**Report of the Working Group on
Statistics, Assessments and Modelling**
(Warsaw, Poland, 29 June to 3 July 2015)

Contents

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Opening of the meeting

1.1   The 2015 meeting of WG-SAM was held at the Ministry of Agriculture and Rural Development, Warsaw, Poland, from 29 June to 3 July 2015. The meeting was convened by Dr S. Parker (New Zealand).

1.2   Mr L. Dybiec (Ministry of Agriculture and Rural Development and former Chair of the Commission), Dr M. Kaniewska-Krolak (Ministry of Agriculture and Rural Development) and Dr M. Korczak-Abshire (Institute of Biochemistry and Biophysics of the Polish Academy of Sciences) welcomed the Working Group and outlined local arrangements.

1.3   Dr Parker welcomed participants (Appendix A) and noted the large number of papers received this year and the large workload that had been directed to the Working Group.

Adoption of the agenda and organisation of the meeting

1.4   WG-SAM discussed the agenda and agreed to include an item on Future work (Item 6). The revised agenda was adopted (Appendix B).

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

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

1.7   The report was prepared by M. Belchier (UK), A. Constable (Australia), R. Currey (New Zealand), C. Darby (UK), A. Dunn (New Zealand), T. Earl (UK), C. Jones (USA), D. Ramm, K. Reid and L. Robinson (Secretariat), M. Söffker (UK), D. Welsford and P. Ziegler (Australia).

Methods for assessing stocks in established fisheries

A review of progress towards updated integrated assessments of toothfish

2.1   WG-SAM-15/24 presented a CASAL assessment of research block 5843a_1 that included tag-release and recapture data from 2005 to 2014 and the sensitivity analyses recommended by WG-FSA-14.

2.2   The Working Group noted that the relatively high number of fish tagged in 2012 and the subsequent recaptures of those fish strongly influenced the model conclusions and, as a

consequence, these data had been excluded from some model runs. However, the Working Group agreed that models that included all the tag data were preferred and requested that consideration be given to additional data analyses that may lead to an understanding of the high level of tag recaptures from 2012.

2.3   The Working Group noted that the model should include stock-specific life-history parameters and age data, when these are available, and requested that model sensitivities be considered that included available age and growth data (e.g. as described in WG-SAM-15/11). Further, the Working Group requested additional model sensitivity analyses that considered the impact on results if the future depth distribution of fisheries were to change.

2.4   WG-SAM-15/25 presented a CASAL assessment for research block 5844b_1 in Division 58.4.4b. The analysis included five model runs, including alternative choices of the catch-per-unit-effort (CPUE) and tag datasets and alternative choices of selectivity for illegal, unreported and unregulated (IUU) fishing. The paper suggested excluding the 2008 tag and CPUE data. The Working Group noted the additional analyses recommended by WG-FSA-14.

2.5   The Working Group noted that IUU catch had been estimated in the model, and these estimates indicated that IUU catch much greater than the research catch had occurred over recent years. The Working Group requested that WG-FSA consider these results and other sources of information on IUU activity in the region to determine the best estimate of IUU catch to include in this assessment.

2.6   The Working Group agreed that the CPUE from 2008 was likely to reflect learning behaviour of the fishery and hence may not be an index of abundance. However, it also noted that the tag data from 2008 should be retained within the assessment model. It requested that model runs be carried out that examine the sensitivity to the 2008 tag data, along with the IUU selectivity modelled as a double-normal function.

2.7   The Working Group noted that the assessment model did not include any consideration of potential impacts on the stock from depredation, and methods to incorporate this into the assessment of toothfish in this division should be explored.

2.8   The Working Group inferred from results presented in WG-SAM-15/25 that it was possible that the catch limit calculated from the CCAMLR decision rule would lead to this stock being below 50% of initial biomass for a large number of years before recovering. The Working Group requested that projections be presented to WG-FSA for this assessment that examine the consequences of different harvest levels for the time to recovery to the target level.

2.9   The Working Group requested that Members provide analyses for discussion on the question of how to provide management advice for stocks that are expected to fall below target levels during the 35-year projection period to WG-SAM-16.

2.10   WG-SAM-15/34 presented analyses that considered potential biases in the calculation of priors for survey catchability coefficients (q) using abundance estimates from a random trawl survey and tag-recapture data. The Working Group concluded that estimates of q from such methods using these data were likely to be biased. The Working Group thanked the authors and noted that such simulation experiments were a valuable method for informing advice from WG-SAM.

2.11   The Working Group noted that WG-SAM-15/34 recommended the use of a uniform prior but also noted that it may be possible to calculate a prior for q based on priors of the components of catchability (i.e. vulnerability, vertical availability and spatial availability) from first principles. However, it also noted that determination of such priors may be confounded by the assumptions in the model and the spatial extent of different parts of the stock available to the survey.

2.12   WG-SAM-15/37 outlined a research plan and initial progress towards the evaluation of the stock structure and spatial distribution of toothfish between Divisions 58.5.1 and 58.5.2, along with simulation studies to evaluate potential bias in spatially distributed tag-release and recapture data, and presented initial work towards the development of methods to use spatially stratified tag-recapture data in an integrated stock assessment model.

2.13   The Working Group welcomed the research outlined by the authors. The Working Group noted that the analyses proposed in the paper would be a valuable contribution to understanding the stock structure spatial distribution and relationship of toothfish between Divisions 58.5.1 and 58.5.2. The Working Group also noted that consideration of how the assessments from Divisions 58.5.1 and 58.5.2 may be harmonised was an important outcome and that this work would lead to a better understanding of how this could be achieved.

2.14   WG-SAM-15/43 presented an investigation of the impact of including different subsets of tag data in the CASAL assessment of toothfish in Division 58.5.1. Previous analyses have indicated a poor fit to tag recaptures in the first recapture season that had a time of liberty of at least 12 months. The paper found that by reducing the minimum time at liberty to six months resolved the systematic lack of fit to recaptures in the first recapture season and resulted in a substantial improvement of the overall model fits to the tag data. The authors also noted that they had undertaken some sensitivity analyses on the choice of time at liberty and that small changes in the number of months at liberty were not influential on the results.

2.15   The Working Group noted that the substantial improvement in the fit of the model to tag data by the change in the time at liberty could be explained by the annual pattern of fishing. Vessels tend to return to similar fishing locations at similar times of the year and fish generally move only short distances, and thus the vessels tend to recover higher numbers of tagged fish after around 12 month of liberty. However, many recaptures were excluded in the model by limiting it to fish with a minimum time at liberty of exactly 12 months, and this pattern led to the poor fits in the original model fits.

2.16   The Working Group discussed whether the pattern of movement of vessels may be related to targeting pre-spawning aggregations or in response to sea conditions during the winter and encouraged additional analyses be undertaken that may allow an understanding of both the vessel and fish patterns of movement.

2.17   The Working Group noted that the likelihood profiles presented suggested that the POKER survey indicated a larger biomass than the tag data and suggested considering raising the upper bound for q, which currently is estimated at the upper boundary of 1, so that it did not unduly constrain the model estimates.

2.18   WG-SAM-15/49 presented additional analyses to the Amundsen Sea region CASAL two stock assessment models. The models had been revised following suggestions made at WG-FSA-14. The paper showed that a two-area model with sex- and age-specific migrations

from small-scale research units (SSRUs) 882C–G to SSRU 882H and back provided the best fits to the age and tag data, but that there were still some unexplained patterns in the residuals of the fit to the tag data.

2.19   The paper considered models that included a resident population in SSRU 882H that was combined with a migrating population from the south, annually varying or density-dependent migration and the choice of subsets of the tag data that excluded small fish. However, none of these provided any improvements to the fits to the tag data.

2.20   The authors noted that this model would be further developed over the intersessional period once additional data had been obtained from the fishery. Dr Welsford noted that otoliths collected by Australian vessels were currently being analysed and toothfish ages would be available for this area in the near future.

2.21   The Working Group welcomed the analyses and developments for the CASAL two-area model and encouraged its development using the additional data, including all available age data.

General

2.22   The Working Group noted different default values being used between assessments where no stock-specific data was present. For example, some assessments used a default value of steepness in the stock-recruit relationships of $h = 0.8$ while others use $h = 0.75$. It recommended that consideration by authors be given to standardising default parameter values, where appropriate, across species-specific assessments for use until there were data available that may allow a more informed approach.

2.23   The Working Group noted that the choice of priors for assessments was an important consideration and that choices of how priors were obtained or assumed should be clearly documented in both the assessment submissions from Members and CCAMLR's Fishery Reports.

2.24   The Working Group encouraged the development of analyses (including, for example, power analyses and simulation experiments) that would allow a better understanding of how much data is necessary for the production of a robust assessment and how long such data collection may take.

A review of stock assessment methodologies used in CCAMLR's integrated assessments

2.25   WG-SAM-15/23 presented an analysis of by-catch in CCAMLR longline fisheries undertaken by the Secretariat, which examined the proportion of target fish species in the total catch in the commercial C2 data and the CCAMLR Scheme of International Scientific Observation (SISO) data from 2008 to 2014 in the Ross Sea. The target catch to by-catch ratio results from the C2 data showed not only differences due to gear and fishing locations, but also a clear distinction into two groups according to Flag State of vessels, with one group having nearly double the ratio of the other. The differences were also apparent in the data reported through SISO.

2.26   The Working Group noted that the requirement to collect both target and by-catch data is the same for all CCAMLR longline fisheries and discussed potential reasons for the observed differences in the by-catch proportions in C2 data between Members.

2.27   Following discussion of WG-SAM-15/23, the Working Group requested that the Secretariat correspond with those Members that have participated in that fishery to obtain information in order to develop a better understanding of how by-catch data are collected and reported on the C2 forms. This correspondence should include a request to:

(i)   provide details, including examples where possible, of instructions provided to vessels on how the C2 data forms should be completed, in particular, how and what target and non-target catch data should be collected and submitted on those forms

(ii)   provide a description of how the data on target and non-target catch are actually collected and reported at-sea (this could be, if available, detailed instructions provided to vessels on methods for estimating catches), including, for example, whether:

(a)   the crew records the number and weight of all target and non-target catch for each haul

(b)   the international scientific observer records the number and weight of all catch and reports this to the vessel for inclusion in the C2 form

(c)   the international scientific observer makes detailed observations of (by-)catch on a sample of the line and the data is scaled up from this sample to complete the C2 form.

2.28   The Working Group recalled CPUE standardisation undertaken in the 1990s and considered that generalised linear mixed models (GLMM) or a case-control approach as used in the Ross Sea (WG-SAM-13/34) could be applied as an alternative to the method used in WG-SAM-15/23. However, the need for data from vessels using the same gear type and configuration (including the same bait type etc.) fishing in close proximity to each other may limit the use of these approaches.

