use the CDS and fine-scale catch and effort data reconciliation process as a data quality input into the integrated assessment for toothfish in that area.

2.11 The Working Group recommended that the Secretariat provide any proposed changes, and links to the catch and effort (C2) forms and observer forms to WG-FSA at each of its annual meetings as a paper.

2.12 The Working Group recalled the discussion at WG-SAM (WG-SAM-2019 report, paragraphs 4.6 to 4.7) on the potential reasons for the underestimation of catches on Ukrainian vessels that had been highlighted by the C2/CDS reconciliation in 2018 (SC-CAMLR-XXXVII, paragraphs 12.3 and 12.4). The Working Group noted that while there was no paper submitted to WG-FSA on this matter, SC CIRC 19/93 was received during the meeting and included a description of the analyses undertaken by Ukraine to identify where underestimation of catch in the C2 data had occurred.

2.13 Based on the details provided in SC CIRC 19/93, and a clarification from Dr K. Demianenko (Ukraine) that the resubmission of data included all data from three Ukrainian vessels (*Calipso*, *Koreiz* and *Simeiz*) from 2015 to 2018, the Working Group noted that there were no discrepancies in the CDS and fine-scale catch and effort data reconciliation in 2019 and this reflected the changes in practices on vessels that had been implemented in 2018/19 by Ukraine.

2.14 The Working Group recommended that Ukraine provide details of the methods used to re-estimate the catches in the resubmitted C2 data and report on the evaluation of the implications of these changes on the provision of management advice to WG-SAM-2020.

2.15 The Working Group recommended that the all data collected on the *Calipso*, *Koreiz* and *Simeiz* from 2015 to 2018 be quarantined by the Secretariat, pending the outcomes of any evaluation by WG-SAM of the methods used to re-estimate the C2 data and the Working Group's advice on the implications of those revisions on the work of the Scientific Committee.

Report on catches in the Convention Area

2.16 SC-CAMLR-38/BG/01 Rev. 1 presented catches of target species from directed fishing on toothfish, icefish and krill in the Convention Area in 2017/18 and 2018/19, as well as catches taken during research activities listed in Table 1 of CM 24-05.

2.17 The Working Group welcomed the details provided in the paper and noted that in future this paper should include a clear reconciliation between the different sources of catch data, including the aggregated catch data used for fishery monitoring, the detailed (haul-by-haul) catch data and the Member-verified landings data (from the *CCAMLR Statistical Bulletin*).

Data management

2.18 WG-FSA-2019/14 presented an overview of the taxon data project currently being undertaken by the Secretariat. This project has compared the current CCAMLR taxon list with the most recent Aquatic Sciences and Fisheries Information System (ASFIS) List of Species for Fishery Statistics Purposes published by the FAO that is currently used as the definitive source by CCAMLR and the World Register of Marine Species (WoRMS) that provides a taxonomic reference for all marine species. The aims of the project are to:

(i) identify inconsistencies between the CCAMLR taxon list, the FAO ASFIS list and WoRMS

(ii) evaluate the value of using WoRMS as a taxonomic reference within the CCAMLR taxon list

(iii) propose a solution to deal with the taxonomic inconsistencies within the CCAMLR master data program.

2.19 The Working Group welcomed this proposal from the Secretariat outlined in WG-FSA-2019/14 and agreed to the use of WoRMS as a taxonomic reference within CCAMLR and its implementation in the CCAMLR data systems. The Working Group requested the Secretariat to provide regular updates on taxonomic code corrections to WG-EMM and WG-FSA and to ensure that any changes to taxonomic codes used, including from changes in species taxonomy in the CCAMLR database, are clearly documented and historical codes used by CCAMLR are retained. The Working Group recommended the Secretariat engage with WoRMS and ASFIS to obtain three-letter alpha codes and AphiaIDs for Antarctic taxa which are needed by CCAMLR and are missing from WoRMS and ASFIS.

Catch and effort data and biological observations from CCAMLR fisheries

2.20 WG-FSA-2019/01 reported on the Coalition of Legal Toothfish Operators (COLTO)–CCAMLR Toothfish Catch and Effort Data Workshop that was held in South Africa in July 2019 that followed the rationale and scope considered in 2018 (WG-FSA-2018 report, paragraphs 2.12 to 2.18 and SC-CAMLR-XXXVII, paragraphs 3.44 and 3.45) and refined in COMM CIRC 19/29. The paper contained a series of recommendations for the consideration of the Working Group and the Scientific Committee.

2.21 The Working Group welcomed the COLTO–CCAMLR Workshop and agreed that it had been a very efficient outreach process that had engaged a broad range of stakeholders, had achieved many useful outcomes and provided clear recommendations for consideration by WG-FSA.

2.22 The Working Group reviewed the recommendations from WG-FSA-2019/01, the outcome of which is presented in Table 2. The Working Group recommended:

(i) the Secretariat continue to develop the proposed new C2 form and fishery data manual intersessionally with Members, noting the endorsed recommendations by this working group on C2 form content and specific instructions (Table 2)

(ii) the Scientific Committee consider removal of the requirement to complete the B2 form where currently specified in the conservation measures

(iii) the Scientific Committee consider the addition of text specifying coordinated universal time (UTC) timing for fishery opening and closure dates in the appropriate conservation measures

(iv) the Scientific Committee consider the removal of the requirement for vessels to report aggregated vulnerable marine ecosystem (VME) data.

Fishery monitoring and closure procedures

2.23 CCAMLR-38/BG/12 described the Secretariat's application of procedures to monitor and forecast closures in CCAMLR fisheries in the 2018/19 season, including a description of the issues in applying the procedures and specific circumstances which can result in catch over-runs and under-runs.

2.24 The Working Group noted that WG-FSA-18/07 described the two-stage process for the forecasting and closure process for exploratory toothfish fisheries and that SC-CAMLR-XXXVII, Annex 11, focused on the first stage of this process.

2.25 The Working Group recommended that the Scientific Committee include the complete two-stage process as an annex to its report.

2.26 The Working Group agreed that any forecasting process depends, for its accuracy, on the extent to which vessels continue to fish in the forecast period in the same manner as they fished in the period prior to the forecast. In the case of the fishery in the special research zone (SRZ) in 2018/19, the Working Group noted the unpredictability in changes in fishing effort (including one vessel setting 66 000 hooks in one day, as well as a general tendency of other vessels to reduce the number of hooks they set as the closure date approaches), as well as the relatively high level of fishing capacity compared to the catch limit, increases the uncertainty of the forecast.

2.27 The Working Group discussed the proposal in CCAMLR-38/BG/12 for an experimental change to a 48-hour period (extended from the current 24-hour period) for the removal of gear from the SRZ to allow a more orderly closure of the fishery to improve the success of the closure forecasting algorithm. The Working Group recommended that the risk of a sudden increase in the number of hooks deployed immediately upon the announcement of the closure, which could lead to an overrun of catch limit, be taken into consideration when this proposal is considered.

2.28 The Working Group thanked the Secretariat for its work on the fishery closure algorithm (CCAMLR-38/BG/12) and noted that the closure algorithm resulted in the fishery closure at a lower catch than predicted at the time that the closure notice was issued (see Figure 1).

2.29 The Working Group recommended that the forecasting process currently used by the Secretariat and as detailed in WG-FSA-18/07 and SC-CAMLR-XXXVII, Annex 11, should be used in 2019/20, and that the Secretariat provide a summary of the operation of the algorithm in the 2019/20 season to WG-FSA-2020.

2.30 The Working Group recommended that the Secretariat review the forecasting algorithm for fishery closures after implementation in the 2019/20 season and consider alternative scenarios in a paper to WG-SAM in 2020.

Fishery Report updates

2.31 The Secretariat presented an update to the web-based set of documents following the discussion at WG-SAM (WG-SAM-2019 report, paragraphs 4.8 to 4.13), using a hierarchical structure for the Fishery Documents for Subarea 48.6, containing a Fishery Summary with links to a Species Description, Fishery Report and the Stock Assessment documents (Figure 2).

2.32 The Working Group welcomed the prototype demonstrated for Subarea 48.6 and encouraged the Secretariat to continue the approach for all Fishery Reports. The Working Group also noted that the same publication process as in previous years would be followed such that the draft reports will be made available for comment by Members prior to being published on the public part of the CCAMLR website.

2.33 The Working Group also recalled the request to those Members providing integrated toothfish assessments to develop the Stock Annexes (e.g. WG-FSA-2019/09) for those stocks (WG-SAM-2019 report, paragraph 4.11 and WG-FSA-2018 report, paragraphs 2.32 and 2.33). The Working Group recommended that Members continue development of a common format for our public domain documentation of these fisheries.

Review of updated stock assessments and provision of management advice (all fisheries)

Champsocephalus gunnari

C. gunnari in Subarea 48.3

3.1 The fishery for mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.3 operated in accordance with CM 42-01 and associated measures. In 2018/19, the catch limit for *C. gunnari* was 3 269 tonnes. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.2 The Working Group noted that in recent years low amounts of fishing effort were being deployed in Subarea 48.3 and that this has resulted in very low catches by the fishery.

3.3 In January/February 2019, as part of its regular monitoring program (WG-FSA-2019/20), the UK undertook a random stratified bottom trawl survey of the South Georgia and Shag Rocks shelves. A total catch of 6.3 tonnes of *C. gunnari* was reported from the research survey. Similar to the 2017 survey, stomach content analysis showed a high proportion of *Themisto* sp., rather than the krill seen in other years.

3.4 WG-FSA-2019/30 presented a preliminary assessment of *C. gunnari* in Subarea 48.3 based on the random stratified bottom trawl survey. A bootstrap procedure was applied to the survey data to estimate the demersal biomass of *C. gunnari* in this subarea. The bootstrap estimated the median demersal biomass at 53 124 tonnes, with a one-sided lower 95%

confidence interval of 32 399 tonnes. A catch limit of 3 225 tonnes for 2019/20 and 2 132 tonnes for 2020/21 would ensure at least 75% biomass escapement after a two-year projection period.

Management advice

3.5 The Working Group recommended that the catch limit for *C. gunnari* in Subarea 48.3 should be set at 3 225 tonnes for 2019/20 and 2 132 tonnes for 2020/21.

C. gunnari in Division 58.5.2

3.6 The fishery for *C. gunnari* in Division 58.5.2 operated in accordance with CM 42-02 and associated measures. In 2018/19, the catch limit for *C. gunnari* was 443 tonnes. Fishing was conducted by one vessel and the total reported catch up to 28 September 2019 was 443 tonnes. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.7 The results of a random stratified trawl survey in Division 58.5.2 undertaken in April 2019 were summarised in WG-FSA-2019/03. Sampling protocols, such as the design and the duration of the hauls, were similar to recent surveys, but with a new set of randomly selected station points. As in previous years, toothfish and skates were also tagged during the survey. Within Gunnari Ridge only five of the 18 stations were completed, after two very large catches of icefish caused the catch limit for the division to be reached.

3.8 Based on data gathered during the survey, an assessment for *C. gunnari* using the generalised yield model (GYM) was presented in WG-FSA-2019/02. The presence of two very large catches in Gunnari Ridge caused the bootstrap distribution to be multi-modal. Consistent with the advice of WG-FSA (WG-FSA-2013 report, paragraphs 4.2 and 4.3) these hauls were removed, which resulted in a unimodal distribution. The one-sided bootstrap lower 95% confidence bound of total biomass of age 1+ to 3+ fish from the 2019 survey and fixed model parameters was estimated at 3 724 tonnes. Estimates of yield indicate that a catch limit of 527 tonnes of *C. gunnari* in 2019/20 and 406 tonnes in 2020/21 would satisfy the CCAMLR decision rules.

Management advice

3.9 The Working Group recommended that the catch limit for *C. gunnari* in Division 58.5.2 should be set at 527 tonnes for 2019/20 and 406 tonnes for 2020/21.

Dissostichus spp.

3.10 The Working Group noted that its advice was based on information from a combination of papers to this Working Group, papers to and corresponding responses by other CCAMLR working groups, advice from Scientific Committee and Commission meetings, peer-reviewed publications and work conducted during this meeting.

3.11 The Working Group recalled the results of the CCAMLR Independent Stock Assessment Review for Toothfish and the conclusions by the Scientific Committee that (SC-CAMLR-XXXVII, paragraphs 3.52 to 3.56):

(i) CCAMLR's approach, using a single modelling framework (CASAL) across stocks, based on surveys, catch and a comprehensive annual tagging program across fisheries is appropriate for the management of these stocks

(ii) in fisheries managed for low overall exploitation rate like toothfish, tagging data are essential because they provide an absolute index of abundance that is generally not provided by other types of data typically used to assess stock status

(iii) CCAMLR's approach with tagging studies makes it a leader in this area, and this knowledge is of interest to the broader stock assessment community

(iv) CCAMLR applies assumptions in the stock assessments in a precautionary manner, when there is uncertainty in parameters and assumptions, and the management of the fisheries is consistent with CCAMLR's precautionary approach and Article II

(v) appropriate practices are being followed and the assessments continue to adapt to new standards in most instances examined. Differences in standards, when they occurred, were within the scope of standards in the assessment field, but were also consistent with management strategies of CCAMLR

(vi) the many instances where the assessment scientists considered spatial structure in fishing and population dynamics indicated a high level of understanding of the importance of this component to the assessment of these fisheries in the future.

3.12 Based on the recommendation of the Scientific Committee (SC-CAMLR-XXXVII, paragraph 3.54) to continue to evaluate the recommendations by the expert group (SC-CAMLR-XXXVII, Table 3), the Working Group assessed how these recommendations had progressed and identified outstanding research issues (Table 3).

3.13 The Working Group recommended that a bridging analysis be used in all stock assessments to explore the effects of changes in the stock assessment due to updated data, revised parameter estimates and changes to model approaches since the last assessment model which has been used to provide catch advice.

CCAMLR decision rules

3.14 SC-CAMLR-38/15 discussed some of the strengths and weaknesses of the CCAMLR decision rules. The paper noted that the decision rule was highly precautionary, as was appropriate for the management of deep-water Antarctic species and shown to be robust to changes in the fishery–stock interactions. The robustness of CCAMLR's toothfish management protocol, based on the decision rule, was evaluated by considering hypothetical, future changes in the fishery–stock interactions and the stock productivity which could result from climate change. However, the robustness of the decision rule to potential climate change induced variation in productivity, highlighted a sensitivity that should be considered by the Scientific

Committee and its working groups. The development of the decision rule to include limit or target reference points, based on exploitation rate would ensure that management advice was also robust to change in productivity. The modification could also provide a basis for the provision of catch advice where historic IUU fishing has occurred and historic biomass is unknown.

3.15 The Working Group noted that the CCAMLR decision rules have a target of 50% of the virgin spawning stock biomass, B_0, and a limit of 20% of B_0 which are considerably higher than the targets and limit levels used in other fisheries around the world. In the management of many fisheries outside the Convention Area, the biomass which leads to maximum sustainable yield (B_{MSY}) is used as targets. Since B_{MSY} for toothfish is around 25% of B_0 (SC-CAMLR-38/15), the CCAMLR approach to setting catch limits in toothfish fisheries is far more precautionary.

3.16 The Working Group recalled that the CCAMLR decision rules rely on an estimate of B_0. However, there are situations where B_0 is unknown or difficult to estimate, such as when there have been unknown levels of IUU fishing in the past. There may also be undetected changes in the productivity of the fish stock which would lead to a change in the values of B_0.

3.17 The Working Group noted that maintaining historic B_0 values within the decision rule if there are undetected changes in productivity in the fish stock will lead to different results when productivity either decreases or increases:

(i) if there is an undetected decrease in productivity to a new lower B_{02}, applying the decision rule reduces the catch limits to the higher biomass target of the old state. Yield is forgone, but the stock is not overfished

(ii) if there is an undetected increase in productivity to a new higher B_{03}, applying the decision rule increases the catch limits to the lower biomass target of the old state. Yield is too high and the stock will be overfished.

3.18 The Working Group noted that the robustness of the current decision rules could be increased by the addition of harvest control rules under specific circumstances, such as when productivity changes are detected or when the level of historical IUU catches is unknown.

3.19 The Working Group noted a simulation of the long-term effects of applying the CCAMLR decision rules using constant exploitation rate instead of constant catch, which was conducted using the Ross Sea region assessment in WG-FSA-2019/08. Both strategies result in the CCAMLR decision rule criteria being met, however, the constant catch strategy (maximum constant yield) results in wider range of realised estimates of stock status than the constant exploitation rate strategy (Figure 3). With the constant catch strategy, spawning stock biomass fluctuated between 20% and 95% B_0, with 75% of the distribution between 40% and 60% B_0. With the constant exploitation rate strategy, spawning stock biomass fluctuated to a smaller extent between 30% and 80% B_0, with 75% of the distribution between 45% and 55% B_0.

3.20 The Working Group noted that any refinements of the CCAMLR decision rules require thorough testing with simulations through, for example, a management strategy evaluation to ensure that they remain consistent with achieving the objectives of Article II of the Convention.

3.21 The Working Group recommended that the Scientific Committee task WG-SAM with investigating potential refinements of the CCAMLR decision rules to increase their robustness in specific circumstances, such as using target and limit exploitation rates, through management strategy evaluations.

3.22 The Working Group compared catch-weighted mean length and the proportion of immature fish in Antarctic (*Dissostichus mawsoni*) and Patagonian (*D. eleginoides*) toothfish catches over the period in which CCAMLR data on toothfish fishing were available, with unstandardised data presented in CCAMLR Fishery Reports, as reported in WG-FSA-2019/40.

3.23 The catch-weighted mean length of fish in the catch varied across fisheries and between species (Figure 4).

3.24 For *D. mawsoni* caught in Subareas 48.6, 88.1 and 88.2 and Divisions 58.4.1 and 58.4.2 for the 1998–2019 seasons, the distributions of mean length ranged from about 100 to 150 cm. Mean length has fluctuated over time, as the fishing focused in research blocks and management areas that contain different components of the population. For instance, the time series for SSRUs 882C–H indicated variation through time as the proportion of the catch changed with the fishery moving from the north with larger fish to the south of the subarea with smaller fish.

3.25 Within the Ross Sea region (Subarea 88.1 and SSRUs 882A–B) there is a latitudinal gradient in mean length. The northern SSRUs, where fish are older than on the shelf and slopes, have a higher mean length in the catch. The closer to the shelf, the more frequent immature toothfish are encountered and the lower the mean length.

3.26 For *D. eleginoides* caught in Subareas 48.3, 48.6 and 58.7 and Divisions 58.4.4b and 58.5.2 for the 1996–2019 seasons, the catch-weighted mean length is comparable across all the fisheries, ranging from 70 to 110 cm throughout the time series. Although some variation over time can be observed, the majority of stocks have a stable time series. Mean lengths for fish caught in Subareas 48.3 and 58.7 have increased in recent years.

3.27 The proportions of fish in the catch that were immature varied also across fisheries and between species (Figure 5).

3.28 For *D. mawsoni*, the proportion of immature fish in the catch is higher for fisheries in higher latitudes, which is consistent with current stock hypotheses (Hanchet et al., 2015 and WG-SAM-18/33 Rev. 1). For example, the slope and shelf of the Ross Sea region comprise higher proportions of immature fish, 60% and 80% respectively.

3.29 For *D. eleginoides* there is considerable variation across CCAMLR fisheries, ranging from 20% to 80% proportion of immature fish which is due to different depths and spatial locations of the different *D. eleginoides* fisheries. As with mean length, the percentages have been relatively stable across time in Subareas 48.3 and 58.7 showing decreases in the proportion of immature fish in the catch in recent years, consistent with the increase of mean length in the catch.

3.30 For each of the integrated assessments in Subareas 48.3 and 58.6 and Divisions 58.5.1 and 58.5.2 and the Ross Sea region, the effect of fishing on the proportion of fish that are immature in the total population was estimated for the virgin biomass (i.e. B_0), the current total population, and the population at the target level point at the end of the future 35-year projection

period (Figure 6). The estimated proportion (by number) of fish in the population that were immature in the virgin biomass, across areas and species, was relatively high at 70–85%, as expected in an unfished population. With fishing, the proportion of fish that are immature in the population is predicted to increase slightly as the mature biomass is gradually reduced towards its target level. For those stocks currently at or near the 50% of the B_0 target level (e.g. in Subarea 48.3 and Division 58.5.2), the change was small, indicating that fishing activities between now and when the population is at the target biomass will not further change the structure of the population.

3.31 The Working Group noted that, consistent with the CCAMLR decision rules, each of the assessed stocks is following the trajectory of biomass reduction of the mature fish, resulting in a slight increase of the proportion of immature fish in the population (Figure 6).

3.32 Given that there is a potential for bias in the interpretation of raw length distributions, the Working Group recommended that catch-weighted length distributions and the derived metrics, including mean length presented in Figures 4 to 6, be added to the Fishery Reports.

3.33 The Working Group noted that this analysis demonstrated that the CCAMLR decision rules result in similar trajectories for different fish stocks, independent of stock-specific characteristics such as different growth and maturity rates across two species, or different fishery characteristics such as area and depth-specific selection patterns.

3.34 The Working Group noted that:

(i) CCAMLR toothfish stocks have inherent variability in the ratio of mature and immature fish in the catch, resulting from a range of specific biological and fishery characteristics for each fishery

(ii) without data standardisation for fishing effort, depth, area, gear selection and historic recruitment events, trends in the structure of the catch data in isolation cannot be used to determine the characteristics of the underlying population

(iii) when standardised, the catch data do not exhibit trends over time that would indicate that the stocks are being overexploited or fished inconsistent with CCAMLR's precautionary approach

(iv) through the application of the CCAMLR decision rules with a long-term average target of 50% of B_0, all assessed stocks are managed using a process that is independent of changes in the interactions between the fishery and the stock.

3.35 The Working Group noted that the position of the authors of WG-FSA-2019/40 stating that the CCAMLR management process applied to its toothfish stocks is not precautionary and is inconsistent with Article II, was not consistent with this analysis, conducted during the meeting of WG-FSA-2019.

3.36 The Working Group noted that any fishery is expected to have an impact on the fished population. The CCAMLR precautionary approach defines what impact is acceptable and that changes need to be reversible over a time frame of two to three decades as defined in Article II of the Convention.

3.37 Dr S. Kasatkina (Russia) noted that in her opinion, the CCAMLR approach was not precautionary and could not provide rational use of the toothfish stock in Subarea 48.3.

3.38 All other participants of the Working Group agreed that the CCAMLR assessment and management decision rule protocols are:

(i) consistent in the application across all toothfish stocks, including the stock in Subarea 48.3

(ii) in accord with the precautionary approach and CCAMLR's objectives under Article II

(iii) appropriate for the robust management of CCAMLR's toothfish stocks, given the wide range of stock and fishery characteristics across the CAMLR Convention Area.

3.39 Given the lack of agreement by the Working Group that the CCAMLR management of all of its fish stocks is precautionary, the Working Group noted it had been unable to provide consensus catch advice for all assessed stocks and research proposals associated with them. However, for all assessed stocks, the Working Group provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules.

3.40 The Working Group requested that the Scientific Committee consider precautionary catch limits for all the assessed stocks and research proposals associated with them so that advice to the Commission can be provided on the basis of the best available science. The Working Group also requested that the Scientific Committee consider how WG-FSA can provide advice on precautionary catch limits in the future.

3.41 In response to the nature of some of the discussions during the meeting, the Working Group recalled some of the principles set out in Article IX of the CAMLR Convention, as well as Resolution 31/XXVIII, particularly:

(i) the function of the Commission shall be to give effect to the objective and principles set out in Article II of this Convention. To this end, it shall formulate, adopt and revise conservation measures on the basis of the best scientific evidence available

(ii) Members work together to ensure that scientific information is adequately collected, reviewed and applied in a transparent fashion in accordance with sound scientific principles

(iii) the role of the Scientific Committee and its working groups is to promote rigorous science-based discussions. In particular, to ensure the participation of scientists with suitable scientific qualifications or experience at meetings of the Scientific Committee and its working groups.

Verification of CASAL runs

3.42 The Secretariat routinely verifies that stock assessments submitted to WG-FSA using CASAL (Table 4) are reproducible by a verification process performed in three steps:

(i) CASAL version: all assessments are requested to use the same version of CASAL. For WG-FSA-2019 all assessments used CASAL v2.30-2012-03-21 rev.4648

(ii) parameter files verification: the files population.csl, estimation.csl and output.csl used in each assessment reported in meeting papers are used as inputs to a CASAL run performed by the Secretariat. If no errors are reported during the process, the files are considered as verified

(iii) MPD (maximum posterior density) estimate verification: the 'B_0' estimate produced by a given model run is compared to that reported in the accompanying meeting paper.

3.43 Verifications of the MPDs were performed for the CASAL assessments submitted to WG-FSA in 2019 and indicated that all verifications produced the same MPDs as supplied (Table 5).

Whale depredation

3.44 WG-FSA-2019/33 presented estimates of *D. eleginoides* catches removed by killer whales and sperm whales when depredating on longlines in four CCAMLR areas (Subareas 58.6 and 58.7 and Divisions 58.5.1 and 58.5.2) and two fisheries outside the CCAMLR area in Chile and the southwest Atlantic. Using generalised additive models (GAMs) fitted to the catch-per-unit-effort (CPUE) data, the results indicated that: (i) whales removed a total of 6 699 tonnes (3 839–9 559 tonnes) of toothfish, equivalent to around 10% of the total catches over the 2009–2016 period and (ii) these removals greatly varied between fisheries, with the largest reported for Subarea 58.6 with 30% and the lowest for Division 58.5.2 with only 0.2% of the total catch.

3.45 The Working Group noted that the findings in WG-FSA-2019/33 provided standardised metrics to assess the economic and ecological implications of depredation, both locally and globally across *D. eleginoides* fisheries. The Working Group noted that this study can provide estimates of catch removals from whale depredation where these have not been available previously and recommended that estimated toothfish removals by whales be included in stock assessments.

3.46 The Working Group noted that the whale depredation risk varies strongly across the Convention Area, and that risk area maps could be created, similar to seabird mortality risk area maps, to improve the understanding of the whale depredation dynamics. However, the Working Group also noted that there is large variation within an area which seems to be related to particular vessels being targeted more by whales than others.

3.47 The Working Group noted that using GAMs as opposed to generalised linear models (GLMs) for estimating whale depredation allows to incorporate non-linear relationships such as the interaction location, and that including the number of whales depredating can improve the accuracy of the catch removals due to the high whale per-capita impact.

3.48 The Working Group noted that toothfish are part of the natural diet of sperm whales and it is unclear whether and how catch removals would modify the natural predation pressures of whales on toothfish.

Dissostichus eleginoides in Subarea 48.3

3.49 The fishery for *D. eleginoides* in Subarea 48.3 operated in accordance with CM 41-02 and associated measures. In 2018/19, the catch limit for *D. eleginoides* was 2 600 tonnes and the total reported removal was 2 172 tonnes. Fishing in the current season finished on 30 September 2019 (www.ccamlr.org/node/75667).

3.50 Dr Kasatkina introduced WG-FSA-2019/40, submitted by Russia, which reviewed multi-year variability in biological parameters in catches from the beginning of the longline fishery (1985–1990) for *D. eleginoides* in Subarea 48.3. Based on analysis of available publications and CCAMLR documents, the paper noted a decrease in the length and weight of females and males at first maturity, and a reduced number of large spawning fish which indicated a change in the length structure of the spawning part of *D. eleginoides* population in Subarea 48.3. The paper noted that for the *D. eleginoides* population, which is characterised by a very long lifespan, the recruitment group is the most vulnerable component. Therefore, a change in the rate and terms of sexual maturity of males and females and their entry into the spawning process, and a change in the length composition of fish in the catches, can be considered as signs of fishing impact on the population. The paper also noted that currently in Subarea 48.3 an excessively large number of immature and maturing *D. eleginoides* (recruitment group), which are undergoing intensive weight increases, are being caught.

3.51 The paper also noted that according to the analysis, a reduction of the catch limit will, as before, be taken mainly from immature juveniles. Currently, the *D. eleginoides* population in Subarea 48.3, which has been fished for more than 40 years, including more than 30 years by longlines, requires protection via the imposition of restrictions on fishing and changes to conservation measures, because the use of *D. eleginoides* resource in the Convention Area does not ensure its rational use. The paper proposed to:

(i) define the catch limit for *D. eleginoides* in Subarea 48.3 for the 2019/20 season as 0 tonnes

(ii) close the fishery in Subarea 48.3 from 2020

(iii) revise the precautionary approach to the use of the *D. eleginoides* stock in the Convention Area (Subarea 48.3) because the current approach does not ensure the rational use of this living resource.

3.52 The Working Group noted that the data and analyses presented in this paper (WG-FSA-2019/40 and SC-CAMLR-XXXVII/BG/25) were identical to those in WG-FSA-18/02 and recalled the discussion at WG-FSA (WG-FSA-2018 report, paragraphs 3.16 to 3.20) and the

Scientific Committee in 2018 (SC-CAMLR-XXXVII, paragraphs 3.64 to 3.71). Specifically, the Working Group recalled the advice from the Scientific Committee that the exclusive use of raw catch length distribution data to make assumptions about the state of the stock, in isolation from other information, was not an appropriate approach for determining the general status of a stock.