2.29   In response to a request from the Working Group, the Secretariat provided a generalised linear model (GLM) analysis that included gear type, fishing location at 1 degree by 1 degree cells in the Ross Sea and Flag State as covariates. This analysis indicated that a significant effect of Flag State remained even when the spatial distribution of fishing and gear type were taken into consideration.

2.30   Dr S. Kasatkina (Russia) highlighted the significant spatial–temporal variability of the target catch ratio as well as variability for different longline gear types and between Flag States. This variability may be a specific characteristic of by-catch in the Ross Sea exploratory fishery and fish distribution patterns. She proposed to use GLMM for analysis of by-catch data. It will provide a possibility to investigate specific and dynamic by-catch as functions of different variables across various spatial units in the Ross Sea. She proposed to undertake this analysis for WG-SAM-16.

2.31   The Working Group recalled that a number of issues related to differences in the reporting of observer data have already been highlighted in the SISO review in 2013 and in discussion of the rationale for the CCAMLR Observer Training Program Accreditation Scheme (COTPAS). The Working Group recommended a review of the training and instructions provided to observers on by-catch reporting.

2.32   The Working Group agreed that it was important to distinguish between differences in by-catch reporting by Members and through SISO, noting that these would be issues for the Commission and Scientific Committee respectively.

2.33   WG-SAM-15/26 described progress towards the development of a set of standard diagnostic principles and tools used to characterise toothfish stock assessment models and evaluate whether a model is well specified and fits the data adequately.

2.34   The Working Group noted the large and increasing number of toothfish stock assessments that are being evaluated by WG-SAM and WG-FSA. It noted that a standard set of diagnostics and model output would help the working groups to provide adequate advice, and could also serve as a teaching aide for scientists with relatively less experience in integrated assessments.

2.35   The Working Group set out to develop a minimum set of diagnostic tools for integrated assessments to evaluate if a model is well specified and fits the data adequately. It also noted that there is a need to determine what tools can be used to assess whether a stock assessment model is sufficiently robust to provide management advice.

2.36   The Working Group developed an initial set of diagnostics that includes two types of information, firstly a description of model structure and baseline data, and secondly a set of model diagnostics. It recommended that as many of this initial set of diagnostics be used in stock assessments presented to WG-FSA-15 as is possible in the given timeframe.

2.37   For each stepwise change in a preliminary stock assessment, diagnostics shown in Appendix D should be submitted with the assessment as an attachment, and the description should include information on:

   (i)   model structure, including catch equations

   (ii)   fixed parameters and what qualitative or quantitative data was used to justify their choice (e.g. growth curve assumption where not estimated, choice of recruitment function)

   (iii) estimated parameters, their priors, associated distributions and bounds, and for each prior what qualitative or quantitative data was used to justify their choice

   (iv)   all observations (including their values, variances and justification of choice) that the model was fitted to.

2.38   In addition, copies of the following files should be submitted for the candidate model runs for preliminary stock assessments presented to the Secretariat together with documents describing the assessment (SC-CAMLR-XXXI, Annex 7, paragraph 12.5):

(i)   the model input files associated with each candidate model run (e.g. for CASAL models, this includes the population.csl, estimation.csl and the output.csl)

(ii)   maximum of the posterior density (MPD) point estimates

(iii)   Markov chain Monte Carlo (MCMC) samples and objectives file (if MCMC sampling has been conducted).

2.39   The Working Group recalled that the Secretariat routinely conducts model validation runs and reports on these to WG-FSA (WG-FSA-06/06, paragraphs 6.1 and 6.2; SC-CAMLR-XXXII, Annex 6, paragraph 4.93).

2.40   The Working Group noted that in addition to this information, a table with the stepwise changes from the model recommended in the previous year to the recommended model in the current year should be presented.

2.41   The model diagnostics relate to the MPD fits, likelihood profiles, MCMC sampling and derived parameters from the model. MPD fits should be used to evaluate candidate models, and the most promising candidate model or models will then be taken forward to MCMC sampling. The management advice should be based on these MCMC estimates.

2.42   Appendix D summarises the recommended diagnostics which include:

(i)   table of process error weighting
(ii)   table of the MPD components
(iii)   plots on age- and length-frequency and abundance data and mean age
(iv)   plots on indices of abundance (e.g. from survey or catch rates)
(v)   plots on tagging data
(vi)   likelihood profiles
(vii)   MCMC model convergence
(viii)   MCMC parameter estimates with MCMC credible intervals
(ix)   model-derived estimates with MCMC credible intervals for e.g. selectivity functions, spawning and total biomass, stock status, year-class strength, stock biomass projections and risk profiles.

2.43   The Working Group recommended that model diagnostics should be developed further and welcomed future developments into how to incorporate structural model and parameter uncertainty into management advice. These issues should be regularly reviewed at future WG-SAM meetings. It further recommended to develop common R code that can be deposited at the Secretariat and be made available when preparing stock assessments. The established Toothfish Assessment Diagnostics e-group was tasked with developing common R code prior to WG-FSA-15.

2.44   WG-SAM-15/29 reviewed the fishery and tagging data for Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 in order to characterise the fishery selectionpattern. The paper provided several metrics to identify whether a cryptic biomass is present outside the fishing range and suggested that the distribution of tag age with depth indicated that a dome-shaped selection pattern is unlikely in this fishery.

2.45   The Working Group agreed that the results from the metrics used in this paper were consistent with the way the stock assessment model was fitted and results from the stock

assessment model in Subarea 48.3. Both analyses support the conclusion that the fish in the deeper waters in Subarea 48.3 mix with the fish at target fishing depth and thus the assumption of a flat-topped selectivity model is appropriate in the stock assessment for Subarea 48.3.

2.46   WG-SAM-15/30 discussed a potential link between the *D. eleginoides* stocks of Subareas 48.3 and 48.4. Different growth rates and maturity suggested that there is no regular exchange between the two areas, but tag-recapture data clearly show a small number of toothfish moving from Subarea 48.4 to Subarea 48.3 and genetic analyses indicate that both stocks belong mostly to the same genetic population. The two areas are currently assessed separately, as this is the most precautionary approach given the limited knowledge.

2.47   The Working Group discussed potential implications of fish movement for the stock assessments of *D. eleginoides* in Subareas 48.3 and 48.4 and the potential for a two-area stock assessment model covering both subareas. The Working Group considered that a two-area stock assessment would pose considerable difficulties, as it would require strong assumptions about movement rates. Currently, there is evidence for movement of some fish from Subarea 48.4 to Subarea 48.3, but only one fish tagged in Subarea 48.3 has been recaptured in Subarea 48.4.

2.48   The Working Group welcomed a proposed workshop that Australia intends to organise in 2016 on complex spatial stock structures and how to represent them in stock assessments. Such a workshop could address stock assessment questions related to the fish movement, stock structures and stock assessment approaches as used in e.g. Subareas 48.3 and 48.4, Divisions 58.5.1 and 58.5.2 and Subareas 88.1 and 88.2.

2.49   WG-SAM-15/33 presented an update on the major overhaul of the CCAMLR database and supporting infrastructure. The new structure follows the Enterprise Data Model and is intended to simplify the database architecture, improve data-quality assurance and modernise the workflow. As a result, data quality and database documentation should substantially improve for users from late 2015 onwards.

2.50   The Working Group welcomed these database developments to improve integration of fishery and observer data from different sources. The Working Group requested that the Secretariat provide sufficient documentation on workflow, data quality control, metadata and changes to the database structure, as well as summaries of any changes to data. The Working Group agreed that a summary log of changes would be useful for each extraction. The Working Group also recalled that an example for data extraction has been documented in WG-FSA-13/56.

2.51   The Working Group requested that the roll-out of the new database structure not be carried out prior to WG-FSA-15. Even with substantial testing and system evaluation conducted by the Secretariat prior to the roll-out, data users will still need to conduct comparisons between the old and new data extracts and such an evaluation may delay any stock assessment work for WG-FSA-15.

2.52   WG-SAM-15/P01 presented an approach to standardise fishing power between vessels fishing in the same area at the same time, whereby the vessel power is calculated relative to a standard vessel that is particularly active and would allow many within-fleet comparisons over the time period of the analysis.

Seabed area

2.53   WG-SAM-15/01 examined differences in (i) planimetric seabed area within fishable depth ranges based on the General Bathymetric Chart of the Oceans (GEBCO) 2008 and GEBCO 2014 datasets, and (ii) planimetric and surface area estimates for the same areas using the most up-to-date global bathymetry dataset provided in GEBCO 2014. Differences between the GEBCO datasets varied between 0% and 62% depending on the research block examined in the fishable depth range. Results from the comparison of total surface and planimetric area within the fishable depth range of a research block showed differences of less than 2% and, therefore, the use of surface area was unlikely to affect calculations of toothfish density using the CPUE analogy method. However, at finer scales, including those used in habitat models, these differences would be important.

2.54   The Working Group thanked the Secretariat for its work to compare the different datasets and agreed that using the most up-to-date dataset (which in this analysis was GEBCO 2014 rather than GEBCO 2008) is the best practice. It recognised that the latest dataset is likely to improve calculations of seabed area, particularly on the continental shelf.

2.55   The Working Group also noted that fishing vessels could provide useful sources of bathymetric data but noted that the data from the vessels' plotters were likely to be more reliable than the depths reported in haul-by-haul records. Calibration of vessel data will be an important part of the process for contributing these data to bathymetric modelling such as, for example, the process being undertaken by the SCAR Expert Group on the International Bathymetric Chart of the Southern Ocean (IBCSO). The Working Group suggested that, where the collection of bathymetric data has been identified in a research plan, consideration will need to be given to how that data will be turned into suitable products within the time frame specified in the research plan.

Depredation

2.56   WG-SAM-15/27 and 15/28 reviewed methods used within the CAMLR Convention Area for reducing depredation of toothfish on longlines by large marine predators and summarised depredation activity within the CCAMLR area. In some subareas, depredation is well studied and included in stock assessments, and these areas have trialled a range of mitigation methods and developed approaches to minimise fishery–mammal interactions. Acoustic methods currently in circulation to mitigate depredation have been found to be ineffective. The most effective method to date uses move-on provisions that minimise interactions with odontocetes together with using shorter lines and faster hauling rates. Inclusion of depredation in stock assessments will be important in those areas with exploratory fisheries where the issue is regularly observed.

2.57   The Working Group agreed that this was an important issue to be resolved urgently. It noted that the issue involves three parts: (i) mitigation, (ii) impacts on stock assessments, including removals and the effects on tagging programs, and (iii) ecosystem effects of altered foraging ecology and the provision of food resources to odontocete populations.