3.53 Dr Kasatkina repeated that WG-FSA-2019/40 reviewed analyses of multi-year variability in biological parameters in catches from 1985 to 2017 using Fishery Reports and other CCAMLR papers, as well as publications in peer-reviewed journals. She noted that papers by UK scientists are widely represented in the list of references, which includes 104 titles (SC-CAMLR-XXXVII/BG/25).

3.54 Dr Darby noted that the paper by Brigden et al., 2017 on Subarea 48.3 has made the same mistake in basing its conclusions on raw data.

3.55 The Working Group recalled WG-SAM-2019/32 which had provided an analysis of the complete time series of CCAMLR data to evaluate changes in the biological productivity parameters in Subarea 48.3, particularly whether the proportion of females in the catch, maturity at length and age, length–weight relationships and growth rates have changed through time and vary over depth.

3.56 WG-SAM (WG-SAM-2019 report, paragraphs 3.12 to 3.19) had noted variation through time in the Subarea 48.3 sex ratio, maturity, growth and length–weight parameter estimates, but no systematic trends. When the effects of confounding factors, such as depth, were included in the analysis, WG-SAM-2019 had agreed that there was no indication of systematic change that would indicate potential impacts from external influences such as the fishery or climate change. WG-SAM-2019 therefore considered that the current stock assessment was robust to the variation in growth and maturity parameters.

3.57 The Working Group noted that WG-FSA-2019/40 did not take into account the findings from WG-SAM-2019/32 and the relevant discussion at WG-SAM (WG-SAM-2019 report, paragraphs 3.12 to 3.19). The Working Group conducted a review of the catch-weighted mean length and the proportion of immature fish in the catch and noted that there were no changes through time that would indicate stock depletion (paragraphs 3.22 to 3.31).

3.58 The Working Group recalled discussions at WG-FSA (WG-FSA-2016 report, paragraph 3.91) which highlighted the importance of the scientific process of developing and evaluating hypotheses. The Working Group noted that where new evidence is presented, this needs to be accounted for in subsequent research.

3.59 The Working Group noted that the revised Fishery Reports, including catch-weighted standardised length distributions, could provide a valuable source of information as to where changes in management practices had occurred which would impact how data are collected.

3.60 WG-FSA-2019/28 presented an updated assessment for *D. eleginoides* in Subarea 48.3. The assessment indicated that spawning biomass has been relatively constant in recent years and that the current status of the stock was at 50% of B_0. Projections indicate that a constant catch of 2 420 tonnes in the 2020/21 and 2021/22 seasons would be consistent with the CCAMLR decision rules.

3.61 The Working Group recommended further work on:

(i) understanding the declining trend in the MPD values of spawning stock biomass prior to fishing (SSB_0) from the time series of cohorts of tagged fish in the likelihood profiles

(ii) conducting model sensitivity analyses excluding data from the trawl survey to evaluate whether the survey provides useful information on stock abundance.

3.62 The Working Group, having not reached consensus on advice on the catch limit, noted that a catch of 2 420 tonnes in 2020/21 and 2021/22 based on the outcomes of this assessment was consistent with the precautionary yield estimated using the CCAMLR decision rules and the management procedure as applied in previous years.

3.63 Dr Kasatkina made the following statement:

> *'There is the need to exclude the possibility of a misunderstanding of her position regarding the management of Patagonian toothfish (*Dissostichus eleginoides*) resources in Subarea 48.3. This position was stated in the paper WG-FSA-2019/40 and the correspondent presentation. Currently, the Patagonian toothfish population in the South Georgia area requires protection via the imposition of restrictions on fishing and changes to conservation measures. Any catch limit here will be taken mainly from immature juveniles. Therefore, it is proposed to close the fishery in Subarea 48.3 from 2020. The paper WG-FSA-2019/28 could not influence her position.*
>
> *Setting the catch limit for Subarea 48.3 could not be supported for the next fishing season (2019/20) as there is no consensus regarding the continuation of fishing in Subarea 48.3 for next season.'*

3.64 Dr Kasatkina noted that the purpose of the CCAMLR Independent Stock Assessment Review for Toothfish was to provide advice to the Scientific Committee and its working groups on the adequacy of the modelling approaches and methods used in CCAMLR's integrated toothfish stock assessments relative to international best practices, and to suggest recommendation regarding: (i) improvements to modelling; (ii) improvements to data; and (iii) the utility of alternative models and structures that could be explored. Conclusions on the stock status and population characteristics of toothfish in Subarea 48.3 were not provided (SC-CAMLR-XXXVII/02 Rev. 1).

3.65 All other participants noted that the statement by Dr Kasatkina did not provide any scientific evidence why immature fish in catches constituted a reason to close a fishery, as almost all of the other toothfish fisheries across the Convention Area have similar proportions of immature fish in their catches. They also noted that this position was in contradiction of recommendations from the CCAMLR Independent Stock Assessment Review for Toothfish and SC-CAMLR-XXXVII (SC-CAMLR-XXXVII, paragraphs 3.52 to 3.56), that CCAMLR's stock assessment approach was appropriate for the management of its toothfish stocks and that CCAMLR applies assumptions in the stock assessments in a precautionary manner and consistent with Article II.

3.66 Dr Darby recalled that the Independent Review Panel review was presented with all input data, results and historic advice for the assessed stocks, to enable it to respond to its terms

of reference, which included inferences on stock status (SC-CAMLR-XXXVII/02 Rev. 1, Appendix 3, term of reference 1ii). Therefore, stock status and population data were included within the Independent Review Panel's conclusion that the assessment approach for all of the CCAMLR stocks was consistent with Article II.

3.67 The Working Group noted that around 40% of fish in *D. eleginoides* catches in Subarea 48.3 were immature and that all toothfish fisheries in CCAMLR contain a substantial proportion of immature fish in their catches (paragraphs 3.22 to 3.31).

3.68 The Working Group also noted that statements and proposals needed to have scientific justification, and that scientific papers should be evaluated on the basis of their scientific merit and evidence.

Dissostichus spp. in Subarea 48.4

3.69 The fishery for *D. eleginoides* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. eleginoides* in Subarea 48.4 in 2018/19 was 26 tonnes and 17 tonnes were taken (www.ccamlr.org/node/75667).

3.70 WG-FSA-2019/29 presented an updated CASAL assessment model for *D. eleginoides* in Subarea 48.4. The assessment data were updated with observations for the 2017/18 season and the data-weighting method revised to be consistent with those applied in other CCAMLR assessment models. The model estimated that the stock was at 67% of B_0 in 2018/19 and that a yield of 27 tonnes in 2019/20 and 2020/21 was consistent with the application of the CCAMLR decision rules.

3.71 The Working Group noted that the growth function, which was fitted within the stock assessment model, fitted poorly to young fish and recommended the evaluation of alternative growth models in future assessments for Subarea 48.4.

3.72 The Working Group recalled that the population of *D. eleginoides* in Subarea 48.4 was most likely connected to that in Subarea 48.3, with currently over 40 tagged fish released in Subarea 48.4 and recaptured in Subarea 48.3, and one tagged fish having moved in the opposite direction and recaptured in Subarea 48.4. The Working Group noted that further research into population connectivity was underway, including genetic and otolith microchemistry research and an evaluation of a spatial stock assessment model covering both subareas. The Working Group agreed that managing the stocks in the adjacent subareas as separate entities was precautionary while this research is progressing.

3.73 The Working Group noted that a catch limit of 27 tonnes for *D. eleginoides* in Subarea 48.4 for 2019/20 and 2020/21 is consistent with CCAMLR decision rules based on the results of this assessment. The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules.

3.74 The fishery for *D. mawsoni* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. mawsoni* in Subarea 48.4 in 2018/19 was 37 tonnes of which 33 tonnes were taken in the fishery (www.ccamlr.org/node/75667).

3.75 WG-FSA-2019/27 presented a Chapman biomass estimate for *D. mawsoni* in Subarea 48.4 from tagging returns. Using estimates from all years since 2010, the average biomass was estimated at 1 109 tonnes, while for the last five years (2015–2019) the average biomass was 1 187 tonnes. Applying a harvest rate of $\gamma = 0.038$ and using the five-year average biomass estimate resulted in a yield of 45 tonnes.

3.76 The Working Group noted that, historically, *D. mawsoni* in Subarea 48.4 has been treated as a separate stock. Based on the biological characteristics of the catches in Subarea 48.4 and the surrounding regions, *D. mawsoni* around the southern South Sandwich Islands are now hypothesised to be part of a larger stock that extends south into Subareas 48.2, 48.6 and possibly 48.5. The Working Group considered that the current tag-based method of assessment provides a precautionary approach to estimating the local biomass.

3.77 The Working Group noted that using the average biomass estimate from the last five years, to smooth the individual year estimates was an appropriate approach to providing robust advice.

3.78 The Working Group noted that the results of this assessment indicated that a catch limit of 45 tonnes for *D. mawsoni* in Subarea 48.4 for 2019/20 would be consistent with CCAMLR's management approach for this fishery. The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules.

D. eleginoides in Division 58.5.1

3.79 The fishery for *D. eleginoides* in Division 58.5.1 is conducted in the French exclusive economic zone (EEZ). Details of the fishery and the stock assessment are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.80 The Working Group noted the development of two integrated CASAL assessment models (WG-FSA-2019/58), including updated data (up to August 2019), growth parameters and year-class strength (YCS) priors and estimation period. The reference assessment model (M1) estimated virgin spawning stock biomass, B_0, at 206 200 tonnes (95% confidence interval (CI): 194 130–218 380 tonnes), with the biomass in 2019 at 124 940 tonnes (95% CI: 112 910–136 490 tonnes) for the model with revised growth and YCS fixed at 1 (constant recruitment). Estimated spawning stock biomass (SSB) status in 2019 was 61% (95% CI: 57–65%).

3.81 The Working Group noted that model 2 which estimates YCS trends (i.e. recruitment) was in development. It also noted that YCS was below average in recent years and encouraged the authors to investigate this trend. Further, the Working Group noted that the parameters for the maturity ogive assumed in the model should be investigated. The current maturity ogive assumed that fish began to mature at about age 1, with 50% maturity at age 8 and full maturity not occurring before age 17. The Working Group recommended considering the stage, location and timing of the spawning season be considered when estimating the maturity ogive.

3.82 The Working Group welcomed the intention by the authors to implement a project to increase the number of otolith readings and recommended to read the otoliths of five individuals per 1 cm bin for every year when data is available. It also noted the importance of the readings

of historical otoliths to improve the understanding of the stock recruitment. The Working Group also welcomed the upcoming POKER survey scheduled for 2021 to track juvenile abundance and suggested that the possibility to locally track the juvenile abundance every year was to be considered. These would improve the YCS and recruitment estimations which are critical parameters in the model.

3.83 The Working Group agreed that the catch limit set by France of 5 200 tonnes for 2019/20 that accounts for depredation was consistent with the CCAMLR decision rules for the model runs presented.

Management advice

3.84 No new information was available on the state of fish stocks in Division 58.5.1 outside areas of national jurisdiction. The Working Group, therefore, recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2019/20.

D. eleginoides in Division 58.5.2

3.85 The fishery for *D. eleginoides* in Division 58.5.2 operated in accordance with CM 41-08 and associated measures. Details of the fishery and the stock assessment are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.86 The updated stock assessment was presented in WG-FSA-2019/32. The assessment included updated observation data, estimated mortality from lost longlines, updated growth parameters, length–weight estimates and maturity estimates, and a simplified longline selectivity shape. The updated assessment model estimated virgin spawning stock biomass, B_0, at 70 519 tonnes (95% CI: 65 635–76 626 tonnes), with the estimated SSB status in 2019 of 0.51 (95% CI: 0.49–0.53).

3.87 The Working Group noted that the stock trajectory for *D. eleginoides* in Division 58.5.2 was expected to decline below 50% B_0 as a result of weak year classes in recent years and the effect of the historical switch from trawl fishing on younger fish to longline fishing on the same cohorts when older in the area.

3.88 The Working Group noted that the assumption of average recruitment in the future would allow the stock to rebuild to 50% B_0 at the end of the 35-year projection period. However, the estimated YCS has been below average since 1998. Scenarios that assumed future recruitment patterns similar to the average YCS estimated for the period after 1990 would result in the stock failing to rebuild to 50% of B_0 over the 35-year projection period.

3.89 The Working Group noted that the estimated stock status at the time of the next assessment in 2021, irrespective of the assumption of future YCS, was expected to be about 46% of B_0. While the Working Group noted that fluctuations around the target of 50% B_0 would be expected for stocks near or at the target levels (paragraph 3.19), it expressed concern that the stock may continue to decline if below-average YCS continued and were not accounted for in future assessments.

3.90 The Working Group recommended an update on stock parameters, including recruitment indices from the trawl survey, and age-frequency data and tag-recapture data from the fishery be presented in 2020 to evaluate whether recruitment and the stock trajectory were consistent with those estimated by this assessment.

3.91 The Working Group requested that the Scientific Committee task WG-SAM with developing advice on alternative harvest strategies that may provide a more precautionary approach for stocks that fluctuate around, or are below, the target level, and for stocks where recent patterns of weak year classes were apparent in the fishery.

Management advice

3.92 The Working Group noted that a catch limit for *D. eleginoides* in Division 58.5.2, set at 3 030 tonnes for 2019/20 and 2020/21 based on the outcome of this assessment, would be consistent with the precautionary yield estimated using the CCAMLR decision rules and the process for setting catch limits used in previous years. The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules.

3.93 No new information was available on the state of fish stocks in Division 58.5.2 outside areas of national jurisdiction. The Working Group, therefore, recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2019/20.

D. eleginoides in Subarea 58.6

3.94 The fishery for *D. eleginoides* at Crozet Islands is conducted within the French EEZ and includes parts of Subarea 58.6 and Area 51 outside the Convention Area. Details of this fishery and the stock assessment are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.95 WG-FSA-2019/57 Rev. 1 presented an updated stock assessment of *D. eleginoides* at Crozet Islands (Subarea 58.6 inside the French EEZ). The assessment model included updated data (up to August 2019), revised growth curves and catches taken on the Del Cano Rise from outside the Convention Area from 2003 to 2019 (including depredation at the same level as in the Crozet EEZ, model M3).

3.96 The Working Group noted that B_0 was estimated at 54 610 tonnes (95% CI: 48 560–60 880 tonnes), with the stock status in 2019 at 63% (95% CI: 58.2–66.6%) when considering model M3.

3.97 The Working Group noted that the catch composition of the fishery in the model used length observations and recommended that the authors investigate the use of age composition data instead. The Working Group, therefore, suggested to increase the number of otolith readings to five individuals per 1 cm bin for every year when data is available and noted the importance of the readings of historical otoliths to improve the understanding of the YCS estimates.

3.98 The Working Group agreed that the catch limit set by France of 800 tonnes in 2019/20, which accounts for depredation, was consistent with the CCAMLR decision rules for the model runs presented.

Management advice

3.99 No new information was available on the state of fish stocks in Subarea 58.6 outside areas of national jurisdiction. The Working Group, therefore, recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2019/20.

D. mawsoni in the Ross Sea region

3.100 The exploratory fishery for *Dissostichus* spp. in Subarea 88.1 operated in accordance with CM 41-09 and associated measures. In 2018/19, the catch limit for *Dissostichus* spp. was 3 157 tonnes, including 65 tonnes set aside for the Ross Sea shelf survey. Fishing was conducted by 19 longline vessels and the total reported catch was 2 988 tonnes. Details of this fishery and the stock assessment are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.101 WG-FSA-2019/07 presented an updated characterisation of the Ross Sea region fishery, including data from the 2018/19 season. The Working Group noted that the establishment of the Ross Sea region marine protected area (RSRMPA) has led to some redistribution of fishing effort. In 2019, the fishing effort was concentrated on the slope south of 70°S and the tag-recapture rate was increased. The Working Group noted the previous work anticipating the impact of the establishment of the MPA on the assessment of the stock (WG-SAM-17/41) and encouraged further work to develop statistics to assess the spatial overlap of fishing effort between years for this and other fisheries.

3.102 An update of the biological parameters used as input to the CASAL model was presented in WG-FSA-2019/11. Re-estimated growth and length–weight parameters were similar to previous estimates. An alternative, non-parametric, growth function fitted the data slightly better. Model sensitivity runs showed that the revision of growth parameters or non-parametric estimates made very little difference to the overall assessment of the stock. The Working Group encouraged further development of the non-parametric growth model.

3.103 The Working Group noted that the redistribution of effort combined with the variability of growth within the Ross Sea region may lead to bias in the estimation of growth and length–weight parameters. The Working Group noted the large amount of data (18 000 otoliths and over 570 000 measurements) available in the Ross Sea region and recommended that further analysis to quantify any differences in growth between areas be carried out, and the implications of any differences for management advice be considered.

3.104 An updated assessment model for *D. mawsoni* in the Ross Sea region was presented in WG-FSA-2019/08, with diagnostics in WG-FSA-2019/10 and a draft Stock Annex in WG-FSA-2019/09. The assessment used catch, catch-at-age and tag-recapture data from 1998 to 2019 and included the results from the Ross Sea shelf survey from 2012 to 2019. The estimate of B_0 of 71 730 tonnes was within 2% of the estimate in 2017. The Working Group noted that the comparison with previous assessments shows a consistent trend and estimate of B_0, with

uncertainty decreasing as additional data was added. The Working Group noted that the model estimates of uncertainty are likely to be an underestimate of the total uncertainty about the stock size.

3.105 The Working Group noted that data from Members catching toothfish within the South Pacific Regional Fisheries Management Organisation (SPRFMO) area adjacent to the Ross Sea region was reported to SPRFMO using the CCAMLR data reporting forms, and also voluntarily submitted to CCAMLR by those Members. The Working Group recommended that this data continue to be included in assessments where appropriate, as described in WG-SAM-17/41.

3.106 The Working Group noted that catch data from some Ukrainian vessels fishing in the Ross Sea region had discrepancies between the C2 and CDS data (CCAMLR-38/BG/11) in 2015–2018, which had led to the data being quarantined (paragraph 2.15). The Working Group noted that the catch was a relatively small proportion of the overall catch included in the model for those years and inferred that the impact on the assessment of the stock would be small. The Working Group recommended that the effect of excluding this data on the assessment be investigated by performing a sensitivity analysis, for consideration by a future meeting of WG-SAM.

3.107 The Working Group welcomed the progress made by those developing integrated assessments towards the recommendations of the Independent Stock Assessment review. The Working Group's assessment of the progress towards these recommendations is detailed in Table 3.

Management advice

3.108 The Working Group recommended that the catch limit be set at 45 tonnes for the 2019/20 survey and 65 tonnes for the 2020/21 survey.

3.109 The Working Group recommended that following the procedure outlined in CM 91-05, the catch limit for the Ross Sea region (Subarea 88.1 and SSRUs 882A–B) in the 2019/20 and 2020/21 seasons be 3 140 tonnes (see Table 6 for potential catch allocation methods between management areas). The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules.

Research to inform current or future assessments in data-limited fisheries notified under Conservation Measures 21-01, 21-02 and 24-01

Trend analysis and proposed catch limits

4.1 The Secretariat updated the estimates of local biomass with uncertainty for *D. mawsoni* and *D. eleginoides* in research blocks in Subareas 48.6, 58.4, 88.2 and 88.3 as agreed by the Scientific Committee (WG-SAM-2016 report, paragraph 2.28) and the decision rules process using the trend analysis (WG-FSA-2018 report, Figure 4). Data quarantined according to the recommendation in paragraph 2.15 were not included in the process.

4.2 Estimates of local biomass presented in Table 7 used the updated vulnerable biomass estimates from the 2019 assessments in Division 58.5.2 (WG-FSA-2019/32) of 32 917 tonnes (CV 0.0308) and the Ross Sea region (WG-FSA-2019/08) of 84 658 tonnes (CV 0.0612). The estimate of fishable seabed area in the area open to fishing in the Ross Sea region is now 90 968.0 km^2 following the changes introduced with the coming into force of the RSRMPA.

4.3 The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules. It further noted that the catch limits included in Table 7 were developed using the same procedure as used last year, which has in the past been considered to follow a consistent approach and provide precautionary catch limits.

Conversion factors

4.4 CCAMLR-38/02 provided recommendations for developing guidelines for conversion factors. It recommended that a focus topic be undertaken at WG-FSA in 2020 to develop guidelines for standardising the methodology for calculating conversion factors in new and exploratory toothfish fisheries, and that these guidelines serve as 'best practice' for the calculation of toothfish conversion factors in these toothfish fisheries. These guidelines can be progressed during the intersessional period in advance of WG-FSA.

4.5 The Working Group agreed that such a focus topic or workshop would be very beneficial and should also aim to evaluate uncertainty associated with conversion factors. It was also noted that input or participation from fishing industry representatives would be valuable. Further, it was noted that this topic could potentially be an agenda item during WG-SAM.

4.6 It was noted that there are a variety of ways conversion factors are developed and utilised, including where some Members are provided with a conversion factor prior to going fishing, whereas others develop theirs during fishing operations.

4.7 The Working Group requested that the Scientific Committee note that holding a conversion factor workshop, or focus topic, during the coming intersessional period would be of great benefit to the work of WG-FSA.

4.8 The Working Group requested that the Secretariat survey Members to understand how toothfish conversion factors provided in all C forms are calculated and applied and present this to the workshop or focus topic. This review should include how the value is estimated and how it is provided to CCAMLR for all toothfish fisheries.

Stock identification, population structure, and connectivity

4.9 WG-FSA-2019/59 described a morphological analysis of *D. mawsoni* sagittal otoliths using a Fourier analysis to explore the feasibility of using otolith morphology to discriminate between stocks from Subareas 48.1, 48.6 and 88.1. The paper concluded that this method did not detect significant differences between regions, and further noted that otolith shapes alone

can vary substantially even within the same research block. The authors recommended evaluating other techniques, such as otolith elemental signature and genetics to investigate stock structure for this species.

4.10 The Working Group agreed that, although stock discrimination was not detected in this case, it was nonetheless a valuable and useful study and thanked the authors for their efforts. It was suggested that there may be other approaches with different underlying properties that may be valuable to explore, both in relation to the statistical algorithms for stock identification and morphological analysis of otoliths. It was also noted that otolith morphology may change with age and that this could be a factor in future analysis.

4.11 The Working Group agreed that these types of studies should be further explored, particularly in combination with other datasets drawn from, for example, otolith chemistry or genetic samples.

4.12 WG-FSA-2019/61 provided a report on international collaborative research on otolith microchemistry of *D. mawsoni* otoliths in the Southern Ocean. Results indicate heterogeneity in stock structure of *D. mawsoni* between Subareas 48.6 and 88.1. The authors encouraged additional collection of otoliths from Subareas 48.4, 48.5 and 88.3 and Divisions 58.4.1, 58.4.2 and 58.4.3 and the SPRFMO area toward future research with this collaborative project.

4.13 The Working Group agreed that this work was valuable, and encouraged that this work continue and that additional samples be collected from other regions where there is little material. It further encouraged that oceanographic and physical data be collected in conjunction with these samples for potential use in future analyses. The Working Group noted that, based on the previous collaboration (WG-FSA-2018 report, paragraph 4.80), this collaborative project was already extended to Japan, Ukraine and the USA, and will be further extended to Australia, Russia, Spain and the UK.

4.14 WG-FSA-2019/P01 presented the results of a study on genetic stock connectivity of *D. mawsoni*. Samples were collected from Subareas 48.2, 48.4, 48.6, 88.1, 88.2 and 88.3 and Divisions 58.4.1, 58.4.2 and 58.5.2, as well as the SPRFMO area north of Subarea 88.1. The authors noted that this is the largest *D. mawsoni* genetics study to date in terms of sample size, and single nucleotide polymorphism markers and sampling locations. The study indicates that there is no genetic stock structure between management areas, likely due to the distribution of eggs and larvae by the Antarctic Circumpolar Current (ACC). Despite this, the lack of genetic division of stocks does not preclude the presence of local biological stocks in the Southern Ocean. It was noted that the overall quantity of DNA was higher in extractions from fin clips than from muscle tissue.

4.15 The authors of WG-FSA-2019/P01 recommended that: (i) a framework similar to the CCAMLR decision rules should be considered by management bodies outside the CCAMLR area to ensure sustainability due to potential stock linkages, (ii) spawning models should be updated to account for all the new information obtained since 2012, (iii) the inability to define stock boundaries from genetics alone limits the ability for close-kin mark recapture, and (iv) genetics are not a silver bullet for *D. mawsoni* and likely will need to be combined with something like stable isotopes for assigning IUU catch back to location.

4.16 The Working Group noted that there are likely both retention and dispersion processes that influence stock connectivity and agreed that it would be useful to combine this genetic approach with other information from tagging, otolith microchemistry and oceanographic models.

4.17 WG-FSA-2019/36 provided a report on research activities to define population structure of *D. mawsoni*, using samples from 11 geographic localities from Areas 58 and 88, and based on mitochondrial and microsatellite DNA markers. Specific objectives included a genetic diversity assessment and stock identification, and an analysis of phylogenetic relationships. The results indicate low levels of Mitochondrial DNA (mtDNA) diversity; that there was significantly higher mtDNA diversity in Area 58 than Area 88; and higher levels of polymorphism in microsatellites than in mtDNA. It was also noted that the Area 88 region likely represents a 'single' genetic stock, that the highest migration rates were observed from other populations to research block 883_4, and that there were no distinct clades or lineages detected.

4.18 The Working Group noted that the results described in WG-FSA-2019/36 were largely consistent with WG-FSA-2019/P01, and it was noted that it was common in such studies to see a reduction in discrimination between stocks as sample sizes increased where there is genetic mixing.

4.19 It was also noted that evidence in relation to migrations and variations within Subarea 88.3 was supported by population hypotheses for *D. mawsoni* in Area 48 developed during the Workshop for the Development of a *Dissostichus mawsoni* Population Hypothesis for Area 48 (WS-DmPH-18) (WG-SAM-18/33).

4.20 The Working Group agreed that the research presented in WG-FSA-2019/36 was valuable and suggested that further studies should be undertaken including areas that had relatively low sample sizes, and would benefit from increased collaboration with similar research activities such as those described in WG-FSA-2019/P01.

Vessel tagging survey

4.21 WG-FSA-2019/15 Rev. 1 provided a report on the implementation of the Scheme of International Scientific Observation (SISO) during 2018/19 that includes a summary of a survey undertaken by the Secretariat on tagging procedures. The primary themes in relation to tagging were equipment and operation, landing and handling fish, and personnel and training.

4.22 The Working Group noted the variable nature of tagging operations across the fishing fleet, and that 12 of the 17 vessels who responded to the survey rely on observers for all tagging duties, with no crew trained in procedures. It was further noted that only 75% of the fleet considered tagging to be a Flag State responsibility.

4.23 The Working Group noted the relatively low rate of survey participation by vessels. It noted that it would be useful to review who replied to the survey in relation to tagging data quality, as this could provide more information as to which data series should get more weighting, which in turn would improve stock assessments.

4.24 The Working Group noted that there had been previous recommendations endorsed by WG-SAM, WG-FSA and the Scientific Committee to have a workshop focused on tagging

protocols and procedures (WG-SAM-2018 report, paragraph 5.8; WG-FSA-2018 report, paragraph 7.4; SC-CAMLR-XXXVII, paragraphs 2.6 and 2.7). The Working Group requested that the Scientific Committee note the benefit of such a workshop being held in the 2019/20 intersessional period and take this into consideration in developing its work plans.

4.25 The Working Group requested that the Scientific Committee engage with COLTO to explore hosting such a workshop during the upcoming intersessional period. Such a workshop should include scientists, vessel operators, scientific observers and other stakeholders, and should work toward developing a series of best-practice protocols and guidelines for tagging toothfish that could be applied across the fishing fleets in the Convention Area.

Process for reviewing research proposals

Table for evaluating research proposals

4.26 WG-FSA-2019/55 provided a proposal for a revised summary table to be used for the assessment of new and ongoing research plans. The Working Group noted that during WG-SAM-2019, the Conveners of WG-SAM and WG-FSA were requested to simplify language and reduce ambiguity of this table.

4.27 The Working Group agreed that the revised table in WG-FSA-2019/55 was a substantial improvement over the previous version used by WG-SAM and WG-FSA. A number of additional suggestions were made to further refine the table, including elements pertaining to research objectives and capabilities. The final table design was endorsed and used to assess proposals for research notifications in accordance with CM 24-01 (Tables 8 to 10).

4.28 The Working Group noted the large amount of time spent at both WG-SAM and WG-FSA assessing research plans, limiting the ability to focus on other areas of research. The Working Group recommended that proponents provide a self-assessment of their research plan prior to the start of the meetings. This would involve answering the questions shown in Tables 8 to 10 with an additional column providing specific reference to the sections in the research plan which addresses the question being asked. The self-assessments would provide the working groups with a guide for assessing if the research plans are consistent with CCAMLR's objectives.