2.58 Dr Welsford noted that this subject was also a high priority at the recent Coalition of Legal Toothfish Operators (COLTO) meeting of industry and scientists. A working group had been formed by COLTO to address different aspects of the issue.

2.59 Drs K.-H. Kock (Germany) and Currey indicated that the Scientific Committee for the International Whaling Commission (IWC SC) was considering killer whale population studies and that there are synergies between the work needed by CCAMLR and the IWC.

2.60 The Working Group suggested that WG-EMM and WG-FSA consider the process by which the three parts of the depredation issue might be addressed so that recommendations can be made to the Scientific Committee. For example, establishing a group to work on mitigation of depredation may be similar to the approach taken by the Scientific Committee in establishing WG-IMAF to address a specific issue within CCAMLR. The Working Group noted that further discussion on this issue would benefit from coordination with COLTO and the IWC.

2.61 The Working Group recommended that intersessional discussions be initiated to begin work on the first of the three priorities and consider issues around odontocete depredation, including killer whale behaviours and the use of mitigation measures that are effective and easy to put into place to reduce depredation. Drs Belchier, Söffker and Mr N. Gasco (France) agreed to coordinate these discussions.

Management strategy evaluation (MSE)

2.62 WG-SAM-15/48 described the development of a management strategy evaluation (MSE) for the Ross Sea toothfish fishery. It used some example parameters and parameter values to assist in prioritising further MSE analyses on the performance of the feedback mechanisms that the CCAMLR decision rules provide. It noted that different assessment models may be sensitive to different parameters and parameter values, and may require different approaches to MSE. It also noted the importance of simulation studies for testing the sensitivities of assessment models to different parameters and, where possible, developing and maintaining data collections that can contribute to more accurate parameter specifications for any parameters identified as priorities through the MSE process.

2.63 The Working Group noted that the evaluation of management strategies involves testing of assessment scenarios, including the effects of misspecification of parameters, as well as examining the performance of the management strategy in the long term, which could result in biases in assessments that may have long-lasting inadvertent impacts on stocks. Evaluations will be able to help identify whether errors in assessments in one or more years may result in long-term issues.

2.64 The Working Group noted that MSE was also being undertaken in a number of areas, including through the International Council for the Exploration of the Sea (ICES), and in the FRDC project relating to toothfish stock assessments in Divisions 58.5.1 and 58.5.2 (WG-SAM-15/37). It recommended that intersessional correspondence be initiated to progress MSE for toothfish fisheries, including evaluating the performance of data collection methods, assessments and harvest control rules, led by Mr Dunn. The outcomes from this group could be initially reported to WG-SAM-16.

Research plans for data-poor exploratory fisheries

3.1   The Working Group undertook to develop a report card style summary of the progress of each research plan submitted under Conservation Measure (CM) 21-02 and each research proposal submitted under CM 24-01. The criteria consisted of the original research plan evaluation criteria developed by WG-SAM in 2012 (SC-CAMLR-XXXI, Annex 5, Table 6), the requirements for sampling dependent species in CM 22-01 and new criteria to summarise the progress towards an assessment. The Working Group noted that several of the criteria have become irrelevant since the 2012 reviews and that a more structured review process and summary of progress could be developed for the future under Agenda Item 6 (Future work). To provide more detailed information from the self-assessments of research plans and proposals, Drs Parker and Darby, along with the Secretariat, offered to annotate the table and describe how the review process developed under Future work could be further developed by WG-FSA to promote the development of stock assessments.

Subarea 48.6

3.2   The Working Group recalled that South Africa and Japan had been conducting research fishing for *Dissostichus* spp. in Subarea 48.6 under a research plan established in 2012, with the aim of collecting data that would lead to an assessment within 3–5 years. WG-SAM-15/50, jointly authored by South African and Japanese scientists, presented the progress towards the development of a robust stock assessment of *Dissostichus* spp. in this subarea. The Working Group noted that in 2013/14, tagged Antarctic toothfish (*D. mawsoni*) had been recaptured in research block 486_4, which indicated potential to include tagging data for this area in stock assessments in the near future. The Working Group further noted that considerable data on the reproductive biology of *D. mawsoni* had been collected showing a clear pattern of gonadosomatic index peaking during May and June (WG-SAM-15/06), confirming the hypothesis that peak spawning of this species occurs during the austral winter, and spawning fish seem to occur over seamounts in the north of the subarea.

3.3   The Working Group noted that a large amount of data had been collected over the duration of the research plan and requested that a summary of data be submitted to WG-FSA-15. It encouraged the development of a preliminary stock assessment model for research block 486_2 where a sufficient time series of tag recaptures may exist. The Working Group also noted that age data had not yet been developed. It noted that age data were now being prepared and encouraged South Africa and Japan to expedite this work for inclusion in stock assessments.

3.4   WG-SAM-15/06 and 15/39 provided proposed work plans by Japan and South Africa respectively for 2015/16. The Working Group noted that the details of the proposal were similar to those in previous years. It further noted that Japan proposed to add two additional research blocks along the slope of the continent either side of research block 486_4, which would substitute research block 486_5 in case the block is under adverse ice conditions, but that no research had been conducted in research block 486_5 due to persistent sea-ice.

3.5   The Working Group recalled the Commission's request that the Scientific Committee and relevant working groups examine the scientific implications of additional flexibility, such as extending research activities to areas outside the designated research blocks when they are

inaccessible due to ice condition (CCAMLR-XXXIII, paragraph 5.43). The Working Group also recalled its discussion last year on developing new research blocks (SC-CAMLR-XXXIII, Annex 5, paragraph 3.14) and the importance of focussing fishing in the existing research blocks to obtain the data required for a robust assessment. Dr T. Ichii (Japan) indicated that Japan will submit a revised proposal on the design of research block 486_4 to WG-FSA-15.

Subarea 58.4

3.6   WG-SAM-15/02 presented a proposal by Spain to complete the third year of the depletion fishing experimental approach that it is conducting in Divisions 58.4.1 and 58.4.2. During 2014/15, the vessel had not been able to conduct its planned research due to a technical problem. Spain noted that it had initiated an ageing program and an age–length key (ALK) from the previous surveys would now be available for the subarea.

3.7   The Working Group welcomed the progress on developing an ageing program by Spain, and requested it submit a paper describing it to WG-FSA-15. It noted that the proposal included modifications in response to recommendations by the Scientific Committee, in particular that the lines during the depletion experiments would be laid closer together. It further noted that the proposal stated that the vessel would complete the research in Division 58.4.1, after fishing in the Ross Sea (Subarea 88.1) exploratory fishery, if sufficient fuel was available. Therefore, there was a risk that the vessel would not be able to complete the proposed research in 2015/16. The Working Group agreed that while the research plan was appropriate, it requested that Spain consider how to maximise the likelihood that the vessel could undertake its research commitments in a revised proposal for review by WG-FSA-15.

3.8   WG-SAM-15/10 presented a proposal by Australia to undertake a dedicated research fishing in Divisions 58.4.1 and 58.4.2 for the next three years. The vessel planned to visit each of the existing research blocks and deploy spatially separated fishing sets to determine relative density of toothfish and by-catch species, release tagged fish and attempt to recover tagged fish released in the locations where Spain had conducted depletion experiments. Cameras and conductivity temperature depth probes (CTDs) will be attached to longlines to collect data on the habitat and environmental conditions across the research areas.

3.9   The Working Group noted that the research design was appropriate to achieve the stated objectives and progress towards a stock assessment for the exploratory fisheries in Divisions 58.4.1 and 58.4.2.

3.10   The Working Group noted that while the proposal would operate within the existing catch limits for the research areas, there was no information provided as to how much catch the vessel is expected to take to allow comparison with other proposals in the same area such that advice can be provided on research priorities in the area if catches exceed the advised levels. It further noted that the survey would fish in the area that Spain had notified for its three-year research plan (WG-SAM-15/02) and that the research could impact the results of that program depending on the sequence that the Australian and Spanish vessels visited those locations. It agreed that the research program using a dedicated vessel with no other

commitments was an advantage to completing the work. However, it also agreed that there needed to be collaboration and coordination with other Members' research programs to ensure that their objectives would not be impacted.

3.11   WG-SAM-15/04 and 15/05 presented the results of the most recent analysis of data collected by Japan in Divisions 58.4.1 and 58.4.2 and a proposal for a further three years of research using the previously agreed research design. The current season (2014/15) is the final of the three-season research plan in these data-poor fisheries. Catch, effort and biological data were analysed in relation to the development of stock assessments within each research block and stock sizes were estimated using the modified Petersen estimator and the CPUE by seabed analogy. The proposal would include an enhanced tagging program, as well as collection and analysis of biological data, including otoliths and gonads to clarify migration routes and associated life stages of toothfish.

3.12   The Working Group recalled hypotheses regarding stock structure in this region based on exploratory fisheries data (Agnew et al., 2009; WG-FSA-11/35) which indicate that recruitment is likely to occur near Prydz Bay. The gonadosomatic indices (GSIs) during the austral summer tend to be more progressed in SSRU 5842A, suggesting that aggregations of mature fish may move to BANZARE Bank to spawn.

3.13   The Working Group noted that during the previous three-year research plan, very little fishing effort had occurred due to the strong seasonal pattern of sea-ice and prioritisation of research fishing in other areas during the summer when the research blocks are most likely to be open. The Working Group noted that as the vessel proposed by Japan to conduct research in this region was also planning to conduct research in Subarea 48.6 as a priority, there was a risk that it may not be able to conduct research in Divisions 58.4.1 and 58.4.2 in the coming years.

3.14   WG-SAM-15/35 presented the results of the first year of the five-year research plan conducted by the Republic of Korea in Divisions 58.4.1 and 58.4.2 in 2014/15. Korea collected and analysed the catch, effort and biological data (length, weight, gonadal development) and samples of stomach contents and muscle tissue, which it intends to analyse to construct food-web models. Korea also presented a notification (WG-SAM-15/07) to conduct research fishing in Divisions 58.4.1 and 58.4.2 in 2015/16 to collect the catch and effort, CTD, biological and tagging information, including the deployment of pop-up archival tags.

3.15   The research fishing had caught a total of nine species; 706 *D. mawsoni* were tagged at a rate of over 5 fish per tonne and an 80% overlap statistic was achieved. CTD casts were also performed and satellite archival tags had been released, however, not all planned research sets could be completed due to weather and ice conditions.

3.16   WG-SAM-15/15 and 15/16 presented notifications by France to conduct research fishing for toothfish (*Dissostichus* spp.) in Divisions 58.4.1 and 58.4.2. The fishery in these regions had been limited to relatively few vessels with limited fishing activity. France notified its wish to collaborate in the research fisheries with other Members over the coming years in order to participate in the tagging program and achieve a robust stock assessment. The papers presented proposals for a research fishing plan for 2015/16 developed under CM 41-01.