Fishery status and the regulatory framework

4.29 WG-FSA-2019/66 provided recommendations to reduce confusion and better align toothfish fishery status with the CCAMLR regulatory framework. The framework designates five different types of toothfish fisheries: new, exploratory, established, lapsed and closed. The current status of toothfish fisheries has become increasingly disconnected in some fisheries throughout the Convention Area. The paper proposed that a suite of characteristics be developed to better align toothfish fisheries with the regulatory framework, and that these characteristics be used as triggers for assigning or reassigning fishery status based on their stage of development.

4.30 The Working Group agreed that the current designation of toothfish fishery status causes confusion for WG-FSA. It noted that CCAMLR's regulatory framework as applied to fishery status designations is not explicitly documented in one location, but is instead referred to throughout various Scientific Committee and Commission reports and discussions across many years.

4.31 The Working Group noted the potential triggers set out in WG-FSA-2019/66, and that these triggers would be useful to further develop and refine, given the nature of the regulatory framework.

4.32 In light of these discussions, the Working Group recommended that the Scientific Committee consider:

(i) Subarea 88.1 and SSRUs 882A–B (Ross Sea region toothfish fishery): Remove the term 'exploratory' in CM 41-09, but retain all elements required by Members to participate in the fishery in the conservation measure.

(ii) Division 58.4.4: This toothfish fishery, currently closed in accordance with CM 32-02, be reclassified as an exploratory fishery in accordance with CM 21-02, with a new CM 41-XX established for this exploratory fishery.

(iii) Division 58.4.3b: Change the current status of the exploratory toothfish fishery as set out in CM 41-07 to a status of 'lapsed'.

(iv) In relation to (iii), it was recommended that the Scientific Committee consider any toothfish fisheries that have had no fishing or research activities for 3–5 years classified as a lapsed fishery.

4.33 The Working Group agreed that it would benefit from a clear strategy from the Commission as to how the regulatory framework can be interpreted in order to better define the status of a toothfish fishery at its current stage of development and requested the Scientific Committee consider how to progress this. Such a strategy would assist the Working Group in developing scientific advice for toothfish fisheries.

Map data

4.34 The Working Group recalled previous discussions on maps provided in research plans (WG-FSA-2017 report, paragraph 4.13), regarding the use of a standard map projection as specified within the CCAMLR GIS, or providing the projection used in the map. Additionally, the Working Group recommended that maps within papers provide references for data layers used (e.g. bathymetry). This would allow the re-creation and analysis of maps/research design within the Working Group, should that be required.

Management area research reviews and management advice

Dissostichus spp. in Area 48

Subarea 48.1

4.35 WG-FSA-2019/17 presented a summary of the results of the longline survey for *Dissostichus* spp. conducted under CM 24-01 by the Ukrainian vessel *Calipso* in Subarea 48.1 during the 2018/19 season, as well as a one-year research proposal for the continuation of this survey. The purpose of the research is to assess the local status and population structure of *Dissostichus* spp. in this area, as well as contribute to the evaluation of stock hypotheses for toothfish across Area 48 (WS-DmPH-18).

4.36 The Working Group noted that the research design presented in WG-FSA-2019/17 was updated from that shown in WG-FSA-18/20 Rev. 1 to account for sea-ice conditions (SC-CAMLR-XXXVII, paragraph 3.118). This new design included nine stations in research block 481_1 (northernmost) and 20 stations in research block 481_2 (central block). Research block 481_3 (southernmost block) was removed from the proposal. The authors indicated that this effort-limited research plan was intended to collect data for one more year, however, the research analysis and reporting would continue after the on-water activities were completed. They further clarified that the planned longline stations were distributed across three depth strata, as specified in WG-FSA-2019/17, Table 2, and that the location of the sets was based on the expectation to recapture tagged fish and to enable catch rate comparisons between the two seasons.

4.37 The Working Group noted that a more detailed presentation of the results from the 2018/19 survey was given in WG-SAM-2019/33. The survey had been restricted by sea-ice conditions and only deployed and successfully retrieved seven sets (of the planned 29) in research block 481_1, due to an inability to access research block 481_2; two additional lines, comprising 25% of the hooks deployed, had also been lost under ice and not retrieved.

4.38 The Working Group noted that the risk to the completion of research objectives remains even if the survey is conducted in February 2020 because sea-ice models run during WG-FSA-2018 predicted general low accessibility of research block 481_2 (WG-FSA-2018 report, paragraphs 4.48 to 4.52).

4.39 A power analysis was run during WG-FSA in order to test whether the number of stations was sufficient to detect potential changes in abundance index over time. The sampling rate proved to be adequate as the 29 planned stations resulted in 80% chance of detecting a 30% change in CPUE.

4.40 The Working Group considered a map showing the completed stations in the 2018/19 survey and the planned stations for the proposed survey in 2019/20 to assess whether the data collected in the first season were representative of the population and could be used to update the management advice regarding catch limits in the next season. Based on this consideration, the Working Group concluded that the CPUE data estimated from the seven completed stations could be used to update the management advice on catch limits. The Working Group agreed that a catch limit of 43 tonnes should apply in this effort-limited survey, based on multiplying the number of planned stations by the upper 75th percentile of the average CPUE from the seven completed sets in the 2018/19 season.

4.41 WG-SAM-2019 noted that the tag-overlap statistic for the 2018/19 survey presented in WG-SAM-2019/33 was lower than the 60% threshold specified by CM 41-01 (WG-SAM-2019 report, paragraph 6.38). The Secretariat informed the Working Group that the tag-overlap statistic had been recalculated using the catch-weighted length frequency and was found to be higher than 60%.

4.42 The Working Group requested more information to assess the likely impacts from the proposed research on dependent and related species, consistent with Article II, and particularly regarding fish by-catch composition and biomass. The proposal indicated that the proponents are using Spanish-type longlines with minimal impact on benthic organisms (WG-SAM-2019/23) and that they will use deep-sea cameras to help understand the interaction of the longline with the bottom. It provided more information on fish by-catch and showed that by-catch to catch ratio was 30% with *Macrourus* spp. being the dominant species. The Secretariat provided a map showing that the distribution of by-catch was relatively uniform across the sampling locations completed in 2019/20.

4.43 The Working Group noted that this proposal had not specified a conservation measure exemption (CM 24-05) under CM 24-01 and, as such, noted that a by-catch limit for *Macrourus* spp. should be 7 tonnes (16% of the target species catch limit), consistent with CM 33-03.

4.44 The Working Group noted that all recommendations by WG-FSA-2018 and WG-SAM-2019 were accounted for in the new proposal, except the increase in sampling effort for biological measurements on by-catch species (WG-FSA-2018 report, paragraph 4.47). The authors agreed to increase the biological sampling of by-catch species to a minimum of 30 individuals per species on each line as suggested by the Working Group.

4.45 The Working Group suggested prioritising the research in the southern research block (481_2) in order to provide key information about stock structure and stock hypothesis in Area 48, subject to the proposal being agreed.

4.46 The Working Group welcomed the high level of international collaborations in this proposal. Part of the otoliths and toothfish genetic samples were sent to scientists at the Alfred Wegener Institute for Polar and Marine Research (Bremerhaven, Germany). Some toothfish otoliths were transferred to scientists at the Shanghai Ocean University (China) for microchemical analysis and age reading cross-laboratory validation. Otoliths of grenadiers will also be read. The results of the analysis will be presented at working group meetings in 2020.

4.47 The Working Group reviewed the research proposal as an ongoing research proposal and summarised its advice in Table 8.

Subarea 48.2

4.48 WG-FSA-2019/51 presented the results of the final fifth year of the longline survey conducted by the Ukrainian vessel *Simeiz* in Subarea 48.2 in March–April 2019, as set out in WG-FSA-18/49. Significant reductions were noted in the CPUE of *D. mawsoni* in the survey area compared with 2018. Data on the CPUE time series by research blocks of the target and main by-catch species, biological characteristics of toothfish and by-catch and seabird and marine mammal observations were presented. The authors noted that there was no plan to

continue fishing activities in 2019/20, but to instead focus on delivery of research objectives off the water. The authors clarified that they will continue working on CPUE time series once the catch will have been re-estimated (paragraphs 2.12 to 2.15).

4.49 The Working Group welcomed the high level of international collaborations in this proposal. Part of the otoliths and toothfish genetic samples were sent to fellow scientists at the Alfred Wegener Institute for Polar and Marine Research (Bremerhaven, Germany). Some toothfish otoliths were transferred to scientists of the Shanghai Ocean University (China) for microchemical analysis and age reading validation across laboratories. Otoliths of grenadiers are also planned to be read.

4.50 The Working Group noted that a member of the Ukrainian research team, Illia Slypko, is a CCAMLR scholarship recipient who spent one week at the Australian Antarctic Division (Kingston, Australia) with the team led by his mentor (Dr Welsford) prior to WG-FSA this year, working on ageing of *Dissostichus* spp. with Australian colleagues.

4.51 The Secretariat noted that there were no tag-release details for two of the fish recaptured in this subarea in 2019, despite these being CCAMLR tags issued by the Secretariat. The Working Group expressed its concern that toothfish tagging had taken place using CCAMLR-issued tags but the details had not been supplied to the Secretariat as this was crucial for the development of stock hypotheses and biomass estimation. It requested the Secretariat to continue its enquiries and work with the Member that was supplied with these tags to discover the original tagging details.

4.52 The Working Group encouraged all Members to ensure that details of all toothfish tagging activities are submitted in a timely manner. Where there are any concerns about tagging data that was not amenable to submission using the SISO observer form, Members were requested to correspond with the Secretariat to determine the most appropriate data submission mechanism.

4.53 The Working Group requested an analysis of fish by-catch from Subarea 48.2 over the five-year survey period and a power analysis to be run to assess whether the number of stations in their sampling design was adequate to achieve their research objectives.

4.54 The Working Group recalled the importance of using a standard ageing protocol for *D. mawsoni* across areas and encouraged the proponents to ask for assistance from their New Zealand and Korean colleagues who are conducting ageing programs in Subarea 88.3 as part of their joint research plan.

4.55 The Working Group welcomed the increasing numbers of ageing programs being undertaken by Members.

Subareas 48.2 and 48.4

4.56 WG-FSA-2019/25 presented preliminary results from the final data collection year of a five-year research survey investigating the stock connectivity of toothfish species in Subareas 48.2 and 48.4. The three years of data collection will now be followed by a two-year period of data analysis. Data from a long-distance tag recapture was presented from a fish which

travelled from the south of Subarea 48.6 to Subarea 48.4 (released 2013, recaptured 2017). It was noted that this movement was congruent with the stock structure hypothesis for this region (WG-SAM-18/33 Rev. 1, WG-FSA-2019/05).

4.57 The Working Group welcomed the inclusion of a period of time dedicated to post-survey analysis and suggested that a synthesis of all data collected from recent research fishing for toothfish for the region would be of merit.

Subarea 48.6

4.58 WG-FSA-2019/22 reported on annual research fishing operations from a multi-Member longline survey targeting *D. mawsoni* in Subarea 48.6. At the time of WG-FSA-2019 the research fishing activities were not yet completed. Eleven other papers were presented at WG-SAM-2019 (five papers) and WG-FSA-2019 (six papers) to address research questions and Working Group requests. The Working Group congratulated Japan, South Africa and Spain for the effectiveness of their collaboration, and the progress that was being made in assessing the status of stocks in this subarea.

4.59 Preliminary results from a satellite tagging experiment (six pop-up satellite archival tags (PSATs) deployed) were presented and showed two tags that were released earlier than expected and suggest long range (>200 n miles) and unexpectedly fast (20 km/day) movement if the data are accurate. Argos locations are yet to be obtained from the tag manufacturer.

4.60 The Working Group asked for details on the offal reported from the stomach content analysis. As no offal is discarded south of 60°S, suggestions were made as to its origin, including that the offal may have been heavily digested prey items, or as a result of vessels using offal as bait. The Working Group agreed that an option to record offal as bait be added to the C2 form, also noting the discussions at the COLTO–CCAMLR Workshop (Table 2).

4.61 The Working Group suggested some modifications to the spotlights used on benthic monitoring cameras to improve the quality of the image. It also emphasised the utility of fishing vessels as platforms to collect environmental data using devices such as conductivity temperature depth probes (CTDs) and PSATs as demonstrated in this report.

4.62 The Working Group noted that there were large discrepancies between the age readings of Spain and Japan and suggested they partner with more experienced readers to attempt to reduce this variability. It also noted the recent publication of ICES *Handbook of fish age estimation protocols and validation methods*, and encouraged Members to compile similar documentation for ageing species found in the Convention Area.

4.63 The Working Group noted that there may be the possibility of matching opportunistic observations of baleen whales taken during the survey with a latitudinal array of acoustic recorder moorings present in the Weddell Sea (e.g. Thomisch et al., 2016). It was also noted that there were no sightings of toothed whales during the survey and there was no evidence of depredation.

4.64 WG-FSA-2019/21 presented a preliminary integrated stock assessment model for *D. mawsoni* in research block 486_2 using CASAL. The authors identified issues with the stock assessment as it stands but noted that it is a useful exercise to identify areas of development for

future work; no future projections of the stock or sustainable yield calculations were attempted. It was noted that all iterations of the model predicted far higher estimates of biomass than the trend analysis used in previous years (WG-FSA-2018 report, Table 4).

4.65 The Working Group requested that a table of model parameters be included in future reports to help with interpretation. It noted that there was an issue with poor fits of modelled data to the age–length keys (ALK) and that this could be due to several reasons. Two CASAL models were presented, one with data aggregated over several years and one with ALKs separated by year. The proposed level of five samples from every 5 cm length bin was suggested to be too low for annual ALKs and the Working Group proposed an increased sampling effort and age readings. The Working Group also suggested to use simulations to test the effect of otolith sample number and length class binning on ALKs and calculated growth parameters.

4.66 The Working Group noted that research block 486_2 sits within a wider hypothesised stock. It noted the importance of the assessment area reflecting the stock for an integrated assessment and recommended further work to reflect this in future models.

4.67 The Working Group highlighted the utility of collating all available data when attempting a CASAL stock assessment to identify gaps and give an indication of where to target future work. It was also suggested that certain parameters could be considered global for a single species and may be used from other areas that have existing CASAL assessments.

4.68 WG-FSA-2019/05 presented tag-derived movement data for *D. mawsoni* which provided new insights on the stock structure hypotheses developed during WS-DmPH-18. Most of the long-distance tag movements highlight an east to west direction and no migrations were seen between the hypothesised spawning grounds in the northern seamounts and the feeding grounds of the southern shelf.

4.69 The Working Group suggested the use of the newly developed CCAMLR tag-linking algorithm to try and identify any further tag recaptures in this region. The Working Group noted the need to understand whether continuing data collection will reach the desired outcomes. In this case, it is likely that a significant number of extra tags might be needed to reach a conclusion about the stock hypotheses. It was also raised that the PSATs (presented in WG-FSA-2019/22) are a new development which may lead to a more successful resolution to this question than conventional tagging.

4.70 The Working Group noted that there is little evidence to support north–south migrations from current tagging data in Subarea 48.6 but that there is some evidence for this from ontogenetic size and age structure profiles in the north and south of Area 88. It noted that as larger datasets of age structure are developed, a similar analysis could be done for this region.

4.71 The Working Group highlighted that previous work on trace element finger printing of otoliths from these research blocks showed no significant differences which may indicate movement between them (WG-FSA-18/75). The Working Group also highlighted the importance of data collection at spawning grounds and that any extra oceanographic data collected in these key areas would be of merit.

4.72 Data from the CCAMLR database highlighted a tagged fish recaptured within research block 486_1 but there was no mention of this area otherwise during research presentations from this area. The Working Group noted that this research block has not been fished in this context

for several years due to low catch rates, but when it was, mostly smaller *D. eleginoides* were found there. It noted that ageing any otoliths from these specimens would provide useful information on the linkages between the northern part of Subarea 48.6 and other *D. eleginoides* populations in Area 48.

4.73 The Working Group noted the success of the workshop format in the case of the stock structure hypothesis for *D. mawsoni* in Area 48 (WG-SAM-18/33 Rev. 1) in not only addressing a key issue, but also in guiding the direction of subsequent science in Area 48 through the development of successful research plans.

4.74 WG-FSA-2019/48 reported on correlations of sea-surface temperature (SST) anomalies with sea-ice concentration (SIC) between Subareas 48.6, 88.1 and 48.5/the Weddell Sea. There is some correlation of SIC between Subareas 48.6 and 88.1 with SST data from 2002 to 2019, as well as concurrent spikes in SST anomalies between these areas. This work was explored further in WG-FSA-2019/49 which explored the possibility of predicting SIC in research block 486_5 using SST in research block 486_2.

4.75 The Working Group noted that the SST anomaly spikes correspond well with accessibility in research block 486_5, and that last year only 38% of catch was taken in this research block because of this issue (WG-FSA-2019/22, Table 3). The Working Group noted that these sea-ice diagnostics should be further developed to help planning research design, particularly in regard to expected tag-recapture data. It also noted that the SST anomaly seemed to be declining over the last few years, which may result in limited access to research block 486_5 for the next several years.

4.76 A proposal for the continuation of a multi-Member longline survey of *D. mawsoni* in Subarea 48.6 was presented in WG-FSA-2019/23 by scientists from Japan, South Africa and Spain. The Working Group noted that the Members addressed most of the comments raised at WG-SAM-2019 within their proposal. During the meeting, a revision was made to this proposal to add the milestone table presented in WG-SAM-2019/13 Rev. 1.

4.77 The Working Group requested further clarification at WG-SAM-2020 regarding the suggested statistical approach for calculating the difference in catch efficiency and effective tag-survival and tag-detection rates. The authors noted that the *Tronio* had demonstrated good tagging performance in the Ross Sea region (WG-FSA-17/36) and tagging performance of the two other vessels (*Shinsei Maru* and *Koryo Maru*) proved to be good according to the analyses conducted during WG-FSA-2019 (Figure 7). The Working Group also noted that the tagging performances were relative to the fleet in a given area and requested future work to calculate these statistics for all vessels within Subarea 48.6 when data will be available. The Working Group noted that electronic monitoring, such as installed recently on the Spanish vessel *Tronio*, could also help understand vessel differences in tagging performance. To this end, the Working Group encouraged other vessels to implement electronic monitoring to allow between-vessel comparisons.

4.78 The Working Group noted that the biomass estimates had declined in some of the research blocks in Subarea 48.6 resulting in declining catch limits. It was noted that this was potentially due to an increase in tag returns affecting the output of the Chapman biomass estimate. Research block 486_2 displayed a clear decline in the Chapman estimate between 2018 and 2019 with a high number of tag recaptures following a period of relative stability. This raised concerns about the status of the stock in this area.

4.79 The Working Group reviewed the research proposal as an ongoing research proposal and summarised its advice in Table 8.

4.80 The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules. The Working Group agreed on catch limits to be calculated for Subarea 48.6 using the trend analysis rules (WG-FSA-2017 report, paragraph 4.33) as shown in Table 7.

Dissostichus spp. in Area 58

Divisions 58.4.1 and 58.4.2

Ageing data

4.81 WG-FSA-2019/47 described the progress in age determination of otoliths from *D. mawsoni* collected in Divisions 58.4.1 and 58.4.2. Spanish and Australian scientists are working on the age and growth estimates of *D. mawsoni* within Divisions 58.4.1 and 58.4.2 from 2015 and 2017. In joining this collaborative work, scientists from the Republic of Korea conducted a comparison of age estimation using microscope and photographic methods by the same reader. The authors noted that using two methodologies to determine age allows differences in interpretation to be isolated and monitored.

4.82 Although the authors noted that age determination using a microscope or magnifier appeared more accurate than those from photographs and the bake and embed method of preparing otoliths, age determination using photographs can be used to facilitate exchange between Members to interpret otolith ring patterns and facilitate routine inter-laboratory calibration.

4.83 The Working Group highlighted the importance and need for comparisons within and among ageing programs as a routine procedure to provide confidence in the comparability of ages used for management. The Working Group noted the need for a workshop on age determination of *Dissostichus* spp., similar to the last one that was held concurrently with the first week of WG-FSA-2012 (Workshop on Techniques and Procedures for Ageing of Otoliths from *D. eleginoides* and *D. mawsoni*).

4.84 The Working Group noted that scientists from Australia and New Zealand have developed digital collections of aged *D. mawsoni* otolith images prepared from thin sections. Acknowledging the potential for digital reference collections to support inter-laboratory calibration in multi-Member ageing programs, the Working Group encouraged the development of digital reference sets by all Members undertaking ageing.

4.85 The Working Group recommended that Members provide the appropriate material in order that the Secretariat can create a digital repository on the CCAMLR website containing otolith ageing and calibration instruction manuals (including WG-FSA-17/15), digital reference collections and a record of the locations of physical reference material. The Working Group further noted that a centralised database of ages would facilitate the increasing number or multi-Member ageing programs and recalled that this was discussed at WG-FSA (WG-FSA-2012 report, paragraphs 10.18 and 10.19).

4.86 The Working Group considered WG-FSA-2019/63 which described the results of a modelling study of egg and larval transport of *D. mawsoni* in the East Antarctic region. The Working Group welcomed and thanked the authors for this large body of work and noted that it could be a useful tool to assess different stock hypothesis and provide further context for genetic studies undertaken to understand *D. mawsoni* connectivity, such as WG-FSA-2019/P01.

4.87 The Working Group noted the importance of including egg buoyancy, sink rates and ocean dynamic systems (e.g. barotropic and baroclinic) to the model, especially considering the potential difference between coastal and open oceans regions and using high-resolution data in the coastal region. In addition to this, incorporating accurate information on the depth that eggs hatch would be required. The Working Group further noted that the results from current research conducted by New Zealand on the ecology of toothfish eggs could add further value in the refinement of this study.

4.88 The Working group welcomed the proposed collaboration with other scientists in this study. Prof. G. Zhu (China) would like to include data from west of the Kerguelen Plateau and expressed interest to combine the method with otolith microchemistry. Dr Péron expressed interest in using this method to advance the stock hypothesis of *D. eleginoides* in Area 58.

Research proposals

4.89 Two alternative research proposals were presented for Divisions 58.4.1 and 58.4.2; a proposal to continue a multi-Member research plan, and a new proposal by Russia.

4.90 WG-FSA-2019/44 provided a proposal for the continuation of a multi-Member research plan by Australia, France, Japan, Korea and Spain on the *D. mawsoni* exploratory fishery in Divisions 58.4.1 and 58.4.2 from 2018/19 to 2021/22. Changes to last year's research plan (WG-FSA-18/59) included an update of operational details and the addition of the larval and egg transport study in the milestones. Research blocks will again be allocated between Members to ensure overlap between fishing gear types and vessels to enable further assessment of gear and vessel effects.

4.91 The Working Group recalled that this and the preceding proposal had been thoroughly reviewed over the last three years by WG-SAM and WG-FSA and had achieved all research milestones as noted by the Scientific Committee in 2018 (SC-CAMLR-XXXVII, paragraph 3.138).

4.92 The Working Group recalled that only Division 58.4.2 was open for fishing in 2018/19. A vessel from Australia and one from France undertook research fishing in Division 58.4.2 during the 2018/19 season. The Working Group reiterated its concern that the loss of a season of data from Division 58.4.1 has resulted in a break in the time series of the data collected in the division. The Working Group highlighted that this had caused a delay to the further development of a stock assessment and the ability of the Scientific Committee to provide advice to the Commission for this area.

4.93 Based on a recommendation by WG-SAM-2019, intersessional discussions were held between the existing co-proponent Members and Russia, but no agreement was reached. The Members noted that, should Russia agree to become a co-proponent of this proposal, its research contributions could be integrated in an additional research objective (marked in tracked changes

in WG-FSA-2019/44). One option would be to include an additional objective (Objective 5) aiming to evaluate the effect of standardised sampling design on estimates of toothfish biomass and biological parameters (WG-SAM-2019 report, paragraph 6.72).

4.94 WG-FSA-2019/52 set out a proposal for a multi-Member research program on *D. mawsoni* in the East Antarctic (Divisions 58.4.1 and 58.4.2) from 2019/20 to 2021/22. The paper noted that the methodical aspects of the multi-Member research on the *D. mawsoni* exploratory fishery in the East Antarctic implemented during the seasons 2011/12–2017/18, as outlined in WG-FSA-2019/44, do not provide scientific-based data for understanding abundance, population structure and productivity indices, distribution of toothfish and dependent species according to the objectives and goals of this research in Divisions 58.4.1 and 58.4.2.

4.95 Dr Kasatkina noted that, in her opinion, the methodical aspects of multi-vessel research in 2011/12–2017/18, in Divisions 58.4.1 and 58.4.2 had significant shortcomings, namely:

(i) lack of standardised design of longline surveys (concentration of longline settings in local areas between 1 000–1 500 m in research blocks, use of different gear types and number of sets by year and research blocks

(ii) impact of longline gear type on length and age composition, proportion of mature fish and results of tag-recapture (Kasatkina, 2017, 2016; WG-FSA-17/16; SC-CAMLR-XXXVII/BG/23; Yates et al., 2017)

(iii) data collection does not fully cover the available toothfish habitat in each research block that leads to uncertainty regarding the understanding of impact of spatial process on vital rates, fishing mortality, and parameter estimation being a critical element of stock assessment and the long-term precautionary management

(iv) low efficiency of tag program (40 tag recaptures and 6 567 tag releases 2011/12−2017/18 for six research blocks).

4.96 The authors of WG-FSA-2019/52 also noted that use of different gear types and non-standardised sampling design is the critical factor for efficiency of the multi-Member research on *D. mawsoni* exploratory fishery in the East Antarctic in previous seasons 2011/12–2017/18 (WG-SAM-2019/34).

4.97 Dr Kasatkina noted that WG-FSA-2019/52 proposed a multi-Member research program on *D. mawsoni* in Divisions 58.4.1 and 58.4.2 from 2019/20 to 2021/22 based on standardisation of sampling longline gear and survey design. The objectives and goals for multi-Member research in East Antarctica Divisions 58.4.1 and 58.4.2 for seasons 2019/20–2021/22 would correspond to those in WG-FSA-18/59. The research outlined in WG-FSA-2019/52 proposed that only vessels equipped with a standard autoline system will participate in multi-Member research in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2019/20 to 2021/22. It was noted that haul locations are stratified by depth and distributed across a range of depth strata (550–1 000, 1 001–1 500, >1 500 m) where possible. Each vessel will deploy at least 10 longlines in each depth strata (where present and sea-ice permitting) in each research block. The haul positions have been created based on stratified-randomised design in depth layers for each research block. It was proposed to optimise longline surveys using ‘Neumann’ location in the second year.

4.98 Dr Kasatkina provided the following statement:

'Our position is based on international practice of conducting surveys with the participation of several vessels by using a standard fishing gear and a standardised design. The papers presented at WG-SAM and WG-FSA provide evidence that the longline fishing gear affects biological parameters used in the model for toothfish stock assessment. The CCAMLR Independent Stock Assessment Review for Toothfish indicated that understanding the impact of spatial process on vital rates, fishing mortality, and parameter estimation is a critical element of the long-term precautionary toothfish management. This recommendation is in line with our position on altering the survey design and to cover the available toothfish habitat in the research blocks with data collection. At present, no scientifically based evidence was presented to WG-SAM and WG-FSA that standardisation design and fishing gear should not be used for multi-vessels resource research and such standardisation should be solved by statistical methods. Lack of agreement on research proposals in the East Antarctic is provided by different positions revealed regarding the methodology of research in the East Antarctic. Our position on research in East Antarctica is a standardisation-based scientific program. Other position is to continue research on Dissostichus mawsoni *exploratory fishery in the East Antarctic without standardisation. It is needed to recall that Scientific Committee significantly increased catch limit for research in the East Antarctic to provide a sufficient number of tagged fish recaptures to obtain a stock estimate within a reasonable time (3–5 years) (SC-CAMLR-XXXII, Annex 4, paragraph 2.7). This recommendation is not yet achieved. In order to achieve consensus on the research methodology in East Antarctica and to submit proposals to WG-FSA and WG-SAM, we propose an intersessional discussion to submit an appropriate document to WG-SAM and WG-FSA.'*

4.99 The other participants noted that:

(i) the matter of standardised gears being used in other international surveys such as in the International Council for the Exploration of the Sea (ICES) was discussed at WG-SAM-2019, paragraph 6.5 and that ICES survey designs include substantial overlap in survey strata between vessels to allow statistical standardisation (i.e. GAMs, Berg et al., 2014) of the results prior to conclusions being drawn on stock abundance (Walker et al., 2017)

(ii) currently, no compelling scientifically based evidence has been presented to the working groups on why a single standardised gear should be used in an exploratory fishery multi-Member research plan

(iii) the Independent Review Panel recommended that understanding the impact of spatial processes on vital rates, fishing mortality, and parameter estimation is a critical element of the long-term precautionary toothfish management and suggested that the stocks could be statistically analysed in a manner that took account of those effects and did not necessarily require altering survey designs

(iv) there was a difference between standardised surveys to obtain reference biomass estimates and research fishing which may use a variety of analytical techniques to interpret the data.

4.100 The Working Group recalled the advice of WG-SAM (WG-SAM-2019 report, paragraphs 6.5 and 6.58 to 6.72) for the development of the original proposal in WG-SAM-2019/19.

4.101 The Working Group recalled its previous advice, as well as that of the Scientific Committee and the CCAMLR Performance Review, requiring proponents of new research to collaborate with Members who are currently participating in established research programs within the same area. The Working Group also recalled the WG-SAM-2019 report, paragraph 6.72, outlining the commitment to work intersessionally to develop a joint research proposal for Divisions 58.4.1 and 58.4.2 for consideration by WG-FSA-2019, but noted that no joint proposal had been submitted to WG-FSA.

4.102 The Working Group noted that there was no agreement between the two research proposal proponents to submit a joint research proposal.

4.103 Dr Kasatkina was asked to clarify as to why there is a need to adopt a different approach to research within Divisions 58.4.1 and 58.4.2 and requested for her to outline:

(i) the scientific basis for treating this exploratory fishery differently to other exploratory fisheries within the Convention Area

(ii) a clear scientific justification for the need for a standard gear, considering that the vessels proposed in WG-FSA-2019/52 used different gear configuration (different line weighting; Table 1) and considering statistical methods have been successfully applied for gear standardisation (e.g. WG-FSA-17/16), a subject on which WG-SAM-2019 has held a focus topic and discussed extensively (WG-SAM-2019 report).

4.104 All other participants noted that:

(i) A continuation of the break in the time series in Division 58.4.1 will delay the provision of management advice for this region.

(ii) Multi-Member research is successfully undertaken across the Convention Area by vessels using different fishing gears, and used to develop integrated stock assessments and set catch limits.

(iii) Five papers presented to WG-SAM-2019 have demonstrated the standardisation of catch rates in a multi-vessel and multi-gear fishery and concluded that different vessel and gear types can be accounted for statistically (WG-SAM-2019 report, paragraphs 6.6, 6.7 and 6.11 to 6.13 and Table 1). They considered that there is no clear justification for the deployment of a single gear type in exploratory fisheries.

(iv) Large variances in catches occur even when different vessels fish in the same area using the same gear type, as is the case in the Ross Sea region. The impact of gear type on length frequency of the catches is accounted for in assessment models through the selectivity function, and that the reason as outlined in WG-FSA-2019/52 does not provide a scientific justification.

4.105 They further noted that the estimations of productivity parameters and stock structure in this division are not dependent upon the same gear type being used, that 'Standard gear' does not exist in the CCAMLR context, and that the use of different gear types can be accounted for in subsequent statistical analyses (GAMs), as is demonstrated in WG-FSA-17/16 for these divisions. These statistical analyses were published in 2019 in the international peer-reviewed journal *Fisheries Research* (Yates et al., 2019).

4.106 The Working Group evaluated the research proposal against the standard criteria and format for research proposals as shown in the Area 58 research proposal assessment table (Table 9). This research plan cannot be completed without collaboration from other Members and the proponent has limited off-water research capacity (only one researcher is listed in the proposal section 5a). Moreover, tagging performance of the proposed vessels is poor or unknown; one vessel had very poor tagging performance (*Palmer*) and the other (*Volk Arktiki*) had a good tagging detection rate but unknown tag survival rate.

4.107 The Working Group was unable to reach agreement on how the use of multiple gear types should be reflected in the Area 58 research proposal assessment table. The source of disagreement relates to the gear type being proposed.

4.108 The Working Group noted that the extensive discussions between the proponents of the two research plans to achieve a collaborative research plan in Divisions 58.4.1 and 58.4.2 prior to, and during, WG-FSA-2019 had failed.

4.109 The Working Group noted that the main reason for the difficulty in achieving consensus in the discussions to achieve a collaborative research plan was the requirement by Dr Kasatkina to use standardised autoline gear and a standardised design. The Working Group noted that there was the intention from the proponents from both research plans to find a solution for the spatial design of haul locations.

4.110 The Working Group recalled that the research plan in Divisions 58.4.1 and 58.4.2 is for an exploratory fishery similar to Subarea 48.6, and not a survey under CM 24-01 in a closed area. The Working Group noted that there is no requirement for the exclusive use of one gear type in an exploratory fishery.

4.111 Dr Kasatkina noted that the practice to use standardised gear and standardised gear design for the toothfish research are known in CCAMLR. The research program in the northern part of the Ross Sea SSRUs 882A–B was provided by vessels from New Zealand, Norway, the UK and Russia by using the standard autoline gear and standardised design.

4.112 All other participants recalled that the survey in the northern part of the Ross Sea that was notified under CM 24-01 in a closed area, was designed to investigate the variation in gear types as well as providing information on the stock structure in the region (WG-FSA-15/32). The design used blocks that would be transferred between vessels with different autoline gear types in order to investigate vessel effects. The survey was conducted for only one year as a result of Russia blocking further research in the area.

4.113 The Working Group noted that currently 4 000 tagged fish are estimated to be available in Divisions 58.4.1 and 58.4.2. The Working Group expressed its concern that without a further year of fishing in Division 58.4.1, there would be no opportunity to recapture these fish which had required a substantial multi-year, multi-Member research effort to release.

4.114 The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules. The Working Group agreed on catch limits to be calculated for Divisions 58.4.1 and 58.4.2 using the trend analysis rules (WG-FSA-2017 report, paragraph 4.33) as shown in Table 7.

Division 58.4.4b

4.115 WG-FSA-2019/62 presented a CASAL model for research block 5844b_1 taking into account the suggestions given by WG-SAM (WG-SAM-2019 report, paragraph 6.76), including the impact of incorporating annual ALKs, standardised CPUE and different IUU scenarios into the CASAL model when estimating the current biomass.

4.116 The Working Group noted the robustness of the model in estimating both B_0 and the current biomass across all scenarios that were investigated. The Working Group also noted that the model estimated higher current biomass than the Chapman method. The Working Group further noted the possibility of setting the catch limits based on the result of the CASAL model in this area.

4.117 The Working Group noted that this work shows that forward projection of stocks in time can provide a fairly consistent yield with robust estimates to account for IUU fishing. The Working Group noted the application of this work and the potential to inform the harvest control rules once further refinements had been made.

4.118 WG-FSA-2019/65 presented the annual multi-Member (France and Japan) longline survey for *D. eleginoides* in Division 58.4.4b for the 2018/19 season. The Working Group noted that the on-water research started in 2016/17 and it will conclude in the 2020/21 season.

4.119 The Working Group noted that the research results were for the 2018/19 season only, but that the appendix contained data for all other seasons. The Working Group also noted that the scientific observer data was still in progress at the time of the WG-FSA meeting.

4.120 The Working Group noted that work had progressed on the CASAL model evaluation, but that the low tag-recapture rates across the research block will affect this.

4.121 The Working Group noted the high level of by-catch in this division, with 70% of the total catch weight being by-catch (including weight of individuals discarded and estimated weight of individuals released or lost at the surface). The Working Group noted that the use of cameras on longlines would provide more information on the presence of sea pen hotspots, particularly in the eastern part of research block 5844b_2 where these are known to occur.

4.122 The Working Group noted the importance of making oceanographic data publicly available using international depositories and suggested that these types of data be submitted to the Southern Ocean Observing System (SOOS).

4.123 WG-FSA-2019/53 investigated the distribution and composition of by-catch caught in research fishing for *D. eleginoides* conducted by France and Japan in Division 58.4.4b between 2008 and 2018. The Working Group welcomed the progress made in addressing the concerns

raised about progress against milestones at WG-FSA-2018 and at SC-CAMLR-XXXVII (SC-CAMLR-XXXVII, paragraph 3.158), including conducting by-catch analyses (SC-CAMLR-XXXVII, paragraph 3.159) according to the revised milestones outlined in SC-CAMLR-XXXVII, Annex 12.

4.124 The authors highlighted that the survey design had been amended to avoid sea pen hotspots in the eastern part of research block 5844b_2 (WG-FSA-18/23 and SC-CAMLR-XXXVII, paragraph 3.159).

4.125 The Working Group noted that there were high levels of skate by-catch recorded in both C2 data and observer data. The highest levels occurred in the eastern part of research block 5844b_2, where sea pen hotspots occur.

4.126 The Working Group noted that most skates were released in good or average condition, but further work is needed to assess skate survivability. The Working Group also noted the large number of skates for which the condition was unknown.

4.127 The Working Group noted spatial and bathymetric effects on skate by-catch rate, and that the autoline gear appeared to be less selective than trotlines and Spanish lines when conducting research fishing in this area, although data was not standardised for fishing patterns. When accounting for skates released (cut-off), the by-catch biomass to target catch ratio was 15% for trotlines and up to 70% for autolines. The Working Group considered possible causes for the high level of skate by-catch observed in this area, and that this may be caused by by-catch reporting practice and bait type as opposed to being a direct gear effect.

4.128 The authors informed the Working Group that vessels from the research plan proponents using autoline gear would not be participating in future research fishing in research block 5844_b2 due to the high catches of skate and are investigating ways to reduce the by-catch. The authors also informed the Working Group that they were involved in the update of the International Union for the Conservation of Nature and Natural Resources – the World Conservation Union (IUCN) Red List assessment for *Amblyraja taaf*, whose status is currently data deficient.

4.129 WG-FSA-2019/64 presented the research proposal for *D. eleginoides* in Division 58.4.4b by France and Japan. The Working Group noted that the proposal had been substantially revised to address the concerns expressed at WG-FSA-2018 and SC-CAMLR-XXXVII (SC-CAMLR-XXXVII, paragraph 3.158).

4.130 The Working Group noted the improved research plan and redefined research objectives presented in SC-CAMLR-XXXVII, Annex 12. The Working Group noted that the survey design had been amended to avoid sea pen hotspots in the eastern part of research block 5844b_2 (WG-FSA-18/23), as well as the addition of a new French vessel to increase research survey capacity.

4.131 Considering the progress made in the stock assessment model, and that the level of the estimated yields achieving the CCAMLR decision rules would allow a yield substantially higher than the catch limit set using the Chapman estimate of biomass (Table 7), the Working Group recommended that a 20% increase from the existing catch limit in research block 5844b_1, to 23 tonnes, would be consistent with the trend analysis procedure. However, the Working Group noted it had been unable to provide consensus advice on catch limits (see

paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules. The Working Group agreed on catch limits to be calculated for research block 5844b_2 using the trend analysis rules (WG-FSA-2017 report, paragraph 4.33) as shown in Table 7.

4.132 The research plan achieved all of its milestones and incorporated the advice from WG-SAM (WG-SAM-2019/08) and its evaluation is given in Table 9.

D. mawsoni in Area 88

Capacity

4.133 WG-FSA-2019/06 Rev. 1 provided the update of capacity and capacity utilisation within Subareas 88.1 and 88.2. The updated capacity metrics in the paper showed the same pattern as in previous updates and did not indicate an excess of capacity in the fishery. Interpretations of data for 2018 and 2019 were made in the context of changes in the areas of operation and the application of fishery closures in the exploratory fishery in Subarea 88.1.

4.134 The Working Group noted that WG-FSA-2019/06 Rev. 1 concluded that there was no evidence of capacity issues at the overall scale of the fishery in Subareas 88.1 and 88.2, while CCAMLR-38/BG/12 considered capacity issues in this fishery at the spatial scale at which catch limits and fishery closures are implemented.

4.135 The Working Group recommended that in future the capacity update presented in WG-FSA-2019/06 Rev. 1:

(i) be applied at the same spatial scales as catch limits are set in order to better reflect operational capacity issues in the fishery

(ii) include a measure of hooks set and retrieved each day during the season, to investigate factors influencing gear loss rates.

Regional comparisons of *D. mawsoni* diet

4.136 WG-FSA-2019/37 reported on prey items of *D. mawsoni* collected from two research areas (Areas 58 and 88) from 2016 to 2018 using metabarcoding analysis of 1 329 stomach contents. A total of 71 haplotypes were identified by cytochrome c oxidase subunit I universal primers, which included 60 fish and 8 cephalopod species. Results indicated that the major prey items of *D. mawsoni* are fish species (98%), with Whitson's grenadier (*Macrourus whitsoni*) and *Chionobathyscus dewitti* being the most important prey items.

4.137 The Working Group welcomed the progress of this research and noted the potential of such approaches to improve our understanding of the toothfish ecology and ecosystem interactions.

4.138 While recognising the challenge in comparing qualitative and quantitative approaches, the Working Group suggested that these results should be compared to other stomach analyses.

Prof. H.-W. Kim (Korea) noted his intention to conduct a quantitative per capita recruitment (PCR) analysis using individual stomach samples, which would allow quantitative comparison with the previous morphological analyses (WG-FSA-18/24).

Age determination

4.139 WG-FSA-2019/35 presented a comparison of age readings performed by two otolith readers from age reading programs in Korea and New Zealand, as well as an estimation of the early growth of *D. mawsoni* (less than age 10) in Subarea 88.3.

4.140 The Working Group recognised the homogeneity of the readings from the two readers and welcomed the use of the standardised plots recommended by the 2012 Ageing Workshop (WG-FSA-2012). The Working Group suggested that this work could be part of a larger study on growth estimation that is going to be developed for WG-SAM-2020. It also noted that the von Bertalanffy growth curves may not be well adapted to the small range of size and age data of this study. The Working Group further noted the importance of ageing tagged fish in improving the growth curve accuracy and the understanding of the inter-individual variability of growth and understanding migration strategy effects.

MPA catch allocation

4.141 SC-CAMLR-38/12 provided comments on resource support for conducting scientific programs in the RSRMPA. The authors noted that although the RSRMPA has existed for three years, it is still unclear how research catch limits in the MPA should be allocated. The operation of the RSRMPA will require significant resource potential directed towards catching *Dissostichus* spp. for the implementation of the research and monitoring plan (RMP). The authors noted that allocation of the overall Ross Sea region catch limit inside and outside the MPA should not limit the Olympic exploratory longline fishery outside the MPA which is a main data source for assessment models of toothfish in the Ross Sea region.

4.142 The authors also claimed that the transfer of catch from the overall catch limit to inside the MPA will have an additional impact on toothfish and the ecosystem in the MPA and will limit the exploratory longline fishery outside the MPA, which is a data source for assessment models of toothfish in the Ross Sea region. The authors further considered that the catch limit for any research in the RSRMPA should not be deducted from catch limits for exploratory fishing outside the MPA.

4.143 The Working Group noted that the transfer of catch from the overall catch limit to inside the MPA is not likely to impact the stock assessment since the catch of the survey represents 1.4% of the total catch limit for the Ross Sea region.

4.144 The Working Group noted that the catch limit in the Ross Sea is provided by the CASAL assessment of the entire Ross Sea stock including areas inside and outside the MPA.

4.145 The Working Group recalled that CM 24-01, paragraph 1(b), specifies how the catch allocations are to be performed.

4.146 Dr Kasatkina highlighted the importance of the shelf survey for the management of the Ross Sea region toothfish fishery noting it had started before the MPA was put in place. However, CM 91-05 did not clearly specify how the allocation of catch should be made for research within the RSRMPA and that in her opinion the catch should be allocated from within the RSRMPA SRZ, rather than allocated from outside the MPA.

4.147 The Working Group agreed on the importance of the shelf survey in this area and noted that before the MPA existed the catch was allocated from the overall catch limit.

4.148 The Working Group discussed the possible options for allocating catch within the MPA from the various areas of the Ross Sea region noting there are three likely allocation options for the shelf survey:

(i) allocation as applied in 2018/19, where the shelf survey catch is removed from the entire Ross Sea region limit before the allocation of catch to the three management areas (north of 70°S, south of 70°S and the SRZ)

(ii) allocation as suggested by Dr Kasatkina, where the shelf survey catch limit is allocated from the SRZ catch limit

(iii) as the MPA is closest to the south of 70°S region, allocate the shelf survey catch limit from the region south of 70°S catch limit.

4.149 The Working Group noted each of these options contains differing levels of risk. It recalled the discussion in CCAMLR-38/BG/12 regarding the difficulty in projecting catch in the SRZ in the presence of large numbers of vessels fishing, and the large number of hooks being set both collectively and by some individual vessels. Lowering the catch limit in the SRZ by allocating the catch limit of the shelf survey from this area, in addition to the potential of 140 tonnes allocated to an SRZ survey (paragraphs 4.156 to 4.169), would potentially exacerbate this issue. A breakdown of catch limits, using the three methods of allocation above, is outlined in Table 6.

4.150 The Working Group also noted that one of the objectives of the SRZ was to provide an area within the MPA that is fished at approximately half the exploitation rate of the fishery to allow comparison between areas of normal fishing, limited fishing and no fishing. Allocating catch from the SRZ for research in other areas of the MPA may impact on the ability to achieve this objective.

Research plans in the MPA

4.151 The Working Group recalled the advice in WG-SAM-2019 report, paragraph 6.16, that any research fishing proposed in MPA zones should ensure it maximises scientific outputs and that robust scientific conclusions can be drawn from those outputs. The Working Group formulated a table (Table 11) which it used to evaluate research plans within the MPAs against the suggested questions from WG-SAM-2019, noting the proponents of these research plans had not seen the table prior to the meeting.

Shelf survey

4.152 WG-SAM-2019/03 described the results from the 2019 Ross Sea shelf survey and the notification for the survey in 2020. The objectives of the survey are to: (i) continue monitoring the abundance and age structure of sub-adult toothfish in the south of SSRUs 881J and 881L in the southern Ross Sea using standardised gear in a standardised approach, (ii) continue monitoring trends of large sub-adult and adult toothfish in two areas situated in SSRU 881M which are of importance to mammalian toothfish predators, and (iii) to collect and analyse a wide range of data and samples from these areas (e.g. demersal fish, benthic invertebrates, stomach and tissue samples, acoustic data, etc.), which will contribute to the RMP for the RSRMPA.

4.153 The Working Group recalled the importance of this time series of surveys for the Ross Sea region stock assessment in delivering a long-term time series of recruitment, as highlighted by the Independent Review (WG-FSA-2018 report, paragraph 4.148). The Working Group welcomed the invitation of a CCAMLR scholarship recipient (Illia Slypko) to participate in the 2019/20 survey and highlighted again the value of the CCAMLR scholarship program in exchanging experience and knowledge between CCAMLR Members.

4.154 The Working Group recalled that the survey is effort limited with a core strata sampled every year and strata sampled in alternate years (i.e. McMurdo and Terra Nova; WG-FSA-2017 report, paragraph 3.83). The McMurdo strata will be sampled in the 2019/20 season.

4.155 The Working Group reviewed the research proposal against the criteria outlined in WG-FSA-2019/55 in Table 10 and the new proposed MPA research evaluation in Table 11. The Working Group recommended a catch limit of 45 tonnes for the 2019/20 season.

Special research zone

4.156 WG-FSA-2019/42 presented a proposal for a research program from 2019 to 2027 to investigate the life cycle, distribution and movement, biological parameters and stock structure of *Dissostichus* spp. in the eastern part of the Ross Sea over the shelf and continental slope in the SRZ.

4.157 During the course of the meeting, the proponents provided a revision (WG-FSA-2019/42 Rev. 1) to clarify the research plan was designed for 2019/20–2021/22 at the request of the Working Group. The revision also added details on the deployment of CTDs as part of the research plan, however, these were not considered in the Working Group's assessment of the research plan.

4.158 The Working Group noted that the proposal (WG-FSA-2019/42) had been updated to address most of the comments expressed during WG-SAM-2019 and recognised the significant progress made by the proponents compared to WG-SAM-2019/17 and WG-FSA-18/33 Rev. 1. Changes included: (i) a corrected catch limit, (ii) survey stratification, (iii) updated locations of stations and overlapping sampling effort by vessels that would allow effects such as vessel effect, gear effect (the integrated weight of autoline of each vessel differs), effective tagging survival and tag-detection rate to be accounted for, and (iv) a vessel that uses autoline with weights while the other two vessels use integrated weighted lines (IWLs) was removed of the research plan.

4.159 WG-SAM (WG-SAM-2019 report, paragraph 6.85) expressed concerns that were partially or not addressed in the proposal:

(i) Tagging performance of the proposed vessels

Two vessels were notified for this research plan. The *Palmer* has poor tagging detection and a tagging survival of zero, the *Volk Arktiki* has a good tagging detection rate but unknown tag survival as the vessel has only completed one season in the Ross Sea region. The Working Group noted that there was still uncertainty as to the cause of poor tagging performance of the *Palmer*. The Working Group therefore recommended that electronic monitoring should be undertaken on the *Palmer* to assess potential causes for its consistently low performance in tagging survival and detection. The Working Group noted that the survey could be conducted with only one vessel, excluding the one with poor historical tagging performance. The Working Group requested the Scientific Committee take this into account in its consideration of this research plan.

(ii) The use of geographic reference data for the SRZ from the CCAMLR geographic information system (GIS) to present station localisation in a consistent projection.

The Working Group reviewed the coordinates of the block boundaries of the research plan, depth strata polygons and the projection used for the map shown in the research plan. The Working Group recommended that the proposal includes reserve stations, should sea-ice prevent operating in some regular stations of the research plan. The Working Group noted that a number of stations were shallower than the 550–1 000 m depth strata specified in the research plan. Additionally, a number of stations were less than 5 n miles apart, while the research plan specified a minimum distance of 5 n miles between hauls.

The Working Group recommended that the sampling locations be updated to account for the points mentioned above.

(iii) The proponents should undertake a power analysis, as requested for every effort-limited research proposal, to determine the required number of survey stations given the research objectives (see WG-SAM-18/06).

A power analysis to estimate the optimal number of stations, requested by WG-SAM (WG-SAM-2019, paragraph 6.18), was conducted for the original four research blocks by the Working Group during the meeting, using the mean catch per set of 1.32 and the standard deviation of 0.41 (WG-FSA-2019/42 Rev. 1). Based on these values, the power analysis estimated the number of stations needed for estimating abundance using the code in WG-SAM-2019/06. The research plan was estimated to have an 80% probability to be able to detect a change of 30% in relative biomass in the core survey strata between two years based on a sample size of 14 sets per year, per vessel and per research block with $\alpha = 0.05$ (3 000 iterations were used). When considering two vessels sampling in four research blocks with overlapping in two research blocks, the overall number of stations calculated with this method was 84.

However, the Working Group noted that these estimates were based on data from 2010–2012, while data from the most recent two seasons were not included. It

further noted that in the 2010–2012 survey, trotline was used while autoline was proposed in the research plan, and that the differences in gear types could influence the results of the power analysis.

The Working Group recommended that Members further develop guidelines for power analysis for consideration by WG-SAM-2020.

4.160 The Working Group recommended that the research plan shall consist of two research blocks, with overlapping distributions of haul stations for the two vessels in each research block. The Working Group recommended that the two vessels participating in the survey should operate in such a way as to maximise the overlap in sampling stations actually fished within each research block. The Working Group also recommended priority be given to research block one, as it contained the greatest ice accessibility.

4.161 The Working Group did not have the time to allocate the number of stations calculated with the power analysis that would comply with the requirement of the research plan (i.e. 5 n miles apart, not shallower than 550 m, 84 stations, overlapping). It therefore recommended that the sampled stations shall be a selection of the stations in the proposal that were not shallower than 550 m. This selection represented 81 stations (Figure 8).

4.162 Dr Kasatkina noted that the SRZ provides a unique opportunity to conduct research directed towards a standardisation of toothfish resource research, combining data from the exploratory Olympic fishery and structured scientific research plans conducted under CM 24-01. Dr Kasatkina noted that proposals for a research survey include research considered a priority within the RMP for the RSRMPA.

4.163 The Working Group calculated the catch limit by multiplying the number of stations (81) by the mean CPUE plus the standard deviation of the seasons 2010–2012, which resulted in a maximum catch limit of 140 tonnes for the effort-limited survey. It also noted data from the most recent two seasons are now available and should be accounted for in future calculations.

4.164 The Working Group noted that objective 1 contained a stock assessment, and that toothfish within the SRZ are already assessed as part of the Ross Sea region stock assessment (WG-FSA-2019/08). The Working Group further noted that the development of time series of local trends in abundance and CPUE would be desirable for this area in order to compare them to trends outside the RSRMPA and within the RSRMPA general protection zone (GPZ).

4.165 The Working Group noted that insufficient details were provided in the proposal about the methods that were going to be used in the analysis of the research plan, and that it was unclear who was going to conduct the off-water analyses.

4.166 The Working Group recalled advice to other research plans that the proposed sampling rate of 10 fish per species, per line, was insufficient to collect enough data for the analysis planned.

4.167 The Working Group noted that Russia had not completed research programs from previous surveys in this region.

4.168 The Working Group emphasised the role of collaboration between Members, for example for calibration of otolith readings and otolith microchemistry. Dr Kasatkina indicated that she would be happy to engage in collaborative work.

4.169 The Working Group reviewed the research proposal against the criteria outlined in WG-FSA-2019/55 in Table 10 and the new proposed MPA research evaluation in Table 11.

4.170 Due to lack of consensus on catch advice for the Ross Sea region toothfish fishery (paragraph 3.39), the Working Group was unable to provide advice on a catch limit for the SRZ survey, which potentially represents a large proportion of the SRZ total catch limit.

D. mawsoni in Subarea 88.2

4.171 WG-FSA-2019/12 provided an update on the Amundsen Sea region toothfish fishery that has been operating since 2003. The biological characterisation of the fishery showed a truncation of the right-hand limb of the age distribution between 2004 and 2014. Few age data are currently available after 2014. The authors recommended that further ageing of toothfish in the Amundsen Sea region be made a priority to develop annual ALKs and age frequencies.

4.172 The Working Group recalled the discussion at WG-FSA-2017 relating to ageing toothfish in this region, specifically WG-FSA-2017 report, Table 1, which outlined priority otoliths for this region to be aged by specific Members.

4.173 Dr Ziegler and Dr Darby noted that ageing has been undertaken for this area by Australia and the UK. Both noted that their research teams had been delayed by the need to train new staff in ageing techniques in order to provide robust age estimates.

4.174 The Working Group once again requested the Members that have otoliths from this region (WG-FSA-2017 report, Table 1) to provide age data to assist in the development of a stock assessment in this region.

4.175 The Working Group highlighted that the fishery in Subarea 88.2 (SSRUs C–H) used to contain an integrated assessment of toothfish biomass and now only has sufficient tag-recapture data to perform a Chapman estimate in one research block (Table 7). The Working Group also noted the low overlap of effort between years within research blocks 882_1 to 882_4 and SSRU H that limited the number of tagged fish likely to be recaptured.

4.176 The Working Group again recommended, recalling WG-FSA-2018 (WG-FSA-2018 report, paragraph 4.174) that a requirement for research plans with milestones as part of the notification for conducting fishing in the area would encourage vessel coordination, and the submission of data for the assessment process and submission of advice to the Scientific Committee. The Working Group noted that currently CM 21-02, paragraph 6(iii) (notifications for participation in exploratory fisheries for *Dissostichus* spp.) included the data-limited exploratory fisheries and recommended the areas covered by SSRUs 882C–H be included here for future notifications.

4.177 The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules. The Working Group agreed on catch limits to be calculated for Subarea 88.2 using the trend analysis rules (WG-FSA-2017 report, paragraph 4.33) as shown in Table 7.

D. mawsoni in Subarea 88.3

4.178 WG-SAM-2019/02 presented a research plan for Subarea 88.3 in its final year with the aim to be fully reviewed at WG-FSA-2020. The main objective of this proposal is to determine the abundance and distribution of *D. mawsoni* in Subarea 88.3. Secondary objectives are to improve understanding of stock structure of toothfish in Area 88, to carry out calibration trials among the vessels, to collect data on the spatial and depth distributions of by-catch species, and to trial scientific electronic monitoring technologies.

4.179 The Working Group noted that sea-ice has been an issue in previous years. It further noted that the ice map that was used to design the survey has proven to not reflect the real ice conditions of the area, limiting vessel accessibility. Ice maps based on remote-sensing data may not give the full story when describing conditions on the water. The Working Group noted that no stations are in the immediate area of Pine Island Glacier (CCAMLR-38/20 and WG-SAM-2019 report, paragraph 6.95).

4.180 The Working Group also noted that all vessels are equipped with on-board electronic monitoring.

4.181 The Working Group reviewed the research proposal against the criteria outlined in WG-FSA-2019/55 in Table 10.

4.182 The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules. The Working Group agreed on catch limits to be calculated for Subarea 88.3 using the trend analysis rules (WG-FSA-2017 report, paragraph 4.33) as shown in Table 7.

Other fisheries research including crabs

4.183 WG-FSA-2019/38 presented results of preliminary analyses of oceanographic data collected by the four Ukrainian vessels operating in Subareas 48.1, 48.2, 88.1 and 88.2 during 2018/19. Temperature profile data from logging devices deployed on longlines were collected from 37 deployment locations.

4.184 The Working Group noted that information on bottom temperatures, particularly how they may change over the period of deployment, may provide useful information on environmental drivers of toothfish distribution and encouraged the authors to investigate toothfish catch rates and size distribution in relation to bottom temperature.

4.185 The Working Group welcomed the presentation of these results and noted that the data may be of interest to researchers studying the wider ecosystem and that they should be made available to WG-EMM. In particular, the data may be useful in regions such as the Antarctic Peninsula where the local oceanography is known to be complex.

4.186 The Working Group noted that the data would be made available to anyone interested upon request to the authors and that additional information on cetacean sightings from these fishing vessel activities was also available.