3.17   The Working Group noted that there was a need to coordinate research across all of Subarea 58.4 to ensure that vessel effort was distributed to make the most effective use of the research and ensure rapid progress towards an assessment of the stock in the area. It suggested that a correspondence group be set up to progress this prior to WG-FSA-15.

3.18   The Working Group noted that the authors of WG-SAM-15/03 referred to large inconsistencies between the C2 and the observer data from 2005/06, and that the observer data had been used as the basis for the tagging information. The Secretariat confirmed that during the initial period of reporting tagging data in the C2 forms (2005/06) there were some differences between the vessel and observer data, but in subsequent years there was good agreement. The Working Group noted that recaptures of tagged fish released early in the development of this fishery may not provide any useful information on stock abundance due to issues with fish condition and tag overlap. It, therefore, requested that sensitivity tests be conducted to evaluate the impact of exclusion of these tags on the stock assessment be presented to WG-FSA-15.

3.19   It also requested that WG-FSA-15 consider developing principles for dealing with tagging data originating prior to the requirements for tagging to occur in proportion to fish length and the development of fish condition assessment criteria.

Division 58.4.3a

3.20   WG-SAM-15/03 presented a proposal by Japan to continue its research fishing in Division 58.4.3a for a further three years using the previously agreed research design. The research would continue the tagging program, as well as collection and analysis of biological data, including otoliths and gonads, to document migration routes and associated life stages of the fish.

3.21   The Working Group noted that the authors of WG-SAM-15/03 suggested that the stock is a closed unit. However, the Working Group recalled that genetic studies indicated that a metapopulation was likely to exist across the Indian Ocean sector (WG-FSA-03/72). Furthermore, evidence of spawning activity and juvenile recruitment would be required to confirm that Elan Bank supported a self-sustaining population.

3.22   WG-SAM-15/11 presented the results of research fishing and assessment analysis in Division 58.4.3a since 2012 by two vessels from Japan and France. France also notified its intention to continue the multi-Member research fishing over the coming years in order to achieve a robust stock assessment that would provide advice on a catch limit according to CCAMLR decision rules.

3.23   The Working Group noted that a CASAL assessment was being developed for the stock by France and Japan, but that this had been associated with data that had high concentrations of fishing effort and in the most recent year an increasingly high catch rate of tagged fish. It noted that the CASAL models had shown substantial uncertainty, but could still be used to integrate the various sources of data to provide an evaluation of the trends in the stock, identify critical data gaps and the level of risk associated with the current level of removals.

Generic

3.24   The Working Group noted that there was a need to agree time frames that were realistic to the objectives of research proposals in developing assessments that can be used to provide management advice. However, there was also a need to provide a review process such that research in each fishery could be prioritised and coordinated between Members and reviewed to ensure the Scientific Committee is satisfied with progress towards CCAMLR's objectives. Such a review process could also guide proponents in adapting their research plans.

3.25   The Working Group noted that with the increase in the number of research proposals in Subarea 58.4 there was a possibility that conducting research fishing under the conditions of an Olympic fishery may impact the quality of, and ability to successfully complete, each individual research program and delay reaching the overall objective of developing a stock assessment. The Working Group agreed that there needed to be a review of the proposals in each area relative to their progress in developing assessments for each region such that the Scientific Committee can advise the Commission on priorities for future research. Areas in which multiple Members have applied to conduct research need to be coordinated among proponents – as some areas were not being visited while others had potentially competing proposals. It was agreed that further consideration of combined coordinated proposals should be brought forward to WG-FSA-15.

Research proposals in other areas (closed areas, areas with zero catch limits, Subareas 88.1 and 88.2)

Subarea 48.2

4.1   The Working Group reviewed WG-SAM-15/38 which described the preliminary results obtained from a research survey for toothfish undertaken by Ukraine in Subarea 48.2 in 2015. This was the first year of a three-year program of research carried out using trotlines.

4.2   The Working Group thanked Ukraine for the report and noted that it would be developed further for consideration at WG-FSA. The Working Group requested that more detailed information regarding the distribution of the two species of toothfish in the survey area be provided to WG-FSA. It noted that there are marked spatial and bathymetric differences in the distribution and abundance of the two species across the banks and seamounts in the research area. The Working Group noted that there had been difficulties in tagging large fish during the research but this had been resolved by modifying the method by which fish were brought on board (using a net mounted in a frame as described in WG-FSA-07/36).

4.3   The Working Group was informed that ageing of the sampled catch would be undertaken by Ukraine and that fish tissue samples had been provided to the UK which, subject to funding, will be used as part of a genetic study to investigate stock linkages.

4.4   The Working Group considered WG-SAM-15/40 which summarised the plan for continuing the Ukrainian toothfish research in Subarea 48.2 in 2016. The Working Group noted the proposal to stratify the survey by area by dividing the survey region into the northern bank and the southern seamount area. The Working Group also noted that a

reduction of the tagging rate to 3 fish per tonne was proposed in the southern seamount stratum as a result of the density of longline sets in this area being higher than in the northern banks region.

4.5   WG-SAM-15/53 described a proposal by Chile to undertake a three-year program of toothfish research fishing in Subarea 48.2 using cachalotera trotline gear. The Working Group noted the marked similarity in the survey design, station location and area presented in the proposal with that currently being carried out by Ukraine (paragraphs 4.1 to 4.4) and recommended that Chile coordinate its research program with Ukraine's, noting that it is effort limited not catch limited, in the first instance. The Working Group also noted that the Chilean research would be a year behind that of Ukraine and the proponents should consider how this work could be better coordinated in view of the common aim of an integrated stock assessment for the area. The Working Group also noted that no precautionary catch limit had been provided in the proposal.

4.6   The Working Group agreed that the use of the cachalotera nets on the trotlines was considered unnecessary for this planned research as whale depredation has not previously been observed in the area and was unlikely to occur in Subarea 48.2. The use of cachaloteras was also considered more likely to cause damage to the catch which could reduce the availability of fish suitable for tagging.

4.7   WG-SAM-15/12 summarised a research proposal by Chile to conduct a trawl survey of finfish resources on the shelf areas of Subareas 48.1 and 48.2. The Working Group noted that this research had previously been approved by the Scientific Committee (SC-CAMLR-XXXII, paragraphs 9.1 and 9.2).

Subarea 48.5

4.8   WG-SAM-15/22 presented a reanalysis by Russia of data collected during the 2012/13 Russian research program in the Weddell Sea (Subarea 48.5). In the paper, C2 and logbook data collected by the vessel *Yantar 35* from Subareas 88.1 and 88.2 were compared with that obtained from the same season in Subarea 48.5. Vessel monitoring system (VMS) positional data were also presented.

4.9   Dr Kasatkina noted that WG-SAM-15/22 reported on data from of the Russian research program in Subarea 48.5 (Weddell Sea) in 2012/13. In her view, the data were analysed in accordance with the Scientific Committee recommendations (SC-CAMLR-XXXIII, paragraphs 3.230 to 3.234). Catches, positioning the vessel, tagging program and recommended fishing indices in Subareas 88.1, 88.2 and 48.5 were analysed and compared. The paper reported that CPUE (kg/thousand hooks; daily catch) in the Weddell Sea was higher in comparison with the Ross Sea and Amundsen Sea in 2012/13. Dr Kasatkina highlighted that the Russian Federal Agency for Fisheries established a special group and identified responsible persons for the purpose of completing analysis of research fishing data from the Russian program in the Weddell Sea in 2012–2014. She indicated that the analysis will include contact with the captain of the vessel and the international observer on board the Russian vessel. The report will be submitted when finalised.

4.10   The Working Group thanked Russia for the analysis of the 2012/13 data but recalled the advice of the Scientific Committee (SC-CAMLR-XXXIII, paragraph 3.232) that Russia had been requested to provide a finalised analysis of data obtained by the *Yantar 35* in Subarea 48.5 for both the 2012/13 and 2013/14 seasons for consideration by WG-SAM-15. As WG-SAM-15/22 reported only on the data reanalysis from the 2012/13 season, the Working Group was unable to provide any further assessment of the analyses and recommended that the data concerned remain quarantined until such time that the complete analysis has been undertaken and submitted for consideration by WG-SAM.

4.11   The Working Group sought further analysis and explanation of the VMS-derived vessel track data presented in WG-SAM-15/22, Figure 7, which appeared to show inconsistencies between fishing locations and vessel movements within research blocks. The vessel VMS showed consistent tracks in positions where no lines had been deployed according to the report. There were also two tracks presented of the vessel entering and leaving the area. The Working Group noted that this report from the Russian Federation should therefore be brought to the attention of the Standing Committee on Implementation and Compliance (SCIC).

4.12   Dr Kasatkina presented in WG-SAM-15/18 a proposal based on the original research program approved in 2012 with some modifications that, in her opinion, were consistent with the original research objectives approved in 2012 (SC-CAMLR-XXXIII, paragraph 3.233) for implementation in 2015/16. She noted that:

(i)   the proposed program would be conducted with a new fishing company and fishing vessels and scientific observers

(ii)   a scientist from another Member country will be invited to take part in the cruise

(iii)   implementation of the Russian research program will provide information about toothfish distribution and biological parameters to estimate stock status in the future

(iv)   values of CPUE were four times higher than in the Ross Sea and concluded that the Weddell Sea is a prospective area for an exploratory fishery.

4.13   The Working Group considered the proposal by Russia (WG-SAM-15/18) to revise the original research fishing proposal submitted in 2012 (WG-FSA-12/12). It was noted that this proposal was based on an assumption that there was no information originally available for the area. During 2012/13, Russia fished in the area and was only able to deploy eight lines before the quota was exhausted. The revised proposal detailed two vessels fishing in the area in which the catch rates, if consistent with those noted in WG-SAM-15/22, would imply that only a very small number of lines would be deployed by each vessel providing very limited information for analysis. The Working Group also concluded that once the analysis of the quarantined data was complete, the strategy recommended to achieve the research objectives may change and, therefore, the proposed design cannot be considered appropriate at this time to reach the original objectives agreed by the Scientific Committee (SC-CAMLR-XXXIII, paragraphs 3.232 and 3.233).

4.14   The Working Group also noted that the area of option 3 of the proposal had not been free of ice in recent years and, therefore, the proposal for this area was unlikely to be

achieved. The Working Group also recalled the concerns expressed regarding the ability to carry out research safely in Subarea 48.5 in locations that were frequently ice covered.

4.15   The Working Group agreed that, as a result of the uncertainty created by the incomplete analysis conducted by Russia, the Russian revised research plan for Subarea 48.5 did not meet the CCAMLR objectives and could thus not be recommended. The Working Group noted the request by Russia to conduct collaborative research in the area. The Working Group will be able to revisit proposals for this area when the data reanalysis requested by the Scientific Committee in 2014 has been fully evaluated.