4.187 The Working Group noted that for some oceanographic applications there is a need for a high level of instrument precision and that calibration of instruments is important. It was noted that the loggers used in this study were either new or had been recalibrated before use by the manufacturers. It was noted that calibration of instruments on board fishing vessels is difficult but information on bottom temperatures would be useful for ecological studies.

4.188 WG-FSA-2019/39 summarised the zooplankton sampling activities carried out on Ukrainian fishing vessels in the Convention Area in 2018/19. Preserved zooplankton samples obtained from 53 vertical lift-net deployments to depths of 100 m have been sent to the University of British Columbia for identification and analysis.

4.189 The Working Group considered the results of the first season of research on crabs undertaken by the Russian vessel *Volk Arktiki* in Subareas 88.2 and 88.3 in March 2019 presented in WG-FSA-2019/41. The Working Group recalled that there had been considerable discussion of the results of this research at WG-SAM (WG-SAM-2019 report, paragraphs 6.101 to 6.106) and noted that the research had been severely constrained by ice conditions. The Working Group noted that the continental shelf region had been inaccessible in Subarea 88.2 and research effort was restricted to a region of offshore seamounts.

4.190 The Working Group thanked the authors for the report of the research and noted that 2 040 pots had been set during the research and catches of two species of lithodid crab were low, totalling 569 kg (1 696 individuals). Total weight of toothfish by-catch was 434 kg (17 individuals).

4.191 The research report presented length–weight relationships, length distributions, sex ratios and reproductive state, and samples were collected for histological, genetic, isotope and parasite studies. By-catch of *D. mawsoni*, *M. whitsoni* and *C. dewitti* was reported, for which length and weight were taken. Otoliths were sampled from 12 of the 17 by-caught toothfish, and two toothfish were tagged and released. The Working Group noted that analyses of size at sexual maturity are ongoing and requested that additional information on crab distribution with depth, CPUE and effects of soak time on catch rate be investigated and presented in the future.

4.192 The Working Group noted that approximately 45 pots were lost during operations as well as a further 30 damaged, and there was some concern about the potential to impact seabed communities in this area. Dr Kasatkina confirmed that the pots were fitted with biodegradable 'escape panels'. The Working Group also noted that deep-water cameras were not deployed on pots during the research, and that this was a specific requirement set out by the Scientific Committee (SC-CAMLR-XXXVII, paragraph 4.3iv) and the Commission (CCAMLR-XXXVII, paragraph 5.73) for this research to proceed. There is no additional information of the impacts of pot fishing on benthic habitats.

4.193 The Working Group noted that on-water research would not continue in 2019/20 but further research was planned for the future.

4.194 Dr Kasatkina noted that an analysis of all aspects of further research was carried out taking into account the results from the 2018/19 season and financial side. The pilot project was approved by CCAMLR only for one season 2018/19 without clarity about the further plans for these studies (SC-CAMLR-XXXVII, paragraph 4.3). Therefore, a balanced decision was made to not proceed with the pilot project in the next season (2019/20). However, Russia does not

exclude the possibility of continuing crab study in the future. The continuation of the research fishery for craboids in Subareas 88.2 and 88.3 may be conducted in the framework of the new fishery in accordance with CM 21-01.

4.195 The Working Group noted that ice conditions had severely limited the spatial extent of the proposed crab research and no data were available for the continental shelf region of Subarea 88.2 as planned.

4.196 The Working Group requested that the Scientific Committee consider whether future research should be conducted under CM 24-01 or considered as new fishery under CM 21-01 given the limited results and low spatial coverage of the research conducted to date.

Scheme of International Scientific Observation

5.1 WG-FSA-2019/15 presented information on developments in SISO, including the implementation of new observer manuals for finfish and krill fisheries and additional instructions and form alterations to accommodate a focused tagging program in Subarea 88.1 and SSRUs 882A–B, as endorsed by the Scientific Committee last year (SC-CAMLR-XXXVII, paragraph 6.36).

5.2 The Working Group thanked SISO observers and the Secretariat for their hard work during the 2018/19 season and noted the utility of the new observer manuals. The Working Group encouraged alignment between the observer manuals and data collection forms, and instructions and data fields presented as part of the proposed C2 form redevelopment (paragraph 2.22) to ensure consistency in data provided by both observers and vessels.

5.3 The Working Group noted that the development of the new observer manuals would require minor changes to the following conservation measures to ensure the correct manual is referenced:

(i) CM 22-06
(ii) CM 41-01
(iii) CM 51-04
(iv) CM 51-06
(v) Text of SISO.

5.4 The Working Group noted the contributions of SISO observers completing the vessel tagging survey (paragraphs 4.21 to 4.25) and from observers attending the COLTO–CCAMLR Workshop on vessel data reporting (paragraphs 2.20 and 2.21). The Working Group highlighted that this survey was helpful in understanding some of the issues observers may face that are not immediately obvious, such as obstacles present between the hauling bay and tagging station on some vessels, or that in most of the responses, observers manually transport toothfish (which can be of substantial weight) to the tagging station. The Working Group noted that this type of data could usefully inform future recommendations around work health and safety for observers.

5.5 The Working Group reinforced the desirability of SISO observers receiving training in tagging procedures as the majority of vessels in exploratory fisheries rely on observers for all tagging procedures (paragraphs 4.21 to 4.25).

5.6 The Working Group noted that the identification of observer names in papers presented to the Working Group may result in personal data confidentiality issues. The Working Group reflected that some observers may wish to be identified for recognition of working in CCAMLR fisheries and suggested that permission for identifying the observer could be specified in the bilateral arrangement between Designating and Receiving Members and communicated to the Secretariat when submitting the observer deployment notification.

Non-target catch and ecosystem impacts of fishing

6.1 WG-FSA-2019/19 noted that species identification is a major challenge in skate studies due to convergent morphology within and between genera. In order to address this question, the authors applied molecular tools to identify specimens of softnose skates (*Bathyraja* spp.) caught as by-catch from the longline fishery around South Georgia, similar to the methods already applied to resolve taxonomic uncertainty of *Amblyraja* (WG-FSA-18/73). Both mtDNA control region sequence analyses and the analysis with GenBank data highlighted that all *Bathyraja* specimens from South Georgia would be darkbelly skate (*B. meridionalis*), and noted that the genetic information of *B. meridionalis* and McCain's skate (*B. maccaini*) registered in GenBank may need some revision. Genetic diversity of these *B. meridionalis* was low and indicated a single population around South Georgia.

6.2 The authors noted that microsatellite markers are being developed to confirm species identity and conduct further population structure work. The authors also have contacted the owners of the original DNA sequences registered on GenBank to resolve this discrepancy among genetic studies for *Bathyraja*.

6.3 The Working Group noted that additional observer training about skate identification could improve species identification, rather than changing identification guides for skates.

6.4 As part of the objectives of the research plan for Division 58.4.3a detailed in WG-FSA-18/61, WG-FSA-2019/56 evaluated the by-catch composition, distribution and biological characteristics during completed fishing activities of this research plan between 2008 and 2018. Skates (mostly *A. taaf*) was by far the dominant by-catch species on longlines, followed by *Macrourus* spp. and blue antimora (*Antimora rostrata*). Bathymetry and location seemed to be a key factor determining by-catch of *A. taaf*, with higher CPUE in shallower waters above 1 000 m, with CPUE at times reaching 270 kg per 1 000 hooks (when skates released (cut-off) were included in the calculation). While 133 *A. taaf* have been tagged and released since 2009, none have been recaptured to date. The sex ratio between male and female skates was approximately similar, but there was a distinct bimodal distribution in total length for female *A. taaf*. The authors noted that *A. taaf* were caught more frequently and in higher numbers on lines set by a vessel using integrated weight autolines as opposed to trotlines, concluding that autoline may pose a greater risk to *A. taaf*.

6.5 The Working Group noted that the observed differences in size and quantity of skates could be attributed to vessel effects, gear effects, or geographical attributes such as depth. It noted that while a vessel effect was apparent in plots of catch and effort, further analyses to evaluate these factors would assist with understanding the extent to which skate by-catch is attributable to gear type. It also recalled that in other mixed-gear fisheries such as in Subarea 88.1, analyses indicated that vessel effects seem to be a more significant factor

explaining by-catch levels than gear type. It further noted that CPUE standardisation models were in development for Division 58.4.3a, but due to limited overlap between vessels and gears this may need to be conducted on a subset of the data presented in WG-FSA-2019/56.

6.6 The Working Group noted that information of post-release survivorship was important to understanding the likely impact of by-catch of skates. It recalled that a survival study had been conducted by the French-flagged autoline vessel *Saint André* (WG-FSA-14/05), and had concluded that post-release skate survival was high, however, as it related to different species of skate to those by-caught in Division 58.4.3a, it was uncertain how applicable these results were in this instance.

6.7 The Working Group noted that the length–weight relationships for by-caught skates appeared different for the two vessels that had operated in Division 58.4.3a. It encouraged further analysis of this data to determine if this was due to an error in measurement or identification.

6.8 The Working Group noted that under the current move-on rule of 1 tonne per line, the move-on rule for skates has only been triggered once despite concerns raised around the by-catch patterns observed and requested the Scientific Committee to review the methods of mitigating skate by-catch in Division 58.4.3a, including the move-on rule.

6.9 The Working Group noted that for the purposes of the focused skate tagging program to be conducted in 2019/20 and 2020/21 in the Ross Sea region, all live skates up to a maximum of 15 per line should be tagged following the protocols in CM 41-01, Annex 41-01/C. As part of the maximum of 15 tagged skates per line, vessels may tag skates alive but with a low probability of survival if the condition of the skate is recorded along with the tag number during 2019/20 and 2020/21 in the Ross Sea region.

6.10 The Working Group clarified that for the purpose of the focused skate tagging program to be conducted in 2019/20 and 2020/21 in the Ross Sea region, the selection of skates for tagging would not be restricted to those in good condition and that for each skate tagged the species, disc width and injury category should be recorded along with tag numbers (WG-FSA-2018 report, paragraph 6.36).

Incidental mortality of seabirds and marine mammals

6.11 The Secretariat provided an update on incidental mortality of seabirds and marine mammals in CCAMLR fisheries during 2018/19 (WG-FSA-2019/16). The paper summarised incidental mortality associated with fishing activities collected in scientific observer and vessel data during 2018/19 as received by the Secretariat up to 8 October 2019, and included a short report, as requested by the Scientific Committee (SC-CAMLR-XXXVII, paragraph 5.22), providing details on multiple Antarctic fur seal (*Arctocephalus gazella*) mortalities that occurred during the 2017/18 season.

6.12 There were two seal mortalities reported in 2018/19 CCAMLR longline fisheries. The Working Group noted that the extrapolated total of 103 seabirds killed in the 2018/19 season was the third-lowest mortality figure on record.

6.13 In CCAMLR trawl fisheries, the Working Group noted that there had been three seabirds and three seals killed through interactions with fishing gear. The Working Group thanked the Secretariat for the report on the 19 Antarctic fur seal mortalities in the krill fishery in 2017/18. The report stated that an ineffectively attached marine mammal exclusion device (MMED) may have contributed to the issue.

6.14 Noting that MMEDs have been highly effective in reducing marine mammal mortalities, the Working Group encouraged trawl vessels to inspect their MMED in the event of any marine mammal mortality to ensure that it is in structurally good order and correctly attached.

6.15 WG-FSA-2019/60 presented results collected from surface and underwater video observations during the 2018/19 season designed to monitor the behaviour of *A. gazella* interacting with krill trawling operations in Subarea 48.3. No seals were observed inside the trawl net from the underwater video operations. The paper noted that when krill swarms were distributed deeper, this usually resulted in more aggressive behaviour as seals chased a krill-filled trawl. The Working Group noted that this study is still in progress, that analyses presented here are preliminary, and that additional detail will available on completion of the work.

6.16 The Working Group appreciated the initiation of this work and encouraged similar research to increase understanding of marine mammal interactions with trawl gear and how such interactions could be managed. However, the Working Group also noted that currently the deployment of underwater cameras is difficult and that these operations impact the fishing process negatively.

6.17 The Working Group recalled advice to the Scientific Committee that there are currently no by-catch limits for marine mammals specified for the krill fishery (WG-FSA-2018 report, paragraph 6.57).

6.18 WG-FSA-2019/31 presented a final report on fishing effort and seabird interactions during three season extension trials (1–14 April, 1–14 November and 15–30 November) in the longline fishery for *D. eleginoides* in Division 58.5.2. Due to the application of effective seabird by-catch mitigation by participating fishing vessels, the overall risk of seabird mortality in this fishery was low with 20 mortalities in total reported between 2003 and 2018. The rate of seabird mortality in the core fishing season and the existing post-season extension from 15 September to 31 October was less than 0.0001 birds per 1 000 hooks (or less than 0.1 birds per million hooks). The rates of seabird mortality for the pre-season and two post-season extension trials were comparable to that during the existing pre-season extension from 15 to 30 April.

6.19 The Working Group noted that in the last three years all seabird mortalities occurred during the season extensions while seabird mortalities had occurred prior to that during the core season. It was unclear whether there was a temporal trend or pattern in seabird mortalities during the core season due to the rare nature of these mortality events.

6.20 The Working Group noted the conclusion of the three season extension trials, with seabird mortality risk in the trial periods being highly uncertain but similar to one of the existing season extension periods. Therefore, the Working Group recommended that the specifications of the longline fishing season in CM 41-08 (CM 41-08, paragraph 3) remain unchanged.

6.21 The paper also recommended the requirement for any vessel to demonstrate full compliance with CM 25-02 in the previous season be removed from CM 41-08 (CM 41-08,

paragraph 3) since there is already effective seabird by-catch mitigation by fishing vessels in this fishery both in the specification and application of seabird mortality mitigation measures. The Working Group requested that the Scientific Committee review this requirement.

6.22 WG-FSA-2019/34 presented a study investigating the effects of climate change, fisheries interactions and terrestrial invasive species on the demography of four albatross species (black-browed *Thalassarche melanophris*, grey-headed *T. chrysostoma*, light-mantled *Phoebetria palpebrata* and wandering *Diomedea exulans*) using a 20-year monitoring dataset (1995–2014) at Macquarie Island.

6.23 The paper reported that positive Southern Annular Mode indices and La Niña events correlate with increased albatross survival. Increased survival in black-browed albatross was also linked to reduced fishing effort, concurrent gear changes, and improved mitigation methods in the southwest Atlantic and Chilean fisheries. A positive effect was detected on the survival of black-browed albatrosses from the squid trawl fishery of New Zealand, suggesting a possible influence of food provisioning from discards on this population as well. There were no discernible trends associated with the success and survivorship of albatrosses breeding on Macquarie Island from CCAMLR fisheries. The paper also indicated that terrestrial habitat degradation due to rabbit grazing had a negative impact both on the survival and the probability of breeding success on albatross populations for the study species. The authors observe, however, that there were limited options to mitigate climate effects on seabird survival and breeding success.

6.24 The Working Group welcomed this integrated approach as an example for formulating management responses to various influences and effects to enhance breeding success of seabirds.

Invertebrate by-catch and vulnerable marine ecosystems (VMEs)

6.25 The Working Group recalled that a dedicated VME Workshop was held in 2009 (WS-VME-09) (SC-CAMLR-XXVIII/10) and that conclusions of this Workshop were set out in SC-CAMLR-XXIX, paragraph 9.37, and reflected in CMs 22-06 and 22-07, as well as in the SISO observer manual. The Working Group also recalled that SC-CAMLR-XXXVII, and the WG-EMM-2019 report, paragraphs 6.39 and 6.40, recommended further work on VMEs and VME indicator taxa. The Working Group also noted that CM 22-06, paragraph 15, stated that the Scientific Committee would review that conservation measure every two years and that CM 22-07, paragraph 9, indicated that the conservation measure should be reviewed in 2012. Considering the varying degrees of progress on these items, the Working Group recognised that the development of a work plan to review bottom fishing impacts on VMEs in the Convention Area was overdue.

6.26 The Working Group noted that since WS-VME-09, new technologies and methods have emerged and are becoming more accessible. These technologies, such as benthic cameras and electronic monitoring have the potential to rapidly progress questions around VMEs relevant to CCAMLR (paragraphs 6.34 to 6.38).

6.27 The Working Group noted that there is a need to review VME data collected to date within the Convention Area and provide a synthesis of results. Such an assessment would serve as a starting point in the development of a VME workplan. The Working Group identified a

range of topics that should be considered as part of a review on CCAMLR VME protocols and bottom fishing impacts and these are set out in Table 12 and recommended that the table were considered as a basis for a VME work plan for the Scientific Committee.

6.28 The Working Group requested the Scientific Committee to identify the best mechanism to go forward with a review and workplan (e-group, virtual meetings, workshop or any other means), noting that the diverse range of expertise needed (including benthic taxonomists, fisheries experts, ecologists and modellers) may not be present at a typical meeting of the Working Group.

6.29 The Working Group noted that CCAMLR had been at the forefront of developing VME encounter protocols and that many regional fisheries management organisations (RFMOs) had now also developed procedures for reporting on VME encounters, and that a review of methods conducted outside CCAMLR could provide useful information to a review of the CCAMLR process.

6.30 The Working Group noted that summary information is provided via the CCAMLR website but requested that the Secretariat routinely provide more detailed information in spatial and temporal trends in VME triggers to WG-FSA. Noting the issues regarding the collection of by-catch information highlighted by the Scientific Committee in 2018 (SC-CAMLR-XXXVII, paragraph 5.17), the Working Group requested that the Secretariat undertake an analysis of VME data collection practice on board vessels across the Convention Area, comparing encounter rates between vessels and regions in a manner inspired by the assessment of by-catch reporting (WG-SAM-15/23 and WG-FSA-18/67).

6.31 The Working Group recommended that CCAMLR VME taxa identification materials be reviewed and evaluated, including an assessment of whether the current VME taxa list is comprehensive and appropriate. The Working Group noted that the CCAMLR VME indicator taxa guide would need to be revised in light of the work carried out as part of the CCAMLR taxon data project (WG-FSA-2019/14).

Determining fishing footprint

6.32 An updated method for calculating the CCAMLR fishing footprint was presented (WG-FSA-2019/67). The method used a data-derived estimate of the uncertainty around the locations of longlines to define a buffer around these lines. Within a georeferenced framework, buffered lines are then matched to a 10 km grid. The proportion of the area of each grid cell that is covered by buffered lines is then used as a footprint index. Accuracy of line position on the seabed was an issue that may affect the footprint estimates.

6.33 The Working Group recommended that the new method for assessing fishing footprint presented in WG-FSA-2019/67 be reviewed and compared with existing methods such as presented in WG-SAM-10/20 and WG-FSA-18/43 and be presented at WG-SAM-2020.

Determining fishing impact on seabed and use of electronic monitoring

6.34 The Working Group noted that a comparison between electronic monitoring results and benthic camera observation could provide a good assessment of the accuracy of VME reporting by vessels and provide an estimate of organisms lost during hauling.

6.35 The Working Group noted that electronic monitoring (e.g. WG-FSA-2019/13; CCAMLR-38/BG/40) should be encouraged and could be used for assessing VME taxa. The Working Group encouraged Members to provide analyses of data on the detection of VME indicator species during hauling comparing observer-derived observations with electronic monitoring.

6.36 The Working Group noted that gear interactions with the seabed have been addressed in the past (e.g. WG-SAM-10/20), however, new methods have been developed and new technology is now available that can be used to assess impacts of gears more directly. WG-FSA-2019/24 reported on benthic cameras and movement sensors deployed on longlines (autolines). Results showed that horizontal line movement was very limited (10's of centimetres rather than 10's of metres) and occurred mostly during hauling. Habitats observed in footage were mostly unconsolidated or gravel substratum with low levels of density of epibenthic organisms. Benthic organisms that were observed were mostly restricted to dropstones and rarely encountered. The data collected on line movement will be used to model the behaviour of autolines on the seabed.

6.37 The Working Group noted that VME taxa observed at the surface may only be a portion of those impacted. Benthic cameras are becoming cheaper and widely available and can be used to provide direct observations of gear interactions with the seabed (e.g. WG-SAM-2019/03). Systematic camera deployments on lines would help to develop a greater understanding of benthic habitats, VME indicator taxa distribution and could be used to inform on the development of VME management strategies in the future.

6.38 A further advantage of in situ benthic cameras would be data collected to help understand differences in VME reporting from vessels using autolines and vessels using Spanish lines or trotlines and whether these differences are linked to gear type. The Working Group encouraged Members to use benthic cameras more widely.

Thresholds, risk areas and move-on rules

6.39 An example of taxon-specific thresholds to trigger risk areas was presented at WG-EMM (WG-EMM-2019/52) and an R code provided in WG-FSA-2019/46. These papers use sea pen data collected in research block 5844b_2 and show that despite the high number of individual organisms collected, no threshold was reached. The issues that were identified were a result of the low weight and small volume of sea pens. The probability of reaching a 5-VME-unit threshold was shown to be null whereas the probability of reaching a 2.5-VME-unit threshold would be much higher and more appropriate for the sea pen assemblage. The Working Group noted that light or heavy weight organisms have different probabilities to trigger thresholds and this should be more systematically investigated. The R code provided in WG-FSA-2019/46 may provide a starting point to evaluate differential thresholds as a function of mass.

6.40 The Working Group recommended, as suggested in WG-FSA-18/51, that since multiple taxa may be encountered, the use of measures of diversity (taxonomic or functional) of taxa should be further investigated as part of the trigger threshold in CM 22-07.

6.41 The Working Group noted that additional camera deployments following VME encounters could provide more comprehensive information on the composition, distribution and extent of VMEs and to better characterise risk areas. The Working Group noted that VME encounter protocols could be revised in order to obtain this additional information on VME distribution and that a suitable sampling strategy would need to be developed as part of this.

6.42 The Working Group recommended that analysis methods for incorporating new (electronic monitoring and camera) data streams and external data streams (e.g. from research voyages), including distribution modelling, should be considered. The Working Group noted that accurate VME taxa reporting is necessary to provide presence data for single or multi-species modelling. Benthic cameras could be used to provide an extensive set of environmental and taxonomic data (substratum type, organisms 3D structure and coverage, diversity). The Working Group recalled that modelling techniques for data-deficient areas should be investigated to produce suitable habitat maps that have been identified as useful to put by-catch observation in a broader context (WG-EMM-2019 report, paragraph 6.38).

Marine debris

6.43 The Secretariat presented WG-FSA-2019/18 on gear loss as reported by longline vessels for the 2017/18 and 2018/19 fishing seasons, including differences in the rate of loss by gear type. There was no difference in the relative rates of reporting of lost hooks by gear type, however, there was a significant difference found in the frequency of complete line loss, with trotline gear having higher rates of complete line loss than Spanish or autoline gear.

6.44 The Working Group noted the importance of accurate reporting of gear loss by vessels to understand environmental impacts, particularly given that longline gear often contains polymer materials that degrade slowly, and that gear loss is cumulative over time. The Working Group recommended that a 'length of line lost' data field be included in the C2 data form and that instructions on completing fields on gear loss be clarified in a fishery data manual.

6.45 The Working Group further considered the need to identify and understand causes of gear loss, noting that there are numerous circumstances that may lead to gear loss events. The Working Group recommended that a description of the circumstances that led to a line being lost should be provided along with the C2 data when they are submitted to the Secretariat in order to evaluate the information requirements for a text field to be included in the future C2 form to enable routine reporting of causes of gear loss to be specified.

6.46 Further research and monitoring of gear loss causes and trends were encouraged in order to progress understanding and subsequent advice to support reduction and mitigation of ALDFG, noting that increased application of environmental monitoring may assist in accurate reporting of gear loss.

6.47 The Working Group recommended that the Secretariat continue to report on gear loss in the Convention Area annually and suggested that future updates consider temporal trends throughout the season as well as relation of gear loss to capacity.

6.48 The Working Group considered WG-FSA-2019/04 that detailed the use of pop-up buoys for short-term deployment of scientific instruments on the sea floor and recommended that the Working Group consider the use of techniques such as the acoustic pop-up buoy recovery systems in longline fisheries to reduce potential gear loss, particularly in areas with high sea-ice cover.

6.49 The Working Group agreed that this was an important topic to consider and communicate back to the fishing industry, noting that trial and implementation of available technology would be important to assess impacts on frequency of gear loss. It was also noted that use of this type of gear would need to be in accordance with appropriate gear marking requirements as detailed in CM 10-01.

6.50 The Working Group considered SC-CAMLR-38/09 which reviewed the CCAMLR Marine Debris Program, current methodology and data submission procedures, and emerging issues and current knowledge of marine debris levels in the Southern Ocean. The paper highlighted the difficulty in quantifying and monitoring marine debris levels, trends and associated impacts across the Convention Area due to the spatial scale at which data is currently collected and considered ways in which the program could be modernised.

6.51 The Working Group agreed that the review was timely and that further work would be required to identify how to best use current marine debris data holdings, as well as identifying potential sources for currently collected marine debris data, noting that monitoring of microplastics should be incorporated into the program.

6.52 The Working Group supported the recommendation in SC-CAMLR-38/09 that the Scientific Committee establish an Intersessional Correspondence Group on Marine Debris (ICG-MD) to review and develop the CCAMLR Marine Debris Program, which could include defining its objectives, developing program materials and methodology and developing an analytical approach that would allow for quantification of marine debris levels across the Convention Area.

Future work

By-catch and ecosystem considerations

7.1 The Working Group recalled that it had previously been tasked with several wider ecosystem considerations of fishery impacts, including by-catch limits in the krill fishery, regional risk assessments for non-target species, VME protection and management, and incidental mortalities of seabirds and marine mammals, as well as consistent by-catch reporting and reporting requirements by vessels on shark by-catch.

7.2 Recalling discussion at WG-FSA (WG-FSA-2018 report, paragraphs 6.11 to 6.14), the Working Group noted that alternative methods for setting fish by-catch limits might need to be developed further and evaluated. In 2018, the Working Group recommended that the Scientific Committee consider the development of a by-catch work plan that could include the development of standardised reporting metrics and risk assessment methods. The Working Group recommended that a focus topic on the assessment of status of fish by-catch could be scheduled for WG-FSA-2020 to advance this work further.

Cooperation with other organisations

7.3 The Working Group noted that the 10th International Fisheries and Monitoring Conference was planned to be held in Hobart, Australia, from 1 to 5 March 2021 and that this conference would provide opportunities for Members to engage in operational and data collection issues in scientific observer programs outside of CCAMLR.

7.4 The Working Group noted the Scientific Committee on Antarctic Research (SCAR) Open Science Conference to be held in Hobart, Australia, from 31 July to 11 August 2020 and in particular its session on the role of fish in the Antarctic ecosystem. The Working Group agreed on the importance of the cooperation between CCAMLR, SCAR and other organisations or individuals to ensure the use of the latest science advancements in CCAMLR's management approaches.

Spatial planning in Domains 4, 5 and 6

7.5 The Working Group noted the intersessional Expert Workshop on Pelagic Spatial Planning for the eastern sub-Antarctic region (Domains 4, 5, and 6) held in Cape Town, South Africa, from 26 to 30 August 2019 (SC-CAMLR-38/29), noting, in particular, the related results of the genetic work and stock connectivity for *D. mawsoni* presented to the Working Group (WG-FSA-2019/P01).

Notifications of other scientific research

7.6 WG-FSA-2019/58 indicated the intent to continue the quadrennial POKER Survey (multi-species survey focusing on shallow areas), which is scheduled for 2021 and aims to track juvenile abundances of *D. eleginoides* in Division 58.5.1.

7.7 WG-FSA-2019/32 indicated the intent to continue a comprehensive monitoring program which includes an annual random stratified trawl survey to consolidate and estimate recent trends in YCS in *D. eleginoides* in Division 58.5.2.

7.8 The Working Group noted the start of a PhD thesis that focused on skates in French EEZs and the request of the proponents for feedback and collaboration on the subject. It further noted that presentation of this work would be useful to include at WG-FSA-2020 if a focus topic on by-catch was agreed as a priority.

7.9 The Working Group noted Australian projects led by the Institute for Marine and Antarctic Studies, including a project aiming to map the distribution of benthic fauna and assemblages on the Antarctic continental shelf and a project which will focus on the impacts of recent environmental variability on *D. eleginoides* catch at Heard Island and McDonald Islands, and looked forward to results from this work being presented at future Working Group meetings.

7.10 The Working Group noted the large number of potential areas for other future work throughout its report and encouraged Members to contribute work to address these.

Other business

Circular from Russia

8.1 The Working Group discussed a letter from Russia regarding the current meeting of WG-FSA that was issued on 14 October 2019 as COMM CIRC 19/104–SC CIRC 19/94.

8.2 The Working Group agreed that this was an unprecedented situation with a Commission circular from a Member providing direction on the content of the report of the Working Group prior to the conclusion of the scientific discussions and the preparation of the draft report. The Working Group expressed its concern that an unprecedented intervention such as this was not consistent with the normal conduct of scientific discussions in the Working Group.

8.3 The Convener reiterated his comments made at the opening of the meeting that, where consensus could not be reached, alternative scientific hypotheses would be reflected in the report following the normal practice of the Working Group and consistent with the Rules of Procedure of the Scientific Committee.