4.16   The Working Group considered WG-SAM-15/08, a proposal by the Republic of Korea to conduct a three-year program of toothfish research fishing in Subarea 48.5. The Working Group noted that the planned research is based on the preliminary results of the Russian research conducted in Subarea 48.5 from 2012 to 2014 for which the data are currently quarantined (paragraph 4.10). Given the uncertainty surrounding these data, Korea withdrew the proposal for 2015/16 and indicated that it would consider resubmission subject to the outcomes of the reanalysis of the Russian data.

Dissostichus spp. Divisions 58.4.4a and 58.4.4b (Ob and Lena Banks)

4.17   WG-SAM-15/14 described progress with the program of toothfish research undertaken by Japan in Divisions 58.4.4a and 58.4.4b. The Working Group noted the high tag-overlap statistic achieved in 2014 and thanked Japan for the considerable amount of biological information provided in the report. The Working Group also noted that nine lines had been affected by killer whale depredation and encouraged Japan to consider how levels of depredation could be assessed and incorporated into future assessments. The Working Group recalled that France had presented a paper in which relative proportions of target and by-catch had been used to assess levels of killer whale depredation (WG-FSA-14/10) and such an analysis may be informative in this division. The Working Group encouraged the participation of cetacean scientists on future research cruises. The Working Group recommended that Japan starts to collect photographic identification data for killer whales in the region in collaboration with France and noted that a comprehensive online database has already been developed by Mr Gasco (Tixier et al., 2014a, 2014b; Labadie et al., 2014; WG-FSA-13/08).

4.18   WG-SAM-15/13 described a research plan for toothfish in Division 58.4.4b in 2015/16 by Japan. The Working Group discussed whether the difference in biomass estimates derived by CPUE and Petersen methods presented in the paper could result from killer whale depredation. The Working Group recommended that confidence intervals be provided with estimates of expected tag returns that are provided in proposals and this was relevant across all research fishery areas.

4.19   A proposal for a program of French toothfish research in Division 58.4.4 for 2015/16 was presented in WG-SAM-15/52. The Working Group recommended that France also consider the issue of whale depredation and to collect photographic identification data for killer whales in the region in collaboration with Japan.

Subarea 88.3

4.20   WG-SAM-15/09 presented the three-year Korean research plan for dedicated research cruises to study *Dissostichus* spp. in Subarea 88.3. In the first year, the research would focus on exploring and locating fishable habitat, biological sampling of toothfish and environmental data collection in the northern slope and southern shelf of SSRUs 883A–D. The Working Group noted the need for a robust sampling design within each of the research blocks and requested that details on locations of research sets and stratification and research block prioritisation be included in the updated research proposal for WG-FSA.

4.21   The Working Group discussed the potential constraints of sea-ice along the continental margin on returning to recapture tagged fish in future years. It noted the low levels of historic catch from research fishing in this subarea and the importance of completing the research even in the event of low catch rates. It highlighted the importance of returning to previously fished areas to recapture tagged fish and the value of supplementary information to characterise populations and inform stock structure that might be obtained by fishing in research blocks adjacent to SSRU 882G. The Working Group requested that these objectives be incorporated in the research proposal for Subarea 88.3.

Subarea 88.1

Ross Sea shelf survey

4.22   WG-SAM-15/44 presented the results of the fourth CCAMLR-sponsored research survey to monitor abundance of sub-adult Antarctic toothfish in the southern Ross Sea. The original objectives of this research were to: (i) detect changes in relative abundance of recruitment over time, and (ii) estimate variability and autocorrelation in recruitment (WG-SAM-14/25). The survey successfully completed 44 sets in the core survey strata and 15 sets in Terra Nova Bay, detecting a decline in catch rates of sub-adult fish in the core strata and high catch rates and larger fish in Terra Nova Bay. Age composition during the four surveys completed provided clear evidence of modes representing a strong year class progressing through the surveyed population. This information will be incorporated in the upcoming Ross Sea assessment model to help inform recruitment variability and change.

4.23   WG-SAM-15/45 presented a two-year proposal to continue the time series of research surveys to monitor abundance of Antarctic toothfish in the southern Ross Sea. The survey proposal had two key objectives: (i) to monitor toothfish recruitment in the core strata, and (ii) to monitor trends in abundance of larger (large sub-adult and adult) toothfish in two areas of importance to predators: McMurdo Sound and Terra Nova Bay. This second objective was intended to complement existing sea-ice research fishing and predator studies (killer whales and Weddell seals) from Scott Base and Mario Zucchelli Station (e.g. WG-EMM-14/52, WG-EMM-15/52).

4.24   The Working Group noted the importance of estimating trends in sub-adult abundance and recruitment for input to stock assessment models. It recalled that the Scientific Committee agreed that the survey is necessary to collect information on future recruitment (SC-CAMLR-XXXIII, paragraph 3.215).

4.25   The Working Group recommended that the next Ross Sea stock assessment should consider data weighting of survey and commercial data and sensitivities to incorporate the results of the survey series in the model. It further recommended that the priority for ongoing survey effort should be the monitoring of toothfish recruitment in the core strata. The Working Group requested an updated proposal be submitted to WG-FSA to provide further details associated with the objective of monitoring trends in abundance of larger toothfish in McMurdo Sound and Terra Nova Bay.

4.26   In discussion of the forthcoming Ross Sea stock assessment, the Working Group requested that WG-FSA review the mechanism of subdividing the long-term precautionary yield into SSRUs in the Ross Sea region.

Ross Sea winter survey

4.27   WG-SAM-15/47 presented a proposal for a dedicated winter longline survey of Antarctic toothfish in SSRUs 881B–C in 2016. This survey was identified as a priority in the CCAMLR-endorsed medium-term research plan for the Ross Sea (CCAMLR-XXXIII, paragraph 5.52) and proposals have been requested by the Scientific Committee (SC-CAMLR-XXXII, paragraph 3.76iv). The survey is proposed to: (i) investigate spawning time and location in the northern Ross Sea region; (ii) refine the developmental cycle and likely residence time on the spawning grounds; (iii) investigate the potential dispersion areas of eggs and larvae; and (iv) investigate the timing of movement to and from the spawning grounds.

4.28   The Working Group discussed WG-SAM-15/47 and noted that:

(i)   the research blocks were designed to account for variable ice conditions in winter while ensuring broad spatial coverage of sampling locations

(ii)   research on what fish are found under the ice will be needed to help interpret the data arising from this survey

(iii)   while the proposal was for a single season, it provided a template for additional survey proposals in subsequent seasons by any Member, to enable sampling over the necessary spatial and temporal scales to characterise spawning.

In addition, the Working Group recommended that standard protocols and methods be established for this research, in order that any vessels undertaking this research will provide consistent and compatible data.

4.29   The Working Group noted that the proponents would require the vessel to prepare a risk management plan to ensure vessel safety. In discussion of the proposed catch limit, the Working Group noted that the survey proposal was intended to be CCAMLR-sponsored research with the proposed survey catch limit taken from the Ross Sea catch limit to address CCAMLR-agreed priorities. Further discussion of the catch limit was referred to the Commission.

Subarea 88.2

SSRUs 882A–B north survey

4.30   WG-SAM-15/17, 15/31, 15/42 and 15/46 reported the results of the longline survey for toothfish conducted by Russia, the UK, Norway and New Zealand respectively in the northern Ross Sea region (SSRUs 882A–B). Three of four vessels were able to undertake research sets in the research blocks, with two of four vessels reaching their catch limit and undertaking the full seven days bathymetric mapping identified in the original research proposal (WG-FSA-14/61). Catch rates were high and similar to those observed in the adjacent SSRU 881C. Toothfish were large in both areas, consistent with the hypothetical life history of toothfish in the Ross Sea region.

4.31   Dr Kasatkina considered that results of the longline surveys for toothfish in the northern Ross Sea region (SSRU 882A–B) in 2015 showed unexpectedly high values of CPUE (kg/thousand hooks) which amounted to 5 000 kg/thousand hooks and with considerable variation in catches (WG-SAM-15/31 and 15/46). She suggested that this CPUE was four-times higher than in the Weddell Sea and indicated that it is very important to analyse the data to understand fish distribution patterns and the source of the high CPUE.

4.32   Dr Kasatkina made the following statement at report adoption:

'It was proposed to analyse relationship between haul duration and haul speed and CPUE.'

4.33   The Working Group noted the high CPUE and the importance of such data in assessing fish distribution. It noted that despite operational difficulties for two of the four vessels, the survey still collected valuable data in a little studied area and that these data could be utilised for updated analyses in the Ross Sea region spatial population model. It recalled the longstanding recommendation for research collaboration and noted that this survey provided a model for how such collaboration can be achieved.

4.34   The Working Group requested that the biological and bathymetric data from all four survey vessels be combined in a single report for WG-FSA and requested clarification on the acoustic calibration of vessels' echosounders. It requested that the proponents identify a strategy for sampling research blocks for the coming season and include that in their report to WG-FSA.

4.35   The Working Group noted that, while the notification process for this survey was ambiguous, New Zealand (WG-SAM-15/46), Norway (WG-SAM-15/41) and the UK (WG-SAM-15/32) had notified their intention to continue the research using vessels with the same gear configuration as specified in CM 41-10. Dr Kasatkina confirmed that Russia intended to take part in the survey this coming season, using a vessel with the same gear configuration as specified in CM 41-10.

4.36   The Working Group noted that the notification process for this research survey is unclear and recommended that WG-FSA consider how to clarify the process for this research survey. It further recommended that contingency plans be developed for research survey proposals this year to enable alternative vessels with appropriate gear configurations to be substituted to ensure necessary data collection and continuity of CCAMLR-sponsored research survey programs.

SSRU 882A south survey

4.37   WG-SAM-15/21 described a research program on the resource potential and life cycle of *Dissostichus* species from SSRU 882A from 2015 to 2018 and presented an updated version of the survey proposal from 2014 to incorporate recommendations from the Scientific Committee (SC-CAMLR-XXXIII, paragraph 3.226). The Working Group noted the proposal used auto lines to enable comparison of CPUE with the SSRUs 882A–B north survey, consistent with the advice of WG-SAM last year (SC-CAMLR-XXXIII, Annex 5, paragraph 4.20).

4.38   Dr Kasatkina noted that it is important to understand fish distribution patterns by combining data from surveys in the northern part of SSRUs 882A–B and a survey in the southern part of SSRU 882A, planned by Russia.