8.4 The Working Group expressed its strong support for the Convener in his conduct of this and previous meetings of the Working Group and his approach to achieving consensus on science-based management advice.

8.5 The Working Group requested that the Scientific Committee and the Commission consider the content of COMM CIRC 19/104–SC-CIRC 19/94 and provide guidance on the provision of science-based advice from the Working Group.

Electronic monitoring on fishing vessels

8.6 WG-FSA-2019/13 presented examples demonstrating the use of electronic monitoring in the Ross Sea longline toothfish fishery and indicated that such an approach would support research by automating tasks that do not require human effort (e.g. by recording the deployment and operation of a tori line during line setting and other line observations) hence enabling observers to allocate more effort to other – arguably more important – tasks.

8.7 Dr S.-G. Choi (Korea) informed the Working Group that the Korean vessel *Greenstar* is going to use similar electronic monitoring equipment as described in WG-FSA-2019/13 during its research fishing in Subarea 88.3 in 2019/20 and that the data collected during this period would be analysed as part of the multi-Member collaboration in that research fishing.

8.8 CCAMLR-38/BG/40 presented an introduction to electronic monitoring on longline fishing vessels that included information from, inter alia, video cameras, warp sensors and global positioning systems (GPS) and outlined the potential application of this monitoring to assist data collection on vessels. The electronic monitoring system described in CCAMLR-38/BG/40 is installed and secured by a third-party provider and provides an independent means for evaluation of compliance-related events.

8.9 The Working Group welcomed the development of electronic monitoring and agreed that these approaches would help improve the accuracy of data collection in the Convention Area (Table 2). The Working Group noted that electronic monitoring data should not be viewed as a replacement for SISO observers but provides improved efficiency of vessel operations, including improved approaches to the provision of catch reporting data required by CCAMLR. Information to improve understanding of vessel operations and practices that allow more comprehensive analyses enhanced interpretation of conventional data collection.

8.10 The Working Group recommended that the Scientific Committee consider the requirement for electronic monitoring on fishing vessels undertaking research under CM 24-01, paragraph 3.

Trophic biomarkers

8.11 WG-FSA-2019/26 presented a combined fatty acids and stable isotopes approach to investigate the feeding ecology of marbled rockcod (*N. rossii*) and black rockcod (*N. coriiceps*) in the western Antarctic Peninsula. The trophic biomarkers used in the study did not elucidate which was the main prey item as lipid source for *N. rossii* and *N. coriiceps*, suggesting the need for further investigations.

8.12 The Working Group welcomed this study and encouraged the authors to analyse different trophic biomarkers to improve our understanding of the feeding ecology of these species and also to extend the spatial and temporal scale of the study as this is likely to further elucidate differences between species compared to sampling in a single location in one year.

Cetacean interactions with fishing vessels

8.13 WG-FSA-2019/50 presented an easy-to-implement approach to photographing cetaceans using a relatively inexpensive camera system to increase the information available for whale photo identification from fishing vessels and to encourage more Members to engage in the collection of photographic data.

8.14 The Working Group welcomed the detailed technical description provided in WG-FSA-2019/50 and encouraged the collection of photographs of cetaceans on all vessels operating in the CCAMLR area noting the great potential for this data in quantifying and monitoring the effects of depredation on fish stocks as well as understanding cetacean interactions with krill vessels (WG-EMM-2019 report, paragraphs 4.49 and 4.50).

Information from the SIOFA area

8.15 WG-FSA-2019/45 presented an analysis of *D. eleginoides* data collected from observers on board vessels which operated between 2017 and May 2019 in waters managed by the Southern Indian Ocean Fisheries Agreement (SIOFA) (within FAO Subareas 51.7 and 57.4), adjacent to the Convention Area. The analysis included fish weight, length, sex and tagging data from these areas.

8.16 The Working Group noted that this analysis confirmed existing stock hypotheses for this region in respect of the connectivity between toothfish population in the SIOFA area with those around Crozet, Kerguelen and Heard Islands. The Working Group also noted the occurrence of very long soak times, in some case over 100 hours, and the potential importance of these in the analysis of any trends in CPUE that might indicate local depletion.

8.17 The Working Group also noted that the Spanish vessels fishing for toothfish in the SIOFA area collected observer data according to the SISO protocol. The Working Group suggested that CCAMLR Members that undertook fishing on toothfish populations that are included in existing assessments considered by CCAMLR voluntarily provide relevant catch and observer data to CCAMLR until a data-sharing scheme between CCAMLR and SIOFA is agreed.

8.18 WG-FSA-2019/54 presented an analysis of photo-identification data of killer whales and sperm whales in the southern Indian Ocean using French observer data from the Crozet Islands and Spanish observer data on del Cano Rise in the SIOFA area. Of the 37 individual killer whales identified from the del Cano Rise fishery, 26 of these have also been observed interacting with longline vessels in the Crozet and/or Kerguelen Islands. Based on the available data from the period 2009–2019, depredation rates on longlines targeting *D. eleginoides* in the del Cano Rise in the SIOFA area were estimated to be 7.5%.

8.19 The Working Group welcomed the collection of cetacean interaction data in the SIOFA area that enhances the understanding of the ecology of cetacean species, the connectivity of populations and, more importantly, the impacts and patterns of interactions with fisheries. The Working Group asked the Commission to bring this document and the importance of these depredation rates in estimates of removals and management of toothfish to the attention of SIOFA.

Bathymetry data

8.20 The Working Group noted that a 2019 update of bathymetry data had been released by GEBCO and requested that this data be incorporated into the CCAMLR GIS and made available for downloading by Members. The Working Group also requested that the Secretariat provide an analysis of any changes in the estimates of fishable areas used in the estimates of local biomass in exploratory fisheries.

Survey update

8.21 Dr J. Devine (New Zealand) provided an update on the Ross Sea winter survey that was taking place at the time of the meeting, the Working Group looked forward to receiving the results from the survey in due course. Dr Devine also provided an update on the benthic camera to be deployed on New Zealand fishing vessels in the coming season.

Advice to Scientific Committee

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

(i) Reconciliation of CDS and monthly fine-scale catch and effort data –

(a) all data collected on the *Calipso*, *Koreiz* and *Simeiz* from 2015 to 2018 be quarantined by the Secretariat (paragraph 2.15).

(ii) Catch and effort data and biological observations from CCAMLR fisheries –

(a) development of the proposed new C2 form and fishery data manual (paragraph 2.22)

(b) removal of the requirement to complete the B2 form where currently specified in the conservation measures (paragraph 2.22)

(c) for vessels to report aggregated VME data (paragraph 2.22).

(iii) Fishery monitoring and closure procedures –

(a) include the complete two-stage process for the forecasting and closure process for exploratory toothfish fisheries as an annex to the Scientific Committee report (paragraph 2.25).

(iv) Catch limits for *C. gunnari* in Subarea 48.3 and Division 58.5.2 (paragraphs 3.5 and 3.9).

(v) CCAMLR decision rules –

(a) investigating potential refinements of the CCAMLR decision rules (paragraph 3.21)

(b) provision of advice on precautionary catch limits for all the assessed stocks and research proposals on the basis of the best available science (paragraph 3.40).

(vi) Management advice for *Dissostichus* spp. –

(a) lack of agreement that the CCAMLR management of all of its fish stocks is precautionary (paragraph 3.39)

(b) advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules (paragraph 3.39).

(vii) *D. eleginoides* in Division 58.5.1 and 58.6 –

(a) prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2019/20 (paragraphs 3.84 and 3.99).

(viii) *D. eleginoides* in Division 58.5.2 –

(a) advice on alternative harvest strategies for stocks where recent patterns of weak year classes were apparent in the fishery (paragraph 3.91)

(b) prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2019/20 (paragraph 3.93).

(ix) Conversion factors –

(a) conversion factor workshop, or focus topic, would be of great benefit to the work of WG-FSA (paragraph 4.7).

(x) Vessel tagging survey –

(a) benefit of a workshop on tagging protocols and procedures be included in future work plans (paragraph 4.24).

(xi) Fishery status and the regulatory framework –

(a) clarification of the status of toothfish fisheries in Subarea 88.1 and SSRUs 882A–B, Division 58.4.4 and Division 58.4.3b (paragraph 4.32)

(b) benefit of a clear strategy from the Commission as to how the regulatory framework can be interpreted to assist the development of scientific advice for toothfish fisheries (paragraph 4.33).

(xii) Subarea 48.1 –

(a) catch limit for effort-limited survey in Subarea 48.1 (paragraph 4.40).

(xiii) Special research zone –

(a) request to take poor historical tagging performance into account in its consideration of research plan (paragraph 4.159).

(xiv) Subarea 88.2 –

(a) notifications for fishing in SSRUs 882C–H be included in CM 21-02, paragraph 6(iii) (notifications for participation in exploratory fisheries for *Dissostichus* spp.) for data-limited exploratory fisheries (paragraph 4.176).

(xv) Crab fishing –

(a) future research should be conducted under CM 24-01 or considered as new fishery under CM 21-01 (paragraph 4.196).

(xvi) Incidental mortality of seabirds and marine mammals –

(a) requirement for any vessel to demonstrate full compliance with CM 25-02 in the previous season be removed from CM 41-08, paragraph 3 (paragraph 6.21).

(xvii) Invertebrate by-catch and VMEs –

(a) development of a VME work plan (paragraphs 6.27 and 6.28).

(xviii) Marine debris –

(a) description of the circumstances that led to a line being lost provided along with C2 data (paragraph 6.45)

(b) support for the establishment an Intersessional Correspondence Group on Marine Debris (paragraph 6.52).

(xix) Future work –

(a) assessment of status of fish by-catch and methods for setting fish by-catch limits (paragraphs 6.8 and 7.2).

(xx) Provision of science-based advice –

(a) request for guidance on the provision of science-based advice from the Working Group given the content of COMM CIRC 19/104–SC CIRC 19/94 (paragraph 8.5).

(xxi) Information from the SIOFA area –

(a) depredation rates in estimates of removals and management of toothfish brought to the attention of SIOFA (paragraph 8.19).

Adoption of the report and close of the meeting

10.1 The report of the meeting was adopted.

10.2 At the close of the meeting, Dr Welsford thanked all participants for their patience and dedicated work that had allowed the Working Group to make significant progress in addressing the priorities of the Scientific Committee. Dr Welsford also highlighted the positivity and collaboration between many Members, and thanked the rapporteurs and the Secretariat for their efficiency and support throughout the meeting.

10.3 On behalf of the Working Group, Mr Maschette and Mr Somhlaba thanked Dr Welsford for his even-handedness and good humour when guiding the Working Group through a large, and at times challenging, work program and thanked him for the leadership he had provided over four years of serving as WG-FSA Convener.

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Table 1: Gear details for vessels that have notified to fish in exploratory toothfish fisheries in 2019/20 (source www.ccamlr.org/compliance/licensed-vessels).

Vessel	Flag	Statistical Area(s)	Gear type	Integrated weight line	Integrated weighting	Longline weights	Minimum mass longline weights	Maximum spacing between weights	Number of hooks per cluster	Spacing between hook clusters	Spacing between droplines	Number of clusters per dropline	Hook spacing	Snood length
Altamar	Uruguay	88.1, 88.2	Autoline	Y	50								1.4	0.48
Antarctic Discovery	Australia	58.4.1, 88.1, 88.2	Autoline	Y	50								1.4	0.45
Antarctic Chieftain	Australia	58.4.1, 58.4.2	Autoline	Y	50								1.4	0.45
Argos Froyanes	United Kingdom	88.1, 88.2	Autoline	Y	50								1.6	0.4
Argos Georgia	United Kingdom	88.1, 88.2	Autoline	Y	50								1.4	0.4
Calipso	Ukraine	88.1, 88.2	Spanish			Y	9	70					1.5	0.7
Calipso	Ukraine	88.1, 88.2	Trotline			Y	8	28	5	0.5	28	2		
Cap Kersaint	France	58.4.1	Autoline	Y	50	Y		9.6					1.2	0.35
Globalpesca I	Chile	88.1, 88.2	Trotline			Y	6	17	7	5	20	1		
Greenstar	Korea, Republic of	88.2	Trotline			Y	5	35	5	0.5	35	5		
Hong Jin No. 707	Korea, Republic of	58.4.1, 88.1, 88.2	Trotline			Y	5	32	5	0.5	32	3		
Janas	New Zealand	88.1, 88.2	Autoline	Y	50		5						1.4	0.4
Janas	New Zealand	88.1, 88.2	Autoline	Y	50		5						1.4	0.59
Kingstar	Korea, Republic of	58.4.1, 88.1	Trotline			Y	5	35	5	0.5	35	5		
Koreiz	Ukraine	88.1, 88.2	Spanish			Y	9	70					1.5	0.7
Koryo Maru No. 11	Japan	58.4.1, 58.4.2, 88.1, 88.2, 48.6	Spanish			Y	10.62	40					1.5	1

(continued)

Table 1 (continued)

Vessel	Flag	Statistical Area(s)	Gear type	Integrated weight line	Integrated weighting	Longline weights	Minimum mass longline weights	Maximum spacing between weights	Number of hooks per cluster	Spacing between hook clusters	Spacing between droplines	Number of clusters per dropline	Hook spacing	Snood length
Koryo Maru No. 11	Japan	58.4.1, 58.4.2, 88.1, 88.2, 48.6	Trotline			Y	10.62	50	5	0.5	80	9		
Kostar	Korea, Republic of	88.1, 88.2	Trotline			Y	5	23	5	0.5	23	4		
Marigolds	Ukraine	88.1, 88.2	Trotline			Y	8	15	5	0	20	1		
Marigolds	Ukraine	88.1, 88.2	Trotline			Y	8	25	5	0.5	25	3		
Nordic Prince	United Kingdom	88.1, 88.2	Autoline	Y	50								1.4	0.4
Palmer	Russian Federation	58.4.1, 88.1, 88.2	Autoline	Y	50								1.4	0.4
Polus I	Ukraine	88.1, 88.2	Spanish			Y	9	70					1.5	0.7
Polus I	Ukraine	88.1, 88.2	Trotline			Y	8	20	8	0	20	1		
Polus I	Ukraine	88.1, 88.2	Trotline			Y	8	25	4	0.5	25	3		
Polus I	Ukraine	88.1, 88.2	Trotline			Y	8	30	4	0.5	30	2		
Saint André	France	58.4.1, 58.4.2	Autoline		50		5	20					1.4	0.47
San Aotea II	New Zealand	88.1, 88.2	Autoline	Y	50	Y	5	1.4					2.2	1.4
San Aotea II	New Zealand	88.1, 88.2	Autoline	Y	50	Y	5	1.4					1.4	0.5
Shinsei Maru No. 3	Japan	58.4.1, 58.4.2, 88.1, 88.2, 48.6	Trotline			Y	10	45	5	0.5	45	5		
Simeiz	Ukraine	88.1, 88.2	Spanish			Y	9	70					1.5	0.7
Simeiz	Ukraine	88.1, 88.2	Trotline			Y	8	28	5	0	28	1		

(continued)

Table 1 (continued)

Vessel	Flag	Statistical Area(s)	Gear type	Integrated weight line	Integrated weighting	Longline weights	Minimum mass longline weights	Maximum spacing between weights	Number of hooks per cluster	Spacing between hook clusters	Spacing between droplines	Number of clusters per dropline	Hook spacing	Snood length
Sparta	Russian Federation	58.4.1, 88.1, 88.2	Autoline			Y	5	50					1.2	0.4
Sparta	Russian Federation	58.4.1, 88.1, 88.2	Spanish				10.5	80					1.2	0.4
Sunstar	Korea, Republic of	88.1, 88.2	Trotline			Y	5	35	5	0.5	35	5		
Tronio	Spain	58.4.1, 88.1, 48.6	Spanish			Y								
Volk Arktiki	Russian Federation	58.4.1, 88.1, 88.2	Autoline	Y	200								1.4	0.4

Table 2: Outcome of the review of the recommendations of the COLTO–CCAMLR Workshop (WG-FSA-2019/01).

COLTO–CCAMLR Workshop recommendations	WG-FSA-2019	Outcome
There needed to be a better facility for recording multiple bait types and the proportion of bait type used per line.	Endorsed recommendation	Proposed new C2 form contains additional bait type and proportion fields
A detailed description of how baiting percentage was estimated by Members was necessary.	Endorsed recommendation	Clarify method of calculation in C2 form instructions
Hook size should be recorded once per voyage as vessels did not change this over the course of a trip. The addition of measurement fields to categorise hook types would be useful.	Endorsed recommendation	Measurement fields added to proposed new C2 form
The hook code field did not provide useful information given the increasing number of manufacturers and potential differences in hooks. It was recommended that the fishing industry should approach gear manufacturers to receive hook specification sheets that may further inform how this data should best be captured. It was recommended that this information, including photographs of hooks, snoods and swivels would be useful to capture for lost gear identification purposes and for WG-FSA to consider how best to collect and store that data.	Endorsed recommendation	Consider submitting photographs as part of vessel gear notifications
Removal of the 'number of other hooks lost' field as the vast majority of hooks that are lost are those attached to lost sections of line.	Recommendation not supported	Retain hooks lost not attached to sections of line field and addition of a field on length of line lost to proposed new C2 form. Clear instructions on how to complete these fields to be specified in C2 form instructions
The number of droplines per line be included for trotline gear, which was recommended at WG-SAM (WG-SAM-2019 report, paragraph 6.9).	Endorsed recommendation	Proposed new C2 form contains droplines field
Clarity is required in conservation measures regarding UTC being the default for season and small-scale research units (SSRU) openings and closures.	Endorsed recommendation	Addition of UTC timing text to appropriate conservation measures
The Workshop reinforced that all setting/hauling positions/times should be based on anchor deployment/retrievals at the surface and recommended that this should be clear in the instructions.	Endorsed recommendation	To be clearly specified in C2 form instructions
Hauling positions should also be recorded in the C2 form as per the observer data form.	Endorsed recommendation	Proposed new C2 form contains hauling position fields
A haul interruption field be added for the benefit of data users.	Endorsed recommendation	Proposed new C2 form contains hauling interruption field

(continued)

Table 2 (continued)

COLTO–CCAMLR Workshop recommendations	WG-FSA-2019	Outcome
It was noted that bottom-to-line distances may be altered during fishing in double-line systems with an aim to reduce by-catch rates. The Workshop suggested that an analysis be performed and provided to WG-FSA to see if this effect was observed in the data.	Endorsed recommendation	
Removal of the 'setting direction (bearing)' field, as the assumption of setting in a straight line is generally not correct.	Endorsed recommendation	Bearing field removed in proposed new C2 form
Clarity on instructions for vessel requirements to mark gear and report unit segments for vulnerable marine ecosystem (VME) data was required.	Endorsed recommendation	Secretariat consult with Members on methods of marking gear and to specify instructions in fishery data manual
As different product grades could necessitate differing conversion factors, being able to utilise more than three conversion factors in a single line would be useful, and utilising a format similar to the observer longline logbook could achieve this. This could also help with reconciliation of C2 data and Catch Documentation Scheme for *Dissostichus* spp. (CDS) data if the ability to record the same product type multiple times was available on a *Dissostichus* catch document (DCD).	Endorsed recommendation noting that it would be necessary to record product weights for each conversion factor used on each haul for CDS reconciliation purposes	Product weight field introduced on the conversion factor worksheet of the proposed new C2 form
The VME requirements in the C2 form are aggregated from the VME fine-scale reports, and it was recommended that the aggregated VME requirements therefore be removed from the C2 forms.	Endorsed recommendation	Aggregated VME fields removed in proposed new C2 form
Consolidation of CE forms and C2 forms would reduce the workload on vessel operators in some fisheries. Support was expressed for form consolidation in fisheries with 5-day and 10-day CE reporting requirements, however, feasibility concerns were expressed in fisheries where daily CE reporting is required, due to the 0600h deadline for daily reports.	Endorsed recommendation	Move to consolidated reporting once new C2 form is introduced. New C2 form would be submitted at the current CE form frequency, with consequent conservation measure changes required.
As tagging data is a vessel responsibility, vessels should report tagging data. Operationally, observers can still assist with collection of data and completion of forms.	WG-FSA noted that non-reporting of tag data by vessels is a compliance issue, and encouraged vessels to work with observers to ensure tagging data was consistent between observer and vessel submissions	
At the end of the reporting period, vessels should only report completed hauls rather than partially completed hauls. Any data resubmission should include the full form.	Endorsed recommendation	To be clearly specified in C2 form instructions

(continued)

Table 2 (continued)

COLTO–CCAMLR Workshop recommendations	WG-FSA-2019	Outcome
Feedback at the individual vessel level may be a valuable tool to improve vessel data quality, and information on tag-overlap statistic and tagging recapture information relative to the overall fleet operating in that fishery would be greatly appreciated by the fishing industry.	WG-FSA noted the feedback reports supplied by the Secretariat for observer data submissions and agreed that vessel feedback reports would be valuable	Secretariat will work with Members intersessionally to develop feedback reports for vessel C2 submissions
As the requirement to submit fine-scale biological data was now covered under the Scheme of International Scientific Observation (SISO), references to the requirement for vessels to submit B2 data should be removed from the relevant conservation measures.	Endorsed recommendation	Will require removal of B2 references in appropriate conservations measures
Requirements on observer and vessel reporting forms should be consistent where relevant, particularly for set/haul positions and tagging data.	Endorsed recommendation	Proposed new C2 form format has been aligned with observer longline logbook where possible
A fishery data manual be developed to provide clear instructions on how to complete data fields on the C2 forms.	Endorsed recommendation	Secretariat to develop fishery data manual with assistance from Members via e-group intersessionally
The specification of the role of fishery data coordinators should be undertaken by Members.	Endorsed recommendation	Secretariat to coordinate role and detail responsibilities
Electronic monitoring could assist in managing observer workloads and improve task prioritisation.	Noted	Refer paragraphs 8.6 to 8.9
Electronic monitoring can be used to resolve potential disputes or uncertainties that can arise during deliberations at the Standing Committee on Implementation and Compliance (SCIC).	Noted	CCAMLR-38/BG/40 will be presented to SCIC
A presentation to SCIC on electronic monitoring would be useful, which could include proposals on minimum monitoring standards.	Noted	CCAMLR-38/BG/40 will be presented to SCIC

Table 3: Recommendations from the Stock Assessment Review for Toothfish extracted verbatim from the report (SC-CAMLR-XXXVII, Annex 5, where further description of these points can be found) and progress to date. RP – review panel, SC – Scientific Committee, SA – stock assessments, VB – von Bertalanffy.

RP comments	Description of work	Cross-reference	Status
Documentation			
1. It is recommended that a standardised format be developed by CCAMLR for the presentation of details of assessments to facilitate understanding of the assumptions, data preparation and inputs, parameter estimation and results across the assessments performed by CCAMLR, and that a public summary document with these details be developed and updated at a fixed period (e.g. five years).	Stock Annex template being developed	WG-FSA-2019/08, WG-SAM-2019/35	In progress
Stock hypotheses			
2. A number of assessments described the proposed stock hypotheses and described ideas for future work. The RP suggests that appropriate experts be consulted, and a review be planned if these assessments or CCAMLR require evaluation of the hypotheses.	Description of stock hypothesis. Genetics, otolith shape, otolith microchemistry	WG-FSA-2019/32, WG-FSA-2019/36, WG-FSA-2019/59, WG-FSA-2019/61, WG-FSA-2019/P01	Ongoing
Surveys			
3. Where possible, such surveys should be continued and optimised to ensure recruitment variability can be detected.	Survey reports from Subarea 88.1 and SSRUs 882A–B, Division 58.5.2 and Subarea 48.3	WG-SAM-2019/03, WG-FSA-2019/03, WG-FSA-2019/20	Ongoing
4. Subareas 88.1/88.2 – Consideration should be given to restricting the data from the survey to be more representative of recruitment.		WG-FSA-2019/08	Complete
5. Subareas 88.1/88.2 – Consideration should be given to designing the [Ross Sea shelf] survey to take this into consideration or increasing the catch limit, so that the unused catch limit can be released after the survey, or by releasing excess fish, etc.	The survey catch limit has only been reached once in the timeseries		Low priority
6. Division 58.5.2 – a more appropriate approach to fitting the survey might be to fit the index-at-age data using a multivariate likelihood function and the empirical variance-covariance matrix.	Sensitivity – method yet to be developed		Future work

(continued)

Table 3 (continued)

Review panel comments	Description of work	Cross-reference	Status
Ageing			
7. In some cases just a single experienced reader has been used. The RP suggests that, where possible, increasing the number of readers to a minimum of two experienced readers, within laboratories, would be beneficial.	All otoliths are double-read in Division 58.5.2 and Subareas 48.3 and 48.4. All use reference libraries and reader validation. Age reading workshops are being planned.	WG-FSA-2019/32, WG-FSA-2019/28, WG-FSA-2019/29	Ongoing
8. It would be interesting to investigate how smoothing the age–length key (ALK) matrix (by applying a kernel or using some sort of spline function) would affect the SA.	Sensitivity		Future work
Growth			
9. The RP suggests that all SAs implement methods to account for these potential biases in fitting VB growth curves.	The growth model accounts for potential biases by length-bin sampling and selectivity for Division 58.5.2. In Subareas 48.3 and 48.4, random sampling reduces the effect.	WG-FSA-2019/32	Ongoing
10. Additionally, investigation of the impact of errors in ageing on the VB by the SA scientists have shown that the fit is robust to this error. The RP suggests that this be investigated occasionally to ensure that no biases occur.	Sensitivity		Future work
11. Because changing the VB can affect the calculated virgin biomass, and thus the depletion estimates, the RP suggests that the SA scientists explore whether the fitted VB in these cases is sufficiently precautionary.	Bridging analysis in Division 58.5.2 and Subarea 88.1 and SSRUs 882A–B. For Subarea 48.3 and Subarea 88.1 and SSRUs 882A–B analysis used to show robustness to the change over time.	WG-FSA-2019/32, WG-FSA-2019/11, WG-FSA-2019/08, WG-SAM-2019/32	Ongoing
12. The RP also suggests that the SA scientists investigate the use of other growth curves that may exhibit better properties in regard to the data. A more flexible curve might produce a more realistic fit.	Mean length at age maximum likelihood estimation used in Subarea 88.1 and SSRUs 882A–B.	WG-FSA-2019/11, WG-SAM-2019/32	Ongoing

(continued)

Table 3 (continued)

Review panel comments	Description of work	Cross-reference	Status
13. The RP recommends that sensitivity analyses be used to assess the impact of the different choices of the growth model on stock assessment results and on biological reference points.	Sensitivity for Subareas 88.1 and 88.2 and 48.3	WG-FSA-2019/11, WG-FSA-2019/08, WG-SAM-2019/32	Ongoing
14. Potential changes in growth rates and fishery selectivity will influence tag-recapture rates, particularly due to the dome-shaped selectivity of these fisheries. The RP also recommends that more flexible growth curves be investigated.	Sensitivity. Estimated selectivity in Subareas 48.3 and 48.4 not domed	WG-FSA-2019/08	Future work
15. The RP recommends that the use of ALKs be investigated to estimate the age composition of tagged fish released as an input to the assessment models for all the toothfish stocks, instead of the current approach.	Sensitivity		Future work
Data weighting			
16. The RP recommends that data weighting methods for tagging data should be further investigated. For example, consideration should be given to using data weighting methods based on the average time at liberty.	Method yet to be developed	WG-FSA-2019/08	Ongoing
Tag loss			
17. The RP suggests that it is timely to update this analysis for Subareas 48.3 and 48.4 and Subarea 88.1 and SSRUs 882A–B stocks based on more recent information that may include fish with a longer time at liberty. Changes in tag-loss rates should be investigated. Information on the uncertainty involved in the estimation should be provided.	Tagging loss rates for Subarea 48.3 reviewed.	WG-SAM-14/35	Future work
Initial tagging mortality			
18. The RP encourages future research on the estimation of initial tagging mortality rates, and factors that may cause this to vary.	Experimental, sensitivity		Future work
Tag detection			
19. The review panel encourages future research on the estimation of tag-detection rates, and factors that may cause this to vary.	Experimental, sensitivity	WG-FSA-13/29, WG-FSA-2019/07	Future work
20. The RP recommends that implementation of good tagging protocols (release and recapture) be encouraged for all vessels involved in these fisheries.	Regular training of observers and review of tagging procedures, proposed workshop with COLTO. Survey of vessel behaviour. Update of observer manuals.	WG-FSA-13/29, WG-FSA-2019/15, SC-CAMLR-38/01	Ongoing

(continued)

Table 3 (continued)

Review panel comments	Description of work	Cross-reference	Status
Time at liberty truncation			
21. Tagging data was limited to recapture years-at-liberty less than four for Division 58.5.2 (although data exist for up to six years at liberty) and Subarea 48.3 and Subarea 48.4 assessments, but six years at liberty for Subarea 88.1 and SSRUs 882A–882B assessments. The RP recommends further investigation of this issue.	Time at liberty of six years are used in the Division 58.5.2 assessment. Sensitivity reviewed in 2017 for Subareas 48.3 and 48.4	WG-FSA-2019/32, WG-SAM-17/35	Completed
Selectivity			
22. The spatial distribution of the fleets has changed over time, particularly in the early years of the fisheries and in Subarea 88.1 and SSRUs 882A–882B and temporal changes in selectivity should be considered.		WG-FSA-2019/08	Ongoing
Natural mortality			
23. The RP recommends that consideration should be given to estimating age-specific natural mortality rates using a functional form with few parameters and sex-specific natural mortality rates. Simulation analysis should be conducted to determine in what circumstances natural mortality rates can be reliably estimated.	Sensitivity analysis	WG-FSA-2019/32, WG-SAM-2019/04	Ongoing
Recruitment standard deviation			
24. The RP recommends that consideration should be given to adjusting the penalty for years in which there is incomplete information about year-class strength.	Sensitivity		Future work
Sex structure			
25. The RP suggests that a more thorough evaluation is needed on the necessity of sex. If it is concluded that a sex-structured model is appropriate, all the data collection programs need to be modified to collect the appropriate sex information.	Sensitivity Subarea 88.1 and SSRUs 882A–B sex structured		Future work
Diagnostics			
26. A standard set of diagnostic plots across the assessments covering important and sensitive parameters is encouraged to be included in each stock assessment.	Diagnostic plots used as per WG-SAM-15/26	WG-FSA-2019/32, WG-FSA-2019/10, WG-FSA-2019/28, WG-FSA-2019/29	Completed
Ecosystem drivers in assessment models			
27. This was beyond the scope of the terms of reference. However, CCAMLR may wish to consider an external review whose goal is to consider this question specifically.			

Table 4: Initial CASAL assessments reported to WG-FSA-2019. All authors and the Secretariat used the same version of CASAL: v2.30-2012-03-21 rev.4648.

CASAL assessment		WG-FSA document number
Species	Area	
D. eleginoides	Subarea 48.3	2019/28
	Division 58.5.1	2019/58
	Division 58.5.2	2019/32
	Subarea 58.6	2019/57 Rev.1
D. mawsoni	Subarea 48.4	2019/29
	Ross Sea	2019/08

Table 5: B_0 estimates reported to WG-FSA and comparison with Secretariat estimates.

Model run	Reported B_0 (tonnes)	Secretariat B_0 (tonnes)	Difference (%)
D. eleginoides			
Subarea 48.3	82 451	82 451	0
Division 58.5.1			
M1	206 842	206 842	0
M2	232 153	232 153	0
Division 58.5.2	71 210	71 210	0
Subarea 58.6			
M1	54 398	54 398	0
M2	54 426	54 426	0
M3	54 442	54 442	0
D. mawsoni			
Subarea 48.4	1 004	1 004	0
Ross Sea	72 314	72 314	0

Table 6: Potential catch allocation methods for the Ross Sea shelf survey. Method 1 uses the method used 2012–2018 of allocating catch from the overall Ross Sea region toothfish fishery. Method 2 allocates the shelf survey catch limit from the special research zone (SRZ) catch limit and method 3 allocated it from the south of 70°S catch limit.

Area	Percent	No Survey	Method 1	Method 2	Method 3
North of 70°S	19	597	588	597	597
South of 70°S	66	2 072	2 043	2 072	2 027
SRZ	15	471	464	426	471
Shelf survey	-	-	45	45	45
Total	100	3 140	3 140	3 140	3 140

Table 7: Research block biomass estimates and catch limits estimated using the trend analysis and Chapman methods for Subareas 48.1, 48.6, 58.4, 88.2 and 88.3. ISU – increasing, stable or unclear; D – declining.

Subarea/ division	Research block	Species	Catch limit 2018/19 (tonnes)	Trend decision	Adequate recaptures	CPUE trend decline	*B* (tonnes)	0.04×B	0.8×CL	1.2×CL	Recommended catch limit 2019/20 (tonnes)
48.1	48.1_1	*D. mawsoni*	40					0	32	48	43*
48.6	486_2	*D. mawsoni*	175	ISU	Y	N	1 602	64	140	210	140
48.6	486_3	*D. mawsoni*	32	ISU	Y	Y	3 276	131	26	38	38
48.6	486_4	*D. mawsoni*	144	ISU	N	N	4 075	163	115	173	163
48.6	486_5	*D. mawsoni*	274	ISU	Y	N	24 636	985	219	329	329
58.4.1	5841_1	*D. mawsoni*	115	ISU	N	N	7 663	307	92	138	138
58.4.1	5841_2	*D. mawsoni*	116	ISU	N	N	5 285	211	93	139	139
58.4.1	5841_3	*D. mawsoni*	149	ISU	N	Y	4 275	-	119	179	119
58.4.1	5841_4	*D. mawsoni*	19	ISU	N	N	693	28	15	23	23
58.4.1	5841_5	*D. mawsoni*	50	ISU	N	N	4 705	188	40	60	60
58.4.1	5841_6	*D. mawsoni*	130	ISU	N	Y	4 590	-	104	156	104
58.4.2	5842_1	*D. mawsoni*	50	ISU	N	N	5 243	210	40	60	60
58.4.3a	5843a_1	*D. eleginoides*	30	D	N	Y	1 196	-	24	36	24
58.4.4b	5844b_1	*D. eleginoides*	19	ISU	Y	N	180	7	15	23	23**
58.4.4b	5844b_2	*D. eleginoides*	22	D	N	Y	238	-	18	26	18
88.2	882_1	*D. mawsoni*	240	D	N	Y	4 574	-	192	288	192
88.2	882_2	*D. mawsoni*	240	ISU	Y	Y	5 790	232	192	288	232
88.2	882_3	*D. mawsoni*	160	ISU	N	N	4 540	182	128	192	182
88.2	882_4	*D. mawsoni*	160	ISU	N	Y	5 930	-	128	192	128
88.2	882_H	*D. mawsoni*	200	ISU	N	N	3 758	150	160	240	160
88.3	883_1	*D. mawsoni*	20	D	N	Y	1 433	-	16	24	16
88.3	883_2	*D. mawsoni*	25	D	N	Y	2 881	-	20	30	20
88.3	883_3	*D. mawsoni*	50	ISU	N	N	5 736	229	40	60	60
88.3	883_4	*D. mawsoni*	50	ISU	N	N	2 485	99	40	60	60
88.3	883_5	*D. mawsoni*	10	D	N	Y	124	-	8	12	8
88.3	883_6	*D. mawsoni*	30					0	24	36	30
88.3	883_7	*D. mawsoni*	30					0	24	36	30
88.3	883_8	*D. mawsoni*	10					0	8	12	10
88.3	883_9	*D. mawsoni*	10					0	8	12	10
88.3	883_10	*D. mawsoni*	10					0	8	12	10

* see paragraph 4.40

** see paragraph 4.131

Table 8: Summary of the assessment of the new and underway research proposals in Area 48. Summary of the rationale behind footnotes should be taken in the context of the details in paragraphs 4.35 to 4.38 and 4.58 to 4.80. Two research plans had completed their last year of on-water activities in Area 48 in 2018/19 and were not assessed against these criteria (see WG-FSA-2019/51 and WG-FSA-2019/25). Data analyses are underway and results will be presented until the completion of the research objectives. ESP – Spain, JAP – Japan, UKR – Ukraine, ZAF – South Africa, TOA – *Dissostichus mawsoni*; n/a – not applicable.

Subarea/division:	48.1	48.6
Proposal:	WG-FSA-2019/17	WG-FSA-2019/23 Rev. 1
Members:	UKR	JAP, ZAF, ESP
Conservation measure under which the proposal is submitted:	24-01	21-02
Time period:	2019/20	2018/19–2020/21
Main species of interest:	TOA	TOA
Main purpose of the research (e.g. abundance, population structure, movement, …)	Structure	Abundance
Is the purpose of the research linked to Commission or Scientific Committee priorities?	Y	Y
1. Quality of the proposal		
1.1 Is there enough information to evaluate the likelihood of success of the research objectives?	Y	Y
2. Research design		
2.1 Is the proposed catch limit in accordance with research objectives?	Y	Y
2.2 Is the sampling design appropriate to achieve research objectives?	Y	?[6]
2.3 Have the environmental conditions been thoroughly accounted for?	N[1]	Y
3. Research capacity		
3.1 Have the research platforms demonstrated experience in:		
3.1.1 Conducting research/exploratory fishing following a research plan?	Y	Y
3.1.2 Collecting scientific data?	Y	Y
3.2 Do the research platforms have acceptable tag detection and survival rates?	Y	Y
3.3 Have the research teams sufficient resources and capacity for:		
3.3.1 Sample processing?	Y	Y
3.3.2 Data analyses?	Y	Y
4. Data analyses to address the research questions		
4.1 Are the proposed methods appropriate?	N[2]	Y
5. Impact on ecosystem and harvest species		
5.1 Is the catch limit proposed consistent with Article II[a] of the Convention?	?[6]	?[6]
5.2 Are the impacts on dependent and related species accounted for and consistent with Article II[b] of the Convention?	Y	N[3]

(continued)

Table 8 (continued)

Subarea/division:	48.1	48.6
Proposal:	WG-FSA-2019/17	WG-FSA-2019/23 Rev. 1
Members:	UKR	JAP, ZAF, ESP
Conservation measure under which the proposal is submitted:	24-01	21-02
Time period:	2019/20	2018/19–2020/21
Main species of interest:	TOA	TOA
6. Progress towards objectives for ongoing proposals		
6.1 Have the past and current milestones been completed?	n/a	Y
6.2 Has previous advice from the Scientific Committee and its working groups been addressed?	Y	Y
6.3 Are all the objectives likely to be completed by the end of the research plan?	N[1,4]	Y
6.4 Are there any other concerns?	Y[5]	N

[a] Prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment.
[b] Maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations. Prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades.

[1] There are concerns about the accessibility of the fishing grounds due to sea-ice (WG-FSA-2018 report, Figure 5).
[2] Requires higher sampling of by-catch species.
[3] Requires more analysis on by-catch populations, see WG-SAM-2019/09.
[4] The on-water activities will be completed by the end of the research plan but the off-water analyses will continue in future years.
[5] C2 and CDS catch data reconciliation outcomes (see paragraphs 2.11 to 2.14).
[6] See paragraph 4.80.

Table 9: Summary of the assessment of the new and underway research proposals in Area 58. Summary of the rationale behind footnotes should be taken in the context of the details in paragraphs 4.89 to 4.132. AUS – Australia, ESP – Spain, FRA – France, JPN – Japan, KOR – Korea, RUS – Russia, TOP – *Dissostichus eleginoides*; TOA – *Dissostichus mawsoni*, n/a – not applicable.

Subarea/division:	58.4.1/2	58.4.1/2	58.4.4b
Proposal:	WG-FSA-2019/44	WG-FSA-2019/52	WG-FSA-2019/64
Members:	AUS, ESP, FRA, JPN, KOR	RUS	JPN, FRA
Conservation measure under which the proposal is submitted:	21-02	21-02	24-01
Time period:	2018/19–2021/22	2019/20–2021/22	2016/17–2020/21
Main species of interest:	TOA	TOA	TOP
Main purpose of the research (e.g. abundance, population structure, movement, …)	Abundance	Abundance	Abundance
Is the purpose of the research linked to Commission or Scientific Committee priorities?	Y	Y	Y
1. Quality of the proposal			
1.1 Is there enough information to evaluate the likelihood of success of the research objectives?	Y	Y	Y
2. Research design			
2.1 Is the proposed catch limit in accordance with research objectives?	Y	Y	Y
2.2 Is the sampling design appropriate to achieve research objectives?	?[1]	?[1]	?[1]
2.3 Have the environmental conditions been thoroughly accounted for?	Y	Y	Y
3. Research capacity			
3.1 Have the research platforms demonstrated experience in:			
3.1.1 Conducting research/exploratory fishing following a research plan?	N[2]	Y	N[3]
3.1.2 Collecting scientific data?	Y	Y	Y
3.2 Do the research platforms have acceptable tag detection and survival rates?	N[4]	N[5]	N[6]
3.3 Have the research teams sufficient resources and capacity for:			
3.3.1 Sample processing?	Y	N[7]	Y
3.3.2 Data analyses?	Y	N[7,8]	Y
4. Data analyses to address the research questions			
4.1 Are the proposed methods appropriate?	Y	N[8]	Y
5. Impact on ecosystem and harvest species			
5.1 Is the catch limit proposed consistent with Article II[a] of the Convention?	?[13]	?[13]	?[13]
5.2 Are the impacts on dependent and related species accounted for and consistent with Article II[b] of the Convention?	Y	N[9]	Y

(continued)

Table 9 (continued)

Subarea/division:	58.4.1/2	58.4.1/2	58.4.4b
Proposal:	WG-FSA-2019/44	WG-FSA-2019/52 Rev. 1	WG-FSA-2019/64
Members:	AUS, ESP, FRA, JPN, KOR	RUS	JPN, FRA
Conservation measure under which the proposal is submitted:	21-02	21-02	24-01
Time period:	2018/19–2021/22	2019/20–2021/22	2016/17–2020/21
Main species of interest:	TOA	TOA	TOP
6. Progress towards objectives for ongoing proposals			
6.1 Have the past and current milestones been completed?	Y	n/a	Y
6.2 Has previous advice from the Scientific Committee and its working groups been addressed?	Y	Y	Y
6.3 Are all the objectives likely to be completed by the end of the research plan?	N[10]	N[7]	Y
6.4 Are there any other concerns?	Y[11]	Y[12]	N

[a] Prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment.

[b] Maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations. Prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades.

[1] Dr S. Kasatkina (Russia) reiterated that the use of different types of longline gears compromise the achievement of research plan objectives (paragraph 4.95).

[2] One vessel out of eight (*Cap Kersaint*) has not yet fished in a fishery under CM 21-02, however, it has fished within Subarea 58.6 and Division 58.5.1.

[3] One vessel out of four (*Cap Kersaint*) has not yet fished in a fishery under CM 24-01, however, it has fished within Subarea 58.6 and Division 58.5.1.

[4] All vessels have good tagging performance (WG-FSA-17/36), except the *Kingstar* (Republic of Korea) and the vessels proposed by France which do not have their tagging performances calculated but have had tag recaptures before in this area (Divisions 58.4.1 or 58.4.2).

[5] One vessel has very poor tagging performance (*Palmer*) and the other (*Volk Arktiki*) has good tagging detection rate but unknown tag-survival rate due to fishing only one year in 2018/19.

[6] Tagging performance has not been calculated in this region but vessels have had tag recaptures before.

[7] Dr Kasatkina recognised that this research plan cannot be completed without collaboration from other Members and the proponent has limited off-water research capacity (only one researcher is listed in the proposal section 5a).

[8] There is not enough information in the proposal.

[9] The proposed design present risks of high fish by-catch in the shallow and deep strata as it was demonstrated in research block 5841_6 (SC-CAMLR-XXXVI, paragraph 3.148).

[10] Completion of research objectives is conditional on the continuation of the exploratory fishing activities.

[11] Despite extensive discussions between the co-proponents, the different parties were not able to find a common ground to incorporate Russian vessels in the existing multi-Member research plan.

[12] Any new proposals should be integrated within existing research in the area (WG-SAM-2019 report, paragraph 6.70).

[13] See paragraphs 4.114 and 4.131.

Table 10: Summary of the assessment of the new and underway research proposals in Area 88. Summary of the rationale behind footnotes should be taken in the context of the details in paragraphs 4.151 to 4.181. KOR – Korea, NZ – New Zealand, RUS – Russia, UKR – Ukraine, TOA – *Dissostichus mawsoni*, MPA – marine protected area.

Subarea/division:	88.2[a]	88.1[a]	88.3
Proposal:	WG-FSA-2019/42 Rev. 1	WG-SAM-2019/03	WG-SAM-2019/02
Members:	RUS	NZ	NZ, KOR, UKR
Conservation measure under which the proposal is submitted:	24-01	24-01	24-01
Time period:	2019/20–2021/22	2017/18–2021/22	2017/18–2019/20
Main species of interest:	TOA	TOA	TOA
Main purpose of the research (e.g. abundance, structure, movement, …)	Structure	Structure	Structure
Is the purpose of the research linked to Commission or Scientific Committee priorities?	Y	Y	Y
1. Quality of the proposal			
1.1 Is there enough information to evaluate the likelihood of success of the research objectives?	N	Y	Y
2. Research design			
2.1 Is the proposed catch limit in accordance with research objectives?	Y	Y	Y
2.2 Is the sampling design appropriate to achieve research objectives?	?[1,2]	Y	?[2]
2.3 Have the environmental conditions been thoroughly accounted for?	Y	Y	N[3]
3. Research capacity			
3.1 Have the research platforms demonstrated experience in:			
3.1.1 Conducting research/exploratory fishing following a research plan?	Y	Y	Y
3.1.2 Collecting scientific data?	Y	Y	Y
3.2 Do the research platforms have acceptable tag detection and survival rates?	N[4]	Y	Y
3.3 Have the research teams sufficient resources and capacity for:			
3.3.1 Sample processing?	N[5]	Y	Y
3.3.2 Data analyses?	N[5]	Y	Y
4. Data analyses to address the research questions			
4.1 Are the proposed methods appropriate?	N[5,6]	Y	Y
5. Impact on ecosystem and harvest species			
5.1 Is the catch limit proposed consistent with Article II[b] of the Convention?	?[9]	Y	?[10]
5.2 Are the impacts on dependent and related species accounted for and consistent with Article II[c] of the Convention?	N[6]	Y	Y

(continued)

Table 10 (continued)

Subarea/division:	88.2[a]	88.1[a]	88.3
Proposal:	WG-FSA-2019/42 Rev. 1	WG-SAM-2019/03	WG-SAM-2019/02
Members:	RUS	NZ	NZ, KOR, UKR
Conservation measure under which the proposal is submitted:	24-01	24-01	24-01
Time period:	2019/20–2021/22	2017/18–2021/22	2017/18–2019/20
Main species of interest:	TOA	TOA	TOA
6. Progress towards objectives for ongoing proposals			
6.1 Have the past and current milestones been completed?	n/a	Y	Y
6.2 Has previous advice from the Scientific Committee and its working groups been addressed?	N[7]	Y	Y
6.3 Are all the objectives likely to be completed by the end of the research plan?	N[5]	Y	Y
6.4 Are there any other concerns?	Y[8]	N	N

[a] See Table 11 applying to research conducted within MPA.

[b] Prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment.

[c] Maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations. Prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades.

[1] There was not enough information in the proposal but the sampling design was revised during the WG-FSA-2019 with the assistance of the Secretariat and other Members (paragraph 4.161).

[2] Dr S. Kasatkina (Russia) reiterated that the use of different types of longline gears compromises the achievement of research plan objectives (paragraph 4.95).

[3] High variability in environmental conditions (sea-ice) had impacted this research in the past.

[4] One vessel has very poor tagging performance (*Palmer*) and the other (*Volk Arktiki*) has good tagging detection rate but unknown tag-survival rate due to fishing only one year in 2018/19.

[5] There is not enough information in the proposal.

[6] Requires higher sampling of fish by-catch species.

[7] Advice on electronic monitoring, power analysis and tag performance updates were not presented in WG-FSA-2019/42 and had to be calculated during the WG-FSA-2019.

[8] Analyses from previous research by this Member in this region are still pending (WG-FSA-2018 report, paragraph 4.167).

[9] See paragraph 4.170.

[10] See paragraph 4.182.

Table 11: Summary of the assessment of research plans carried out within marine protected areas (MPAs). NZ – New Zealand, RUS – Russia, TOA – *Dissostichus mawsoni*.

Subarea/division:	88.2	88.1
Proposal:	WG-FSA-2019/42 Rev. 1	WG-SAM-2019/03
Members:	RUS	NZ
Conservation measure under which the proposal is submitted:	24-01	24-01
Time period:	2019–2022	2018–2022
Main species of interest:	TOA	TOA
Does the proposal:		
1. Explain which priority research elements are addressed to inform the MPA evaluation process?	Y	Y
2. Explain why the proposed research or data collection cannot be conducted during the exploratory fishery?	Y	Y
3. Explicitly integrate replication and randomisation in their research design?	N[1]	Y
4. Provide a detailed rationale for the choice of comparable reference areas?	N[1]	Y
5. Describe the mechanism by which research fishing is coordinated with other research fishing and with any Olympic fishery?	Y	Y
6. Provide an assessment of how the research may impact the objectives of the MPA?	N[1]	N[1]

[1] There was not enough information in the proposal.

Table 12: Vulnerable marine ecosystem (VME) work plan summary.

Topics	Workflow
1	Collate relevant conservation measures and associated documents (guides, etc.) to review current practice and summarise reporting trends.
2	Review VME impact mitigation procedures in regional fisheries management organisations (RFMOs) that may inform CCAMLR.
3	Review reporting of VME by vessels – assess trends by year, location, gear, flag etc.
4	Review line section marking/recording and develop standard protocol.
5	Provide data on efficacy of current sampling methods by comparing observer-derived observations with electronic monitoring at hauling.
6	Assess efficacy of surface sampling to describe seafloor habitat with the use of benthic camera data.
7	Review new methods for assessing fishing footprint and compare with existing methods.
8	Evaluate VME taxa identification materials.
9	Assess whether current VME taxa list is comprehensive and appropriate.
10	Consideration of actions following VME encounters (e.g. additional sampling with cameras).
11	Consideration of analysis methods/modelling for incorporating new (electronic monitoring and camera) data streams and external data streams (e.g. research voyages), including distribution modelling.
12	Integrating above results to develop recommendations (e.g. review VME thresholds, data collection, and reporting protocols and recommend changes to conservation measures as appropriate).

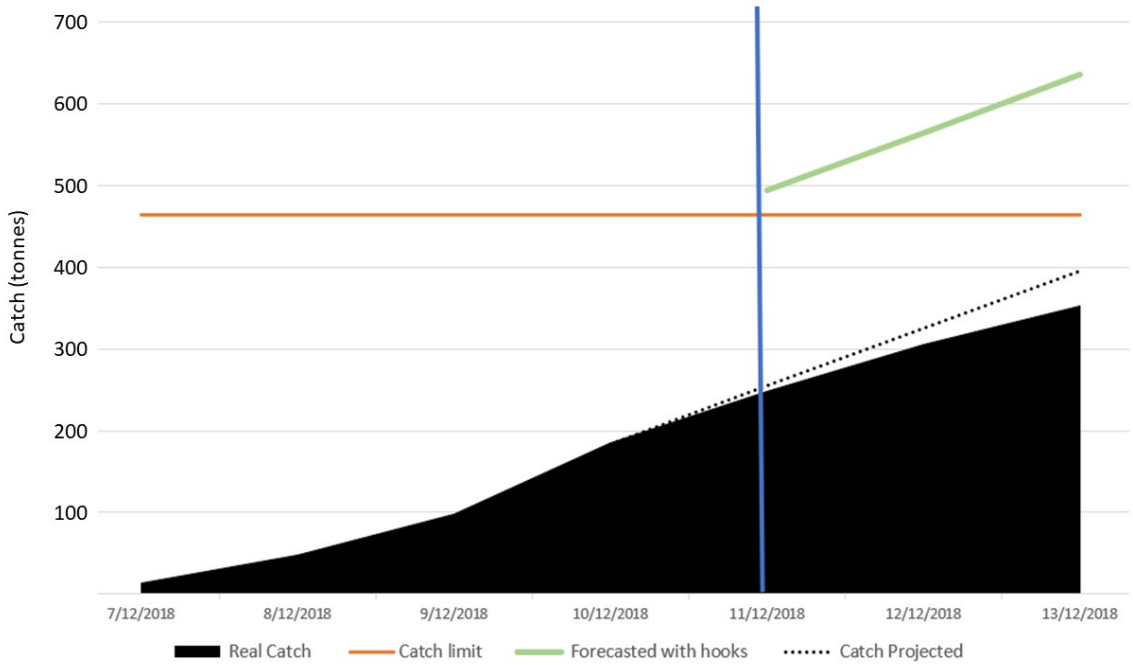


Figure 1: Progression of catches and closure forecasting for the special research zone (SRZ) in 2018/19. The Secretariat issued a notification that the fishery would close at 0930 UTC on 12 December, with no more gear to be set after 0930 UTC on 11 December. At the time of the notification on 11 December, the catch forecasted with hooks in the water was 494.3 tonnes, compared to a catch limit of 474 tonnes.

Fisheries Documents

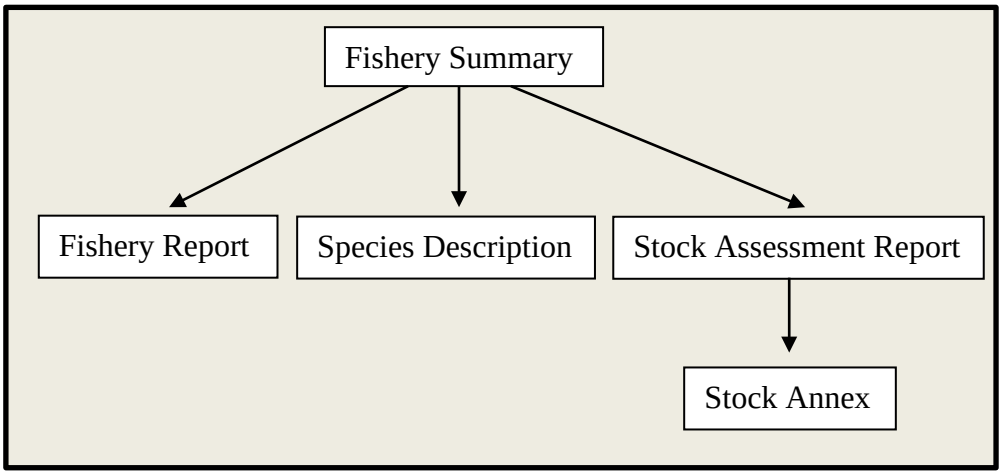


Figure 2: Hierarchical structure of the public domain Fisheries Documents.

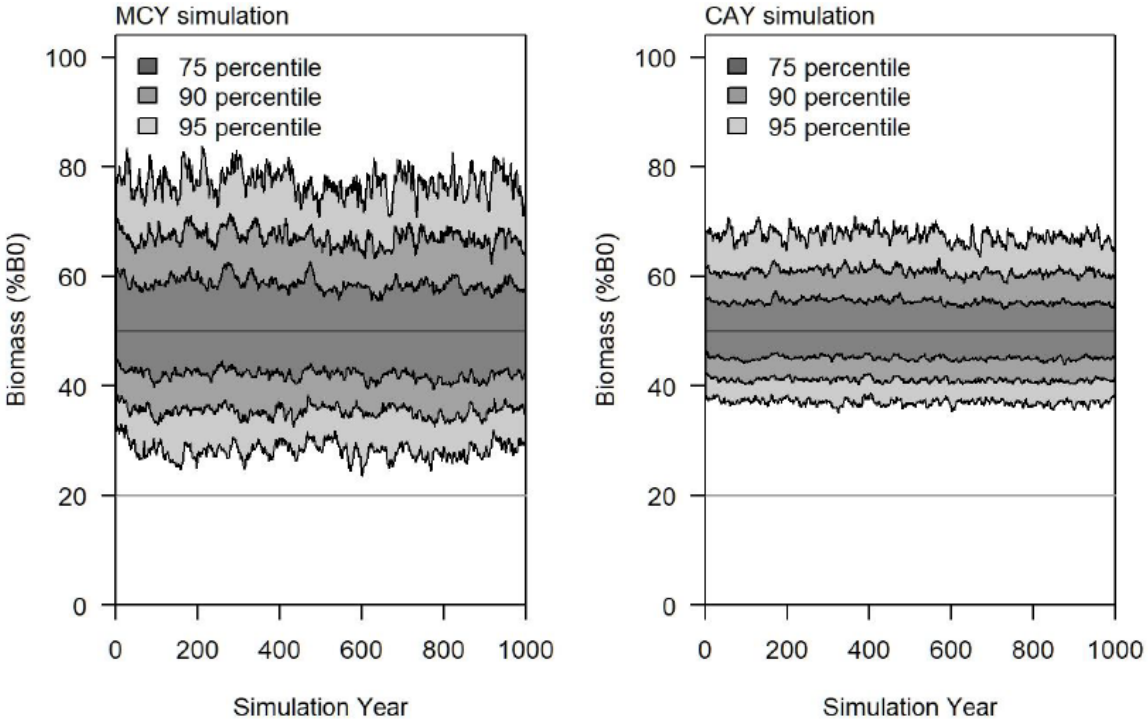
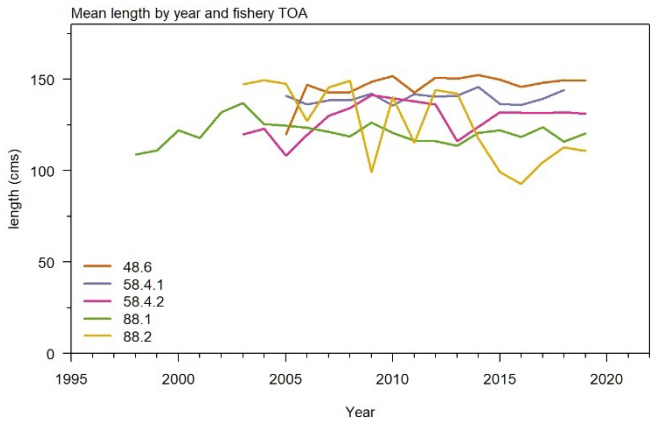
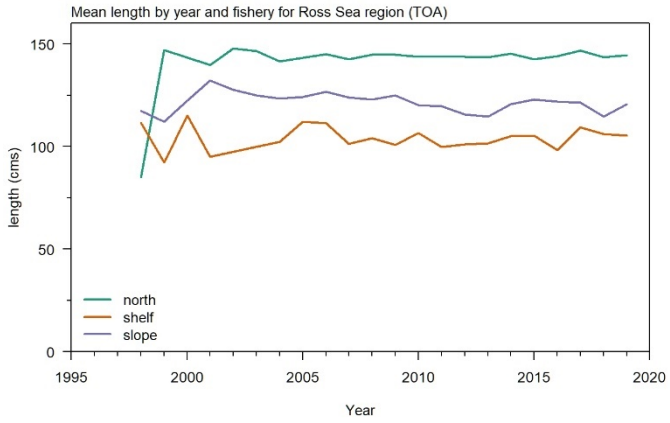


Figure 3: Trajectory of expected values of SSB (% B_0) from 1 000 years of simulating 1 000 Markov Chain Monte Carlo (MCMC) realisations for a constant catch (maximum constant yield, MCY, left panel) and a constant exploitation rate (constant annual yield, CAY, right panel) for the Ross Sea base case model (R1.3) following the CCAMLR decision rule with a target of 50% of B_0 and a limit of 20% of B_0.