4.39   The Working Group agreed that the catch for this research should be subtracted from the Ross Sea catch limit.

4.40   Noting the ongoing investigation of the *Yantar 35*, the quarantine in place for all data collected by that vessel in CCAMLR waters, and the fact the vessel had not notified to fish in Subareas 88.1 or 88.2, clarification was sought as to the availability of alternative vessels with appropriate gear configuration. It was noted that alternative vessels may be available.

4.41   The Working Group concluded that it was unable to complete the review of the investigation of the *Yantar 35* data from 2012/13 and 2013/14 (paragraph 4.10). It agreed that the review needs to be complete and approved by the Scientific Committee prior to that vessel being considered for any further surveys in the CCAMLR area.

4.42   Dr Kasatkina assured the Working Group that the *Yantar 35*, notified in the research proposal for the southern part SSRU 882A, will be replaced by an alternative vessel with appropriate gear configuration.

Other business

5.1   The Working Group noted that WG-SAM-15/19, 15/20 and 15/51 were not directly related to other WG-SAM agenda items. These papers dealt with positioning some statistical boundaries in the Convention Area and opening currently closed SSRUs in Subareas 88.1 and 88.2. Given that these topics are outside the remit of WG-SAM, the Working Group recommended that these papers be forwarded to the Scientific Committee for further consideration.

5.2   Dr R. Leslie (South Africa) acknowledged that repositioning of the boundaries of statistical areas was outside the remit of WG-SAM and noted that WG-SAM-15/51 was tabled to inform the Working Group that South Africa and France intend making a formal submission to the Commission requesting that the boundary between Subareas 58.6 and 58.7 be repositioned taking cognisance of the areas under national jurisdiction.

CCAMLR Science

5.3   The Science Manager, as Editor of *CCAMLR Science*, described the reduction in the number of papers submitted to, and published in, *CCAMLR Science* in recent years and sought the views of the Working Group on whether there was a future for the journal. In recalling the rationale for *CCAMLR Science* to provide a mechanism to publicise the science done in CCAMLR, the Science Manager also noted that many working group papers in the past few years had been published in high-ranking peer-reviewed journals and that this might actually provide a more effective mechanism for CCAMLR to reach a wider scientific audience than via an in-house journal.

5.4   The Working Group noted that the mechanisms available for 'publishing' science have changed considerably since *CCAMLR Science* was launched in 1994 and that continuing the journal in its current form was a considerable overhead for the Secretariat. The Working Group acknowledged the proliferation of science journals and the challenges of maintaining an in-house journal like *CCAMLR Science* and suggested that it may be useful to consider different options for promoting the science contributions to CCAMLR, such as for example, sponsoring occasional 'special issues' in other appropriate journals, and that this should be examined by the Secretariat.

5.5   The Science Manager thanked the Working Group for its comments and advice and undertook to prepare a paper to the Scientific Committee on the future options for *CCAMLR Science*.

Future work discussions

6.1   The Working Group noted that CM 21-02, paragraph 6(iii), requires that all notifications for exploratory fisheries in Subarea 48.6 and Divisions 58.4.1, 58.4.2 and 58.4.3a are submitted before 1 June and that these should include a research plan (that follows the format of CM 24-01, Annex 24-01/A, format 2). This means that each Member that submits a notification is required to submit a research plan each year (and these plans are required to be submitted to WG-SAM for review by 1 June).

6.2   The Working Group agreed that the requirements of the notification process were not consistent with the desire to have multiyear multi-Member research proposals that do not necessarily require an annual presentation and review. The Working Group also recognised that there were several occasions during the Working Group meeting that highlighted an apparent lack of clarity in the process of notifications for research conducted under CMs 21-02, 24-01 and 41-10, Annex 41-10/A. The Working Group requested that the Scientific Committee consider this matter.

6.3   The Working Group also agreed that the research undertaken in CCAMLR with the aim of developing an assessed fishery should be grouped according to the objectives of the research rather than the conservation measure under which the research was proposed.

6.4   The Working Group agreed that there are several key types of information that should be compiled for each fishery in order to help develop a strategy for research toward an assessment:

(i)   Research phase (prospecting/biomass estimation/assessment) –

     (a)   method of biomass estimation in use
     (b)   catch level
     (c)   define stock area
     (d)   Member(s) developing assessment.

(ii)   Characterisation of the fishery –

     (a)   catch and CPUE
     (b)   tag releases and recaptures
     (c)   inventory of age data
     (d)   model parameters available – maturity, growth, tagging-related mortality etc.
     (e)   other sources of mortality.

(iii)   Data collection plan for the fishery.

(iv)   Development of long-term assessments –

     (a)   timeline for developing assessments
     (b)   identify information needed to improve assessment
     (c)   key research questions and priorities
     (d)   MSE.

(v)   Reporting of progress –

     (a)   data available for assessments by vessel, year etc. (see characterisation)
     (b)   performance of the research plan (given sea-ice etc.)
     (c)   check appropriate catch levels based on local data
     (d)   submitted progress reports by Members participating in the plan.

6.5   The Working Group agreed that this information should be available prior to WG-FSA to assist it in reviewing proposals. It also agreed that the Secretariat be asked to assist in preparing a summary table of the elements of the characterisation of the fishery (ii) with data that are routinely submitted to the Secretariat (with the current exception of age data). The Working Group requested that information on the availability of, and/or the age data itself, be made available to the Secretariat and the Secretariat indicated that the structure for an age database currently existed and could be used to store age information and metadata.

6.6   The Working Group noted the value of having a standardised system for plotting research set locations and research blocks. It recommended that all those providing research proposals use the CCAMLR GIS system to display spatial data or to submit spatial data with their research proposals to the CCAMLR Secretariat so that spatial information could be displayed consistently for all proposals.

6.7   The Working Group agreed that the increasing number of multiyear multi-Member research proposals aimed at producing a stock assessment would necessitate greater collaboration among Members, and that it may be beneficial to identify common research themes when developing these proposals. It recalled the success of the focused science, research and assessment activities undertaken with the development of the *Dissostichus* fishery in Subareas 88.1 and 88.2.

6.8   The Working Group agreed that future progress reports that summarise multiyear research efforts should be comprehensive and efforts should be made within progress reports to more formally evaluate whether the objectives of the research are being met.

6.9   The Working Group agreed that the Fishery Report for individual fisheries should include a research annex that describes the status of the research designed to lead to an assessment, and if an assessment has been developed, an assessment annex that describes the status of the stock assessment in a standardised way. For those fisheries with assessments, the research plan would be designed to improve the assessment and could also be included as an annex to the Fishery Report.

6.10   The Working Group recognised that the agenda for its meetings had changed considerably over the past three years and that, along with the other working groups of the Scientific Committee, there was a need for an overview of the priorities that the Scientific Committee had identified for its working groups. The Working Group welcomed the indication that a paper was being prepared for discussion at the Scientific Committee this year on possible options for streamlining the work of the Scientific Committee.

Advice to the Scientific Committee

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

(i)   Integrated assessments of toothfish –

(a)   estimation of IUU fishing (paragraphs 2.5 and 2.6)

(b)   retention of tag data (paragraphs 2.5 and 2.6)

(c)   consistency of stock projections with CCAMLR decision rule (paragraph 2.9).

(ii)   Review of stock assessment methods –

(a)   review of by-catch data and SISO observer training on by-catch reporting (paragraphs 2.27, 2.31 and 2.32)

(b)   development of stock assessment model diagnostics (paragraph 2.43)

(c)   CCAMLR database redevelopment (paragraph 2.51)

(d)   depredation (paragraphs 2.60 and 2.61)

(e)   MSE (paragraph 2.64).

(iii)   Research plans –

(a)   Subarea 88.1 Ross Sea surveys and stock assessments (paragraphs 4.26, 4.29 and 4.36)

(b)   replacement of the *Yantar 35* (paragraph 4.41)

(c)   historical tagging data (paragraph 3.19).

(iv) Other business –

(a)   boundary positions in Subarea 88.1 (paragraph 5.1).

(v)   Future work –

(a)   notifications (paragraph 6.2)

(b)   conservation measures (paragraph 6.3).

Adoption of the report and close of the meeting

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

8.2   In closing the meeting, Dr Parker thanked the meeting hosts for the excellent facilities and very kind hospitality. He also thanked participants for their goodwill and contributions to the work of WG-SAM, and the subgroup coordinators, rapporteurs and Secretariat for facilitating discussions and preparation of the report.

8.3   Dr Jones, on behalf of WG-SAM and the Scientific Committee, thanked Dr Parker for successfully leading his first meeting as Convener of WG-SAM. The Working Group had been able to give due consideration to the large number of papers submitted to the meeting and make further progress in developing assessment methods.

References

Agnew, D.J., C. Edwards, R. Hillary, R. Mitchell and L.J. López Abellán. 2009. Status of the coastal stocks of *Dissostichus* spp. in East Antarctica (Divisions 58.4.1 and 58.4.2). *CCAMLR Science*, 16: 71–100.

Labadie, G., P. Tixier, L. Trudelle, J. Vacquie-Garcia, N. Gasco and C. Guinet. 2014. Sperm whales of the Crozet and Kerguelen Islands, photo-identification catalogue 2014. doi: 10.6084/m9.figshare.1414472

Tixier, P., N. Gasco and C. Guinet. 2014a. Killer whales of the Crozet Islands, photo-identification catalogue 2014. doi: 10.6084/m9.figshare.1060247.

Tixier, P., N. Gasco, T. Poupart and C. Guinet. 2014b. Type-D killer whales of the Crozet Islands, photo-identification catalogue 2014. doi: 10.6084/m9.figshare.1060259.

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Working Group on Statistics, Assessments and Modelling
(Warsaw, Poland, 29 June to 3 July 2015)

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Agenda

Working Group on Statistics, Assessments and Modelling
(Warsaw, Poland, 29 June to 3 July 2015)

1. Introduction

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

2. Methods for assessing stocks in established fisheries

    2.1 A review of progress towards updated integrated assessments of toothfish
    2.2 A review of stock assessment methodologies used in CCAMLR's integrated assessments
    2.3 Other work

3. Review of research plans from Members notifying to fish in exploratory fisheries in Subareas 48.6 and 58.4

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

5. Other business

6. Future work

7. Advice to the Scientific Committee

8. Adoption of report and close of meeting.

List of Documents

Working Group on Statistics, Assessments and Modelling
(Warsaw, Poland, 29 June to 3 July 2015)

WG-SAM-15/01	Comparing surface and planimetric area across multiple scales and assessing the impact of different data sources on seabed area estimation in research blocks in the CAMLR Convention Area CCAMLR Secretariat
WG-SAM-15/02	Continuation in the 2015/16 season of the research plan initiated in 2012/13 for stocks of *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2 Delegation of Spain
WG-SAM-15/03	Research plan for the 2015/16 exploratory longline fishery of *Dissostichus* spp. in Division 58.4.3a Delegation of Japan
WG-SAM-15/04	Research plan for the 2015/16 exploratory longline fishery of *Dissostichus* spp. in Division 58.4.2 Delegation of Japan
WG-SAM-15/05	Research plan for the 2015/16 exploratory longline fishery of *Dissostichus* spp. in Division 58.4.1 Delegation of Japan
WG-SAM-15/06	Research plan for the 2015/16 exploratory longline fishery of *Dissostichus* spp. in Subarea 48.6 Delegation of Japan
WG-SAM-15/07	Research plan for the exploratory longline fishery for *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2 in 2015/16 Delegation of the Republic of Korea
WG-SAM-15/08	Korean research plan for *Dissostichus* spp. in Subarea 48.5 in 2015/16 Delegation of the Republic of Korea
WG-SAM-15/09	Korean research plan for *Dissostichus* spp. in Subarea 88.3 in 2015/16 Delegation of the Republic of Korea
WG-SAM-15/10	Research plan for exploratory fishing for toothfish (*Dissostichus* spp.) in East Antarctica (Divisions 58.4.1 and 58.4.2) by Australia Delegation of Australia

WG-SAM-15/11	Revised research plan for the exploratory longline fishery for *Dissostichus* spp. in 2015/16 in Division 58.4.3a Delegation of France
WG-SAM-15/12	Finfish Research Proposal: Finfish distribution and abundance in Subareas 48.1 and 48.2 Delegation of Chile
WG-SAM-15/13	Research plan for toothfish in Division 58.4.4 b by *Shinsei Maru No. 3* in 2015/16 Delegation of Japan
WG-SAM-15/14	Reports on abundance and biological information of toothfish in Division 58.4.4 a & b by *Shinsei Maru No. 3* in 2013/14 season Delegation of Japan
WG-SAM-15/15	Research plan for exploratory fishing for toothfish (*Dissostichus* spp.) in 2015/16 in Division 58.4.2 Delegation of France
WG-SAM-15/16	Research plan for exploratory fishing for toothfish (*Dissostichus* spp.) in 2015/16 in Division 58.4.1 Delegation of France
WG-SAM-15/17	Implementation of the research program for characterisation of the local toothfish population distribution and quantity in the SSRUs 882 A and B. Marine studies to assess the resource potential of the Subarea within the framework of the Ross Sea MPA proposed by the NZ and USA Delegation of the Russian Federation
WG-SAM-15/18	Plan of research program of the Russian Federation in Subarea 48.5 Delegation of the Russian Federation
WG-SAM-15/19	Proposal of the Russian Federation to amend the borders of the Subarea 88.1 (Ross Sea) Delegation of the Russian Federation
WG-SAM-15/20	Proposal of the Russian Federation to establish research TAC for closed SSRU in Subareas 88.1 and 88.2 Delegation of the Russian Federation
WG-SAM-15/21	Research program on resource potential and life cycle of *Dissostichus* species from the Subarea 88.2 A in 2015–2018 Delegation of the Russian Federation

WG-SAM-15/22   Analysis of the scientific data obtained during Russian research
                   program in the Weddell Sea (Subarea 48.5) in 2012–2013
                   Delegation of the Russian Federation

WG-SAM-15/23   A meta-analysis of by-catch in the Ross Sea toothfish fishery
                   CCAMLR Secretariat

WG-SAM-15/24   Assessment models for Patagonian toothfish in research
                   block 58.4.3a_1 of Division 58.4.3a, Elan Bank for the years
                   2005–2014
                   K. Taki (Japan), S. Mormede (New Zealand) and T. Ichii (Japan)

WG-SAM-15/25   Assessment models for Patagonian toothfish in research
                   block 58.4.4b_1 (SSRU 58.4.4bC) for the years 1990–2014
                   K. Taki (Japan), S. Mormede (New Zealand) and T. Ichii (Japan)

WG-SAM-15/26   Towards developing diagnostics tools for fishery stock
                   assessments
                   P. Ziegler, P. Burch, A. Constable (Australia), C. Darby (United
                   Kingdom), A. Dunn (New Zealand), C. Jones, D. Kinzey (USA),
                   S. Mormede (New Zealand) and D. Welsford (Australia)

WG-SAM-15/27   Review of cetacean depredation in CCAMLR statistical subareas
                   M. Söffker (United Kingdom) and P. Tixier (France)

WG-SAM-15/28   Review of depredation mitigation methods applied within the
                   CCAMLR Statistical Area
                   R. Faulkner, N. Edmonds and M. Söffker (United Kingdom)

WG-SAM-15/29   Fishery selection for Patagonian toothfish in CCAMLR
                   Subarea 48.3, asymptotic or dome shaped?
                   C. Darby, V. Laptikhovsky and M. Söffker (United Kingdom)

WG-SAM-15/30   A potential link between the *D. eleginoides* stocks of Statistical
                   Subareas 48.3 and 48.4
                   M. Söffker, M. Belchier and V. Laptikhovsky (United Kingdom)

WG-SAM-15/31   Results of the longline survey for toothfish in the northern Ross
                   Sea region (SSRU 88.2A) by the FV *Argos Froyanes*, United
                   Kingdom
                   M. Söffker, J. Clark, J.M.G. Rebollo and C. Darby (United
                   Kingdom)

WG-SAM-15/32   Proposal to continue participation in the second year of the joint
                   CCAMLR research survey to collect spatially stratified longline
                   and bathymetric data in 88.2_A and 88.2_B in 2015/16
                   Delegation of the United Kingdom

WG-SAM-15/33   Vacant

WG-SAM-15/34   Using tag-recapture data to estimate catchability of a series of
random stratified trawl surveys
W. de la Mare, P. Ziegler and D. Welsford (Australia)

WG-SAM-15/35   Progress report on the Korean exploratory longline fishery for
Dissostichus spp. in Divisions 58.4.1 and 58.4.2 in 2014/15
Delegation of the Republic of Korea

WG-SAM-15/36   Vacant

WG-SAM-15/37   Progress report on the Australian Fisheries Research and
Development Corporation project to develop robust assessment
methods and harvest strategies for spatially complex, multi-
jurisdictional toothfish fisheries in the Southern Ocean
P. Burch, C. Péron, D. Welsford, P. Ziegler, T. Lamb,
T. Robertson (Australia), G. Duhamel, N. Gasco, P. Pruvost,
C. Chazeau and R. Sinègre (France)

WG-SAM-15/38   The preliminary report on the survey in Subarea 48.2 in 2015 (the
first year of the planned 3-year-old investigations)
Delegation of Ukraine

WG-SAM-15/39   South African work plan for 2015/16 for the joint Japan/South
Africa research on *Dissostichus* spp. in Subarea 48.6
Delegation of South Africa

WG-SAM-15/40   Plan of research program of the Ukraine in Subarea 48.2 in 2016
(second season)
Delegation of Ukraine

WG-SAM-15/41   Proposal to continue participation in the second year of the joint
CCAMLR research survey to collect spatially stratified longline
and bathymetric data in 88.2_A and 88.2_B in 2015/16
Delegation of Norway

WG-SAM-15/42   Results of the longline survey for toothfish in the northern Ross
Sea region (SSRU 88.2A) by the FV *Seljevær*, Norway
Delegation of Norway

WG-SAM-15/43   Investigations on tagging data in the Kerguelen Islands
Patagonian toothfish fishery (Division 58.5.1)
R. Sinegre and G. Duhamel (France)

WG-SAM-15/44	Results of the fourth CCAMLR sponsored research survey to monitor abundance of sub-adult Antarctic toothfish in the southern Ross Sea, February 2015 and further development of the time series S.M. Hanchet, B.R. Sharp, S. Mormede, S.J. Parker (New Zealand) and M. Vacchi (Italy)
WG-SAM-15/45	Proposal to continue the time series of research surveys to monitor abundance of Antarctic toothfish in the southern Ross Sea, 2016−2017 S.M. Hanchet, S.J. Parker, S. Mormede and R.J.C. Currey (New Zealand)
WG-SAM-15/46	Results of the longline survey for toothfish in the northern Ross Sea region (Subarea 88.2 SSRUs A–B) by the FV *Janas*, New Zealand S.J. Parker, R.J.C. Currey and S. Mormede (New Zealand)
WG-SAM-15/47	Proposal for a winter longline survey of Antarctic toothfish in Subarea 88.1 SSRUs B–C in 2016 S.J. Parker, S.M. Hanchet and R.J.C. Currey (New Zealand)
WG-SAM-15/48	Progress in the evaluation of management strategies for the Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region S. Mormede, A. Dunn, S.J. Parker and S.M. Hanchet (New Zealand)
WG-SAM-15/49	Potential modelling structures for a two-area stock assessment model for Antarctic toothfish (*Dissostichus mawsoni*) in the Amundsen Sea Region S. Mormede, S.J. Parker, A. Dunn and S.M. Hanchet (New Zealand)
WG-SAM-15/50	Progress report for the third year of the research fishery for *Dissostichus* spp. in Subarea 48.6 being jointly undertaken by Japan and South Africa: 2013–2015 R.W. Leslie (South Africa), K. Taki, T. Ichii (Japan) and S. Somhlaba (South Africa)
WG-SAM-15/51	Proposal to reposition the boundary between CCAMLR Statistical Subareas 58.6 and 58.7 R.W. Leslie (South Africa) and G. Duhamel (France)
WG-SAM-15/52	2015–16 Research plan in Division 58.4.4 for *Dissostichus* spp. Delegation of France

WG-SAM-15/53   Exploratory longline fishing proposal for *Dissostichus* spp. in
Subarea 48.2
Delegation of Chile

Other Documents

WG-SAM-15/P01   Standardisation of commercial CPUE
A. Salthaug and O.R. Godø
Fish. Res., 49 (2001): 271–281

Diagnostics for integrated stock assessment models

MPD

Table of process error weighting

Looking for: How different datasets are interpreted by model.

MPD components

Comparison of different model runs (e.g. previous and current assessments) and evaluation of the contribution of penalties.

Looking for: Understand the changes in contributions from each dataset between model runs and influence of penalty values and priors on model fits.

Table 1:   MPD objective function values for model runs R1–R5.