(a)



(b)



(c)

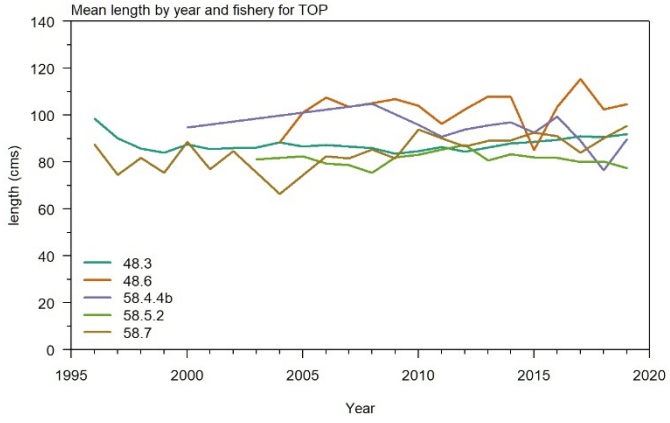
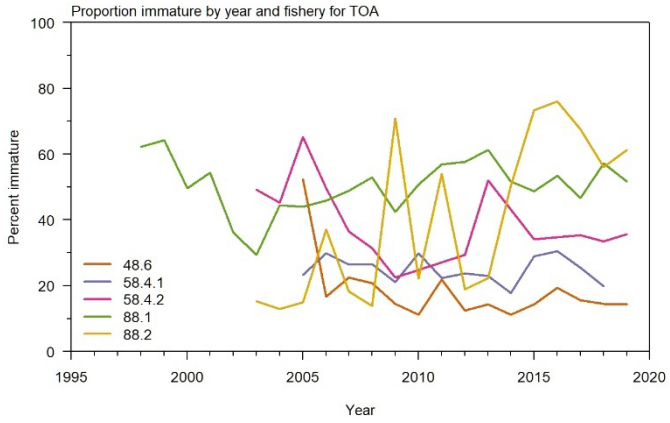
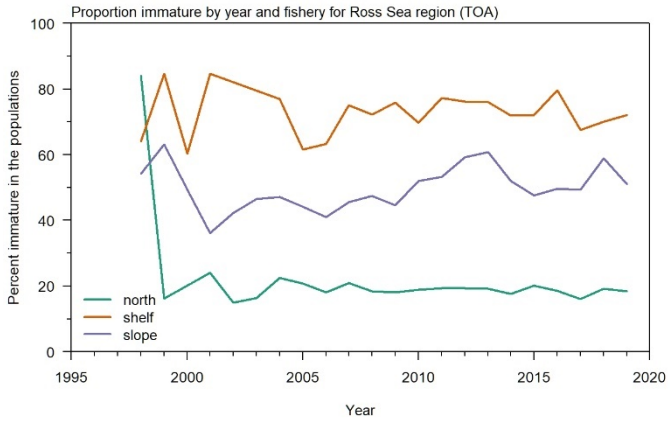


Figure 4: Mean length by year in catches of Antarctic toothfish (*Dissostichus mawsoni*) fisheries in: (a) across the Convention Area, (b) in the Ross Sea, and (c) Patagonian toothfish (*D. eleginoides*) fisheries across the Convention Area.

(a)



(b)



(c)

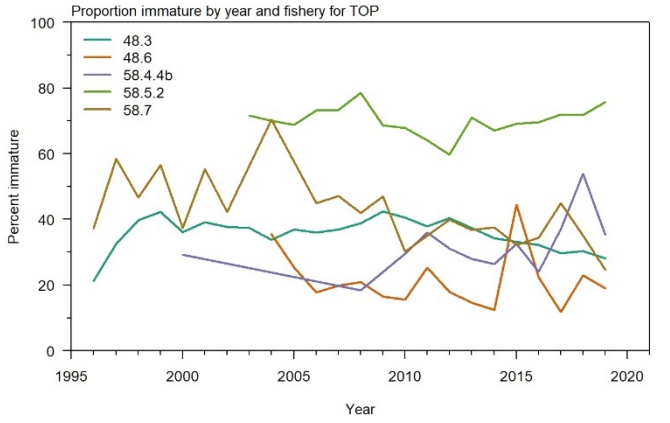


Figure 5: Percent immature fish by year in catches of Antarctic toothfish (*Dissostichus mawsoni*) fisheries: (a) across the Convention Area, (b) in the Ross Sea, and (c) Patagonian toothfish (*D. eleginoides*) fisheries across the Convention Area.

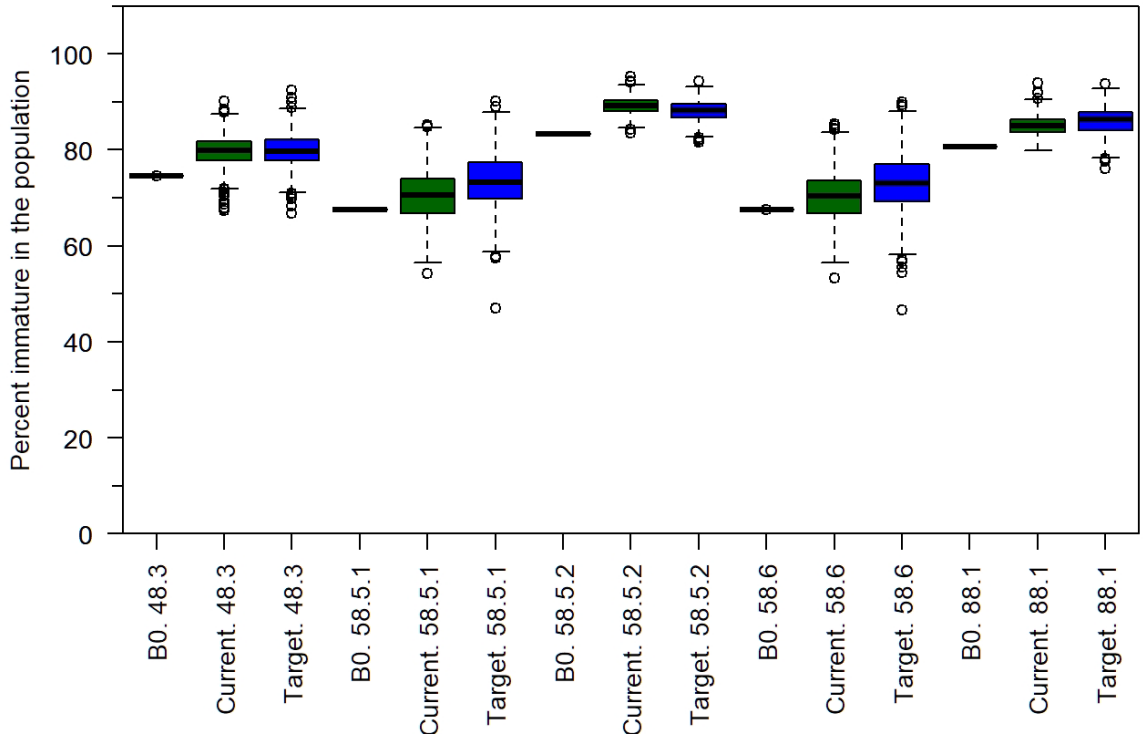


Figure 6: Percent immature fish when the stock is at B_0, in the current year 2019, and at target level at the end of the 35-year projection period, as estimated by the CASAL stock assessment models for the Patagonian toothfish (*Dissostichus eleginoides*) fisheries in Subareas 48.3 and 58.6 and Divisions 58.5.1 and 58.5.2, and for the Antarctic toothfish (*D. mawsoni*) fishery in Subarea 88.1 and small-scale research units (SSRUs) 882A–B.

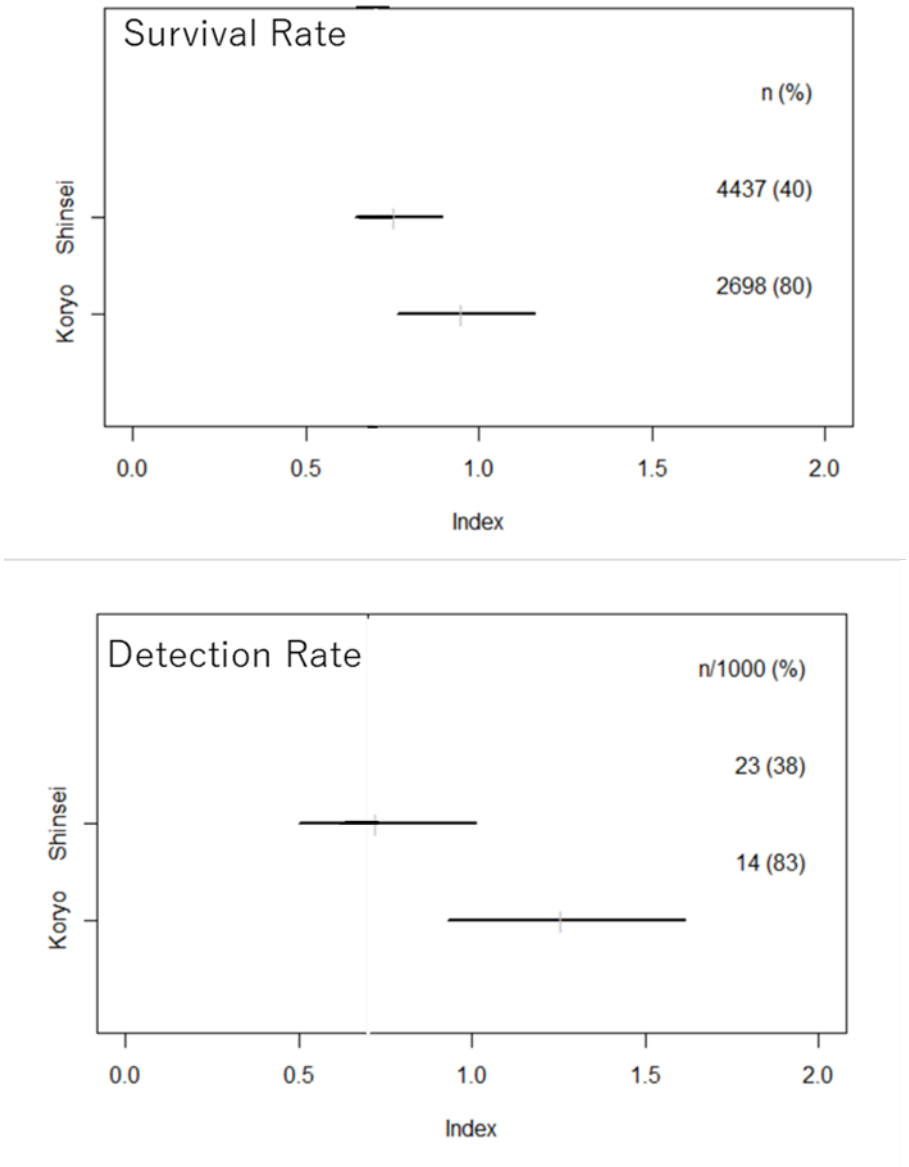


Figure 7: The tag-detection and survivability statistics calculated for the *Shinsei Maru No. 3* and *Koryo Maru No. 11* using data from Subarea 48.6.

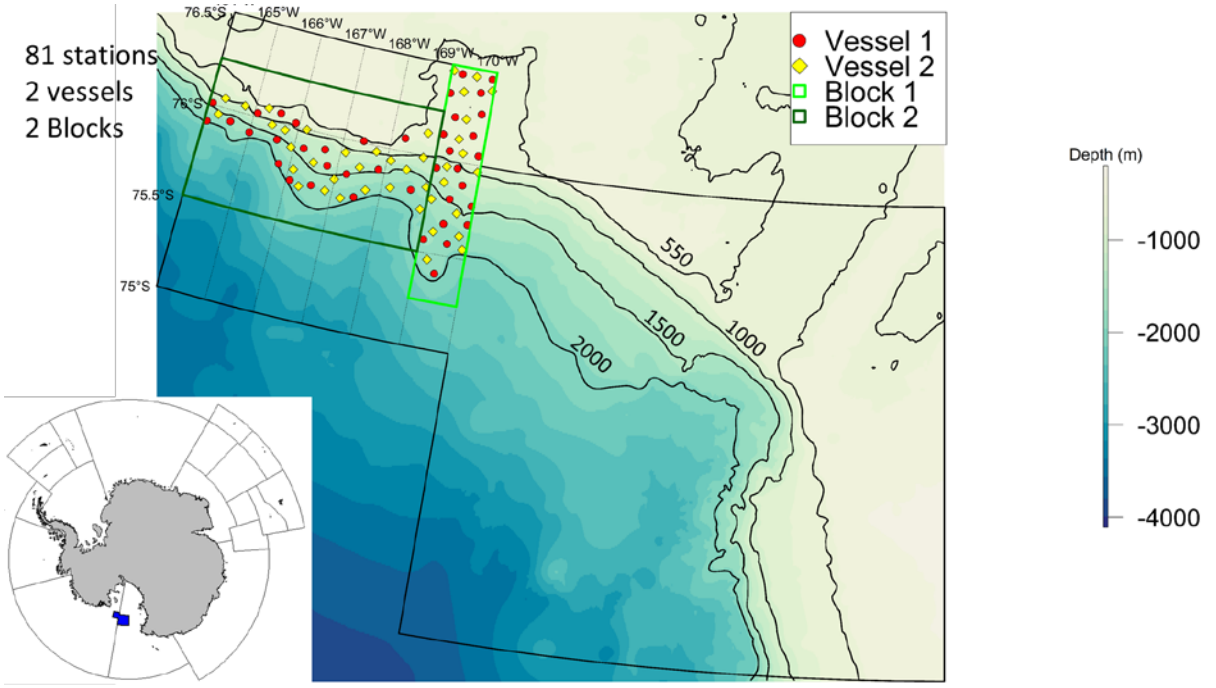


Figure 8: Map of the stations in the special research zone (SRZ) proposed to be conducted as part of the research plan in WG-FSA-2019/42 Rev. 1, following discussion during the Working Group meeting.

Appendix A

List of Participants

Working Group on Fish Stock Assessment
(Hobart, Australia, 7 to 18 October 2019)

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Systems Analyst	Ian Meredith
Data Steward	Dr Elanor Miller
Data Systems Analyst	Gary Dewhurst
IT Support Assistant	Data 3 (Patrick Moore)

Appendix B

Agenda

Working Group on Fish Stock Assessment
(Hobart, Australia, 7 to 18 October 2019)

1. Opening of the meeting

    1.1 Organisation of the meeting and adoption of the agenda

2. Review of data available

    2.1 Data management
    2.2 Catch and effort data and biological observations from CCAMLR fisheries
    2.3 Fishery Report updates

3. Review of updated stock assessments and provision of management advice (all fisheries)

    3.1 *Champsocephalus gunnari*
        3.1.1 *C. gunnari* in Subarea 48.3
        3.1.2 *C. gunnari* in Division 58.5.2

    3.2 *Dissostichus* spp.
        3.2.1 *Dissostichus eleginoides* in Subarea 48.3
        3.2.2 *Dissostichus* spp. in Subarea 48.4
        3.2.3 *Dissostichus eleginoides* in Area 58
        3.2.4 *Dissostichus mawsoni* in the Ross Sea region

4. Research to inform current or future assessments in data-limited fisheries notified under Conservation Measures 21-01, 21-02 and 24-01

    4.1 Generic issues
        4.1.1 Tagging performance
        4.1.2 Process for reviewing research proposals

    4.2 Management area research reviews and management advice
        4.2.1 *Dissostichus* spp. in Area 48
        4.2.2 *Dissostichus* spp. in Area 58
        4.2.3 *D. mawsoni* in Area 88
        4.2.4 Other fisheries research including crabs

5. Scheme of International Scientific Observation

6. Non-target catch and ecosystem impacts of fishing

    6.1 Incidental mortality of seabirds and marine mammals

    6.2 Invertebrate by-catch and vulnerable marine ecosystems (VMEs)
        6.2.1 Updates of fishing footprints
        6.2.2 Modelling benthic taxa distributions and habitats
        6.2.3 Review of listing of VME indicator taxa

    6.3 Marine debris

7. Future work

    7.1 Organisation of intersessional activities
    7.2 Notifications of other scientific research

8. Other business

9. Advice to the Scientific Committee

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

Appendix C

List of Documents

Working Group on Fish Stock Assessment
(Hobart, Australia, 7 to 18 October 2019)

WG-FSA-2019/01	Report of the Convener of the COLTO–CCAMLR Toothfish Catch and Effort Data Workshop (Cape Town, South Africa, 30 July to 1 August 2019) Secretariat and R. Arrangio
WG-FSA-2019/02	A preliminary assessment for mackerel icefish (*Champsocephalus gunnari*) in Division 58.5.2, based on results from the 2019 random stratified trawl survey D. Maschette, G. Nowara and D. Welsford
WG-FSA-2019/03	Estimates of abundance of *Dissostichus eleginoides* and *Champsocephalus gunnari* from the random stratified trawl survey in the waters surrounding Heard Island in Division 58.5.2 for 2019 G.B. Nowara, T.D. Lamb and P. Ziegler
WG-FSA-2019/04	A versatile approach to minimise damage or loss of longline gear due to sea-ice S. Hain, T. Brey and K. Teschke
WG-FSA-2019/05	Movements of tagged Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 48.6 in relation to stock structure hypotheses T. Ichii, M. Okazaki, T. Okuda and S. Somhlaba
WG-FSA-2019/06 Rev. 1	Measurement of capacity in CCAMLR exploratory fisheries in Subareas 88.1 and 88.2: Secretariat update 2019 Secretariat
WG-FSA-2019/07	Characterisation of the toothfish fishery in the Ross Sea region (Subarea 88.1 and SSRUs 88.2A–B) through 2018/19 J. Devine, S. Parker and A. Dunn
WG-FSA-2019/08	Assessment models for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region to 2018/19 A. Dunn
WG-FSA-2019/09	Stock Annex for the stock assessment of Ross Sea region Antarctic toothfish (*Dissostichus mawsoni*) A. Dunn and S. Parker

WG-FSA-2019/10	Diagnostic plots for the assessment models for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region to 2018/19 A. Dunn
WG-FSA-2019/11	Revised growth and length-weight parameters for Antarctic toothfish in the Ross Sea region (881 & 882AB) A. Dunn and S. Parker
WG-FSA-2019/12	Summary of the toothfish fishery and tagging program in the Amundsen Sea region (SSRUs 882C–H) to 2018/19 J. Devine and S. Parker
WG-FSA-2019/13	Research data collection in CCAMLR longline fisheries for toothfish using electronic monitoring on fishing vessels J.M. Fenaughty
WG-FSA-2019/14	The CCAMLR Taxon Data Project Secretariat
WG-FSA-2019/15 Rev. 1	Implementation of the CCAMLR Scheme of International Scientific Observation during 2018/19 Secretariat
WG-FSA-2019/16 Rev. 2	Summary of incidental mortality associated with fishing activities collected in scientific observer and vessel data during the 2019 season Secretariat
WG-FSA-2019/17	Research plan for toothfish survey in Subarea 48.1 by the Ukrainian vessel *CALIPSO* in a season 2019/20 Delegation of Ukraine
WG-FSA-2019/18	Gear loss reported by longline fishing vessels for the 2018 and 2019 fishing seasons Secretariat
WG-FSA-2019/19	Preliminary assessment of genetic diversity in bycatch-caught darkbelly skate (*Bathyraja meridionalis*) from South Georgia S. Pérez-Espona, W.P. Goodall-Copestake, P. Hollyman and M. Belchier
WG-FSA-2019/20	Report of the UK Groundfish Survey at South Georgia (CCAMLR Subarea 48.3) in January/February 2019 S. Gregory, P. Hollyman, T. Earl, A. Clement, J. Visagie, L. Featherstone and M. Belchier

WG-FSA-2019/21	Progress on the integrated stock assessment by CASAL for Antarctic toothfish *Dissostichus mawsoni* in Subarea 48.6 K. Sawada and T. Okuda
WG-FSA-2019/22	Annual report of research fishing operations at Subarea 48.6 in the 2018/19 fishing season Delegations of Japan, Spain and South Africa
WG-FSA-2019/23 Rev. 1	Revised proposal for continuation of a multi-member longline survey on Antarctic toothfish (*Dissostichus mawsoni*) in Statistical Subarea 48.6 in 2019/20 by Japan, South Africa and Spain Delegations of Japan, South Africa and Spain
WG-FSA-2019/24	Use of cameras and sensors to monitor the behaviour and benthic impact of longline gears C. Darby
WG-FSA-2019/25	Preliminary results from the third year of a survey into the connectivity of toothfish species in Subareas 48.2 and 48.4 G. Robson, A. Riley and P. Hollyman
WG-FSA-2019/26	Feeding ecology of the two sympatric fish species Notothenia rossii and *N. coriiceps* from western Antarctic Peninsula: a fatty acids and stable isotopes approach E. Moreira, M. Novillo, K. Mintenbeck, E. Barrera-Oro and M. De Troch
WG-FSA-2019/27	Preliminary tag-recapture based population assessment of Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 48.4 T. Earl and A. Riley
WG-FSA-2019/28	Assessment of Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 T. Earl
WG-FSA-2019/29	Assessment of Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.4 T. Earl and E. MacLeod
WG-FSA-2019/30	Preliminary assessment of mackerel icefish *Champsocephalus gunna*ri in Subarea 48.3 – Based on the 2019 Groundfish Survey T. Earl
WG-FSA-2019/31	Report on fishing effort and seabird interactions during the season extension trials in the longline fishery for Patagonian toothfish (*Dissostichus eleginoides*) in Statistical Division 58.5.2 P. Ziegler, T. Lamb, S. Wotherspoon and J. Dell

WG-FSA-2019/32	Draft integrated stock assessment for the Heard Island and McDonald Islands Patagonian toothfish (*Dissostichus eleginoides*) fishery in Division 58.5.2 P. Ziegler
WG-FSA-2019/33	Catch removals due to killer and sperm whale interactions across sub-Antarctic fisheries P. Tixier, P. Burch, F. Massiot-Granier, P. Ziegler, D. Welsford, M.-A. Lea, M.A. Hindell, C. Guinet, S. Wotherspoon, N. Gasco, C. Péron, G. Duhamel, R. Arangio, R. Tascheri, S. Somhlaba and J.P.Y. Arnould
WG-FSA-2019/34	Disentangling the influence of three major threats on the demography of an albatross community J.B. Cleeland, D. Pardo, B. Raymond, G.N. Tuck, C.R. McMahon, R.A. Phillips, R. Alderman, M.-A. Lea and M.A. Hindell
WG-FSA-2019/35	Comparison of age readings by two readers and preliminary results of age and growth of *Dissostichus mawsoni* in Subarea 88.3 M. Kim, S. Chung, S. Choi, C.P. Sutton and S.J. Parker
WG-FSA-2019/36	Population structure of the Antarctic toothfish, *Dissostichus mawsoni* from the Areas 58 and 88 in the Antarctic Ocean based on mitochondrial and microsatellite DNA markers H.-K. Choi, J.E. Jang, S.Y. Byeon, S. Chung, S.-G. Choi, H.-W. Kim and H.J. Lee
WG-FSA-2019/37	Molecular analysis of stomach contents from Antarctic toothfish (*Dissostichus mawsoni*) collected from Area 58 and 88 from 2016 to 2018 S.R. Lee, S.-G. Choi, S. Chung, D.H. An and H.-W. Kim
WG-FSA-2019/38	New results of oceanological research obtained on Ukrainian longline vessels in the CCAMLR area of responsibility in the season 2018/19 V. Paramonov, L. Pshenichnov, I. Slypko, P. Zabroda, A. Bazhan and T. Pestovskyi
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WG-FSA-2019/40	Revision of the precautionary approach to ensuring the rational use of the living resource (*Dissostichus eleginoides*) in Subarea 48.3 (full version) Delegation of the Russian Federation
WG-FSA-2019/41	Report on implementation of research program for study of species composition, biology and resource potential of craboids (Anomura, Decapoda) in the Antarctic Pacific in 2019 Delegation of the Russian Federation
WG-FSA-2019/42 Rev. 1	Research program to examine the life- cycle and resource potential of *Dissostichus* spp. in the Special Research Zone within the Ross Sea region marine protected area (RSRMPA) in 2019–2027 Delegation of the Russian Federation
WG-FSA-2019/43	Withdrawn
WG-FSA-2019/44	Continuation of multi-Member research on the *Dissostichus mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2018/19 to 2021/22 Delegations of Australia, France, Japan, Republic of Korea and Spain
WG-FSA-2019/45	Patagonian toothfish in the South Indian Ocean outside CCAMLR waters: a preliminary analysis of the SIOFA Patagonian toothfish population R. Sarralde, L.J. López-Abellán and S. Barreiro
WG-FSA-2019/46	VME detection thresholds: provision of a beta version of a R library to compute detection probabilities and preliminary results on the case of the sea pens (Pennatulacea) of the CCAMLR Division 58.4.4b A. Martin and M. Eléaume
WG-FSA-2019/47	2019 update of ongoing work on age and growth of Antarctic toothfish (*Dissostichus mawsoni*) from Divisions 58.4.1 and 58.4.2 Delegations of Australia, Republic of Korea and Spain
WG-FSA-2019/48	Correlation of sea-surface temperature (SST) with sea-ice concentration (SIC) between Subarea 48.6 and other areas such as Ross Sea, Weddell Sea T. Namba, R. Sarralde, S. Somhlaba and J. Pompert

WG-FSA-2019/49	Possibility of predicting sea-ice concentration (SIC) in research block (RB) 48.6-5 (Southern part of Subarea 48.6) using sea surface temperature (SST) in RB 48.6-2 (Northern part of 48.6) T. Namba, R. Sarralde, S. Somhlaba and J. Pompert
WG-FSA-2019/50	Effective, cost-limited and easy-to-implement photo-identification from fishing vessels: an alternative to no effort at all N. Gasco, P. Tixier and C. Lemarchand
WG-FSA-2019/51	Report on the research for *Dissostichus* spp. in Subarea 48.2 by the Ukraine in 2015–2019 Delegation of Ukraine
WG-FSA-2019/52	Proposal for multi-Member research on *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2 from 2019/20 to 2021/22 Delegation of the Russian Federation
WG-FSA-2019/53	Report on fish by-catch during research fishing activities in Division 58.4.4b between 2008 and 2018 C. Péron, C. Chazeau, N. Gasco and F. Massiot-Granier
WG-FSA-2019/54	No boundaries for whales interacting with fishing activities targeting Patagonian toothfish (*Dissostichus eleginoides*) N. Gasco, P. Tixier, F. Massiot-Granier, C. Péron and R. Sarralde
WG-FSA-2019/55	Proposal for a revised summary table used for assessment of new and ongoing research plans C. Péron and D. Welsford
WG-FSA-2019/56	Report on fish by-catch during exploratory fishing activities in Division 58.4.3a (Elan Bank) between 2008 and 2018 C. Péron, C. Chazeau, N. Gasco and F. Massiot-Granier
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WG-FSA-2019/62	CASAL model evaluation incorporating the calculation of harvest rate for *D. eleginoides* at Division 58.4.4b T. Okuda and F. Massiot-Granier
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WG-FSA-2019/65	Annual report of research fishing operations at Division 58.4.4b in the 2018/19 fishing season Delegations of Japan and France
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WG-SAM-2019/03	2019 Ross Sea shelf survey results and notification for research in 2020 S. Parker and C. Jones
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CCAMLR-38/BG/12	Fishery monitoring and closure procedures Secretariat
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SC-CAMLR-38/05	Report of the Working Group on Statistics, Assessments and Modelling (Concarneau, France, 17 to 21 June 2019)
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