Objective function component	R1	R2	R3	R4	R5
2004 tags recaptured	65.1	3.4	4.1	3.2	3.6
2005 tags recaptured	35.9	3.2	4.7	3.9	4.3
2006 tags recaptured	110.5	11.1	12.6	9.1	10.8
2007 tags recaptured	42.0	4.9	6.0	4.2	5.0
2008 tags recaptured	42.4	5.5	6.8	5.5	6.0
2009 tags recaptured	73.2	9.4	10.4	7.4	8.9
2010 tags recaptured	116.7	14.4	14.7	9.8	12.3
2011 tags recaptured	68.7	7.6	7.9	5.5	6.7
2012 tags recaptured	52.4	6.1	5.4	3.6	4.6
Catch-at-age (882G)	194.7	247.0	249.6	2.5	-
Catch-at-age (North)	1169.4	1349.9	1801.3	27.8	98.3
Catch-at-age (Slope)	1031.9	161.5	133.8	8.1	136.5
Sub-total (observations)	3003.0	1823.9	2257.4	90.7	297.1
Penalties	0.0	0.0	0.0	0.0	0.0
B_0 prior	9.3	9.5	8.9	8.8	8.9
All other priors	0.0	0.0	0.0	0.0	0.0
Total objective function	3012.3	1833.4	2266.3	99.5	306.0
Number of parameters	25	25	23	23	15

Age and length-frequency/abundance data

Observed and expected values and residuals by fishery and year.

Looking for: Absence of systematic patterns in lack of fits across years and age classes.
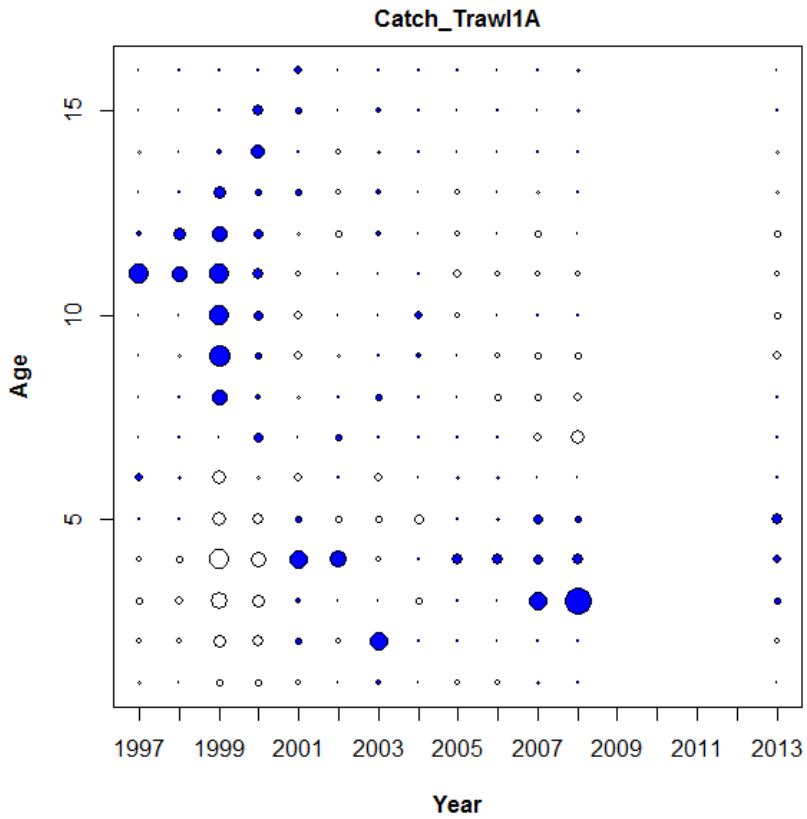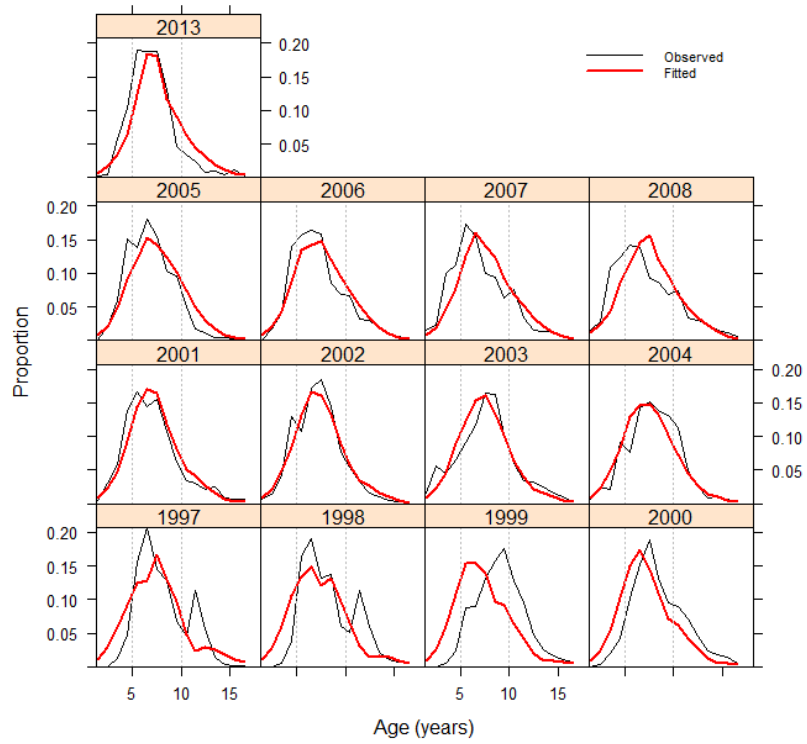
Figure 1: MPD fits to catch-at-age data (top) and Pearson's residuals of MPD fits by age and year for catch-at-age data (bottom). Filled circles are positive, empty circles are negative.

Age and length-frequency/abundance data

For each age by year, and for each year by age: Observed and expected values over time, observed versus expected values, standardised residuals from model fits, quantile-quantile normal plots for normally or lognormally distributed error structures and 1:1 line and ACF plots.

Looking for: Absence of systematic patterns in fits across years and age classes, distribution of residuals should meet assumed error distribution.

Mean age

Expected versus observed values.

Looking for: Absence of systematic patterns across years.
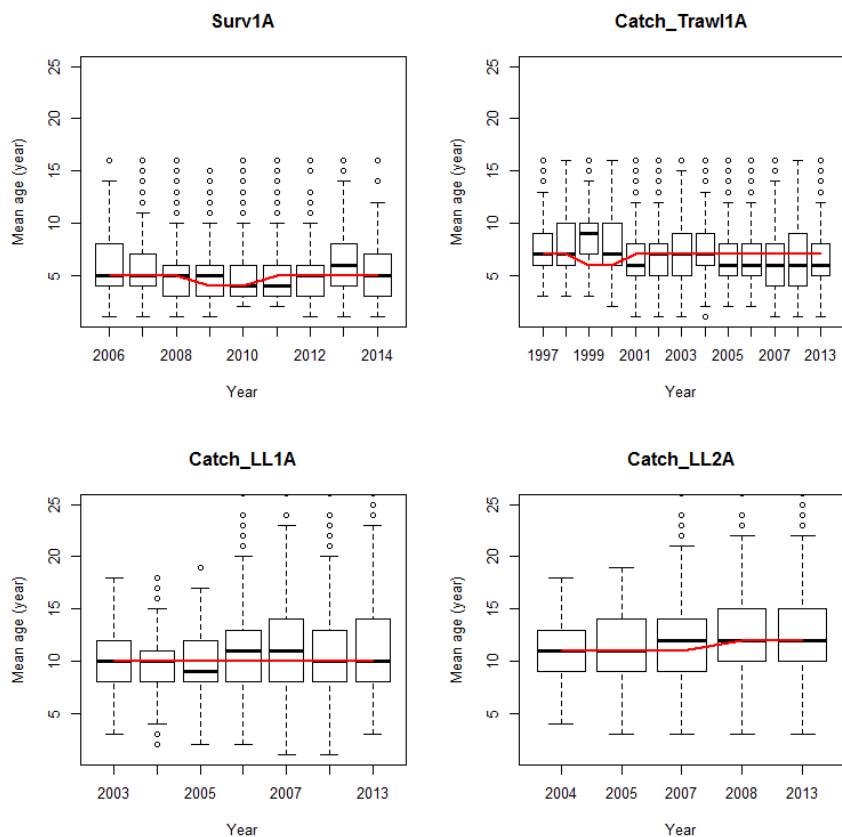
Figure 2:   Boxplots of observed and predicted median age.

Indices of abundance (e.g. from survey or catch rates)

Observed and expected values and residuals by fishery and year.

Looking for: Absence of systematic patterns in fits across years and age classes.

Indices of abundance (e.g. from survey or catch rates)

Observed and expected values over time, observed versus expected values, standardised residuals from model fits, QQ norm plots for normally or lognormally distributed error structures and 1:1 line and ACF plots.

Looking for: Absence of systematic patterns in fits across years and age classes, the distribution of residuals should meet assumed error distribution.

Tagging data

Observed and expected values and residuals by fishery, year and length of recaptured fish.
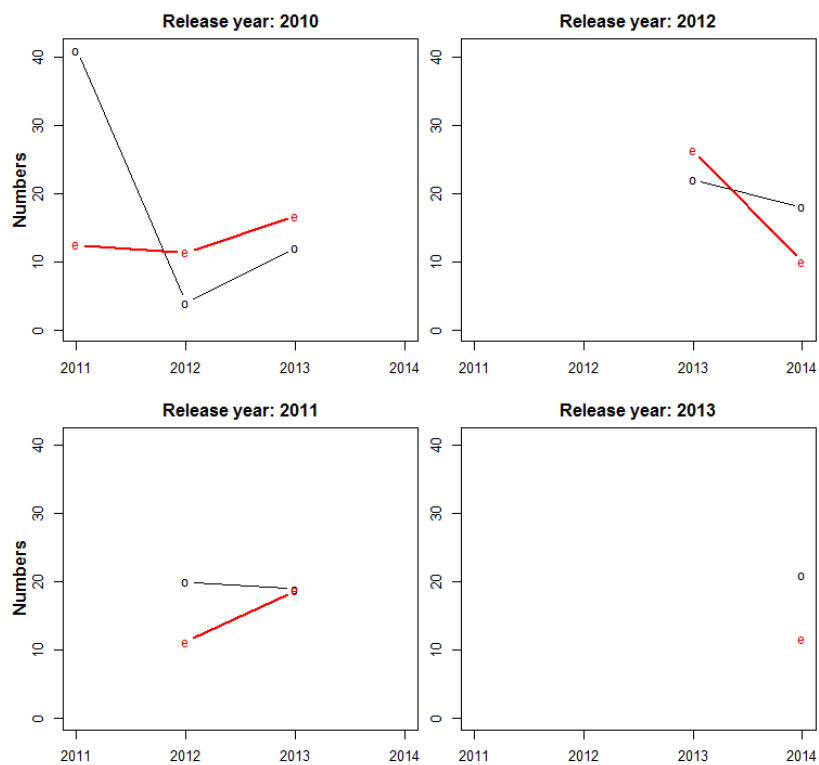
Figure 3:   Observed (black 'o') and expected (red 'e') numbers of recaptures by release year.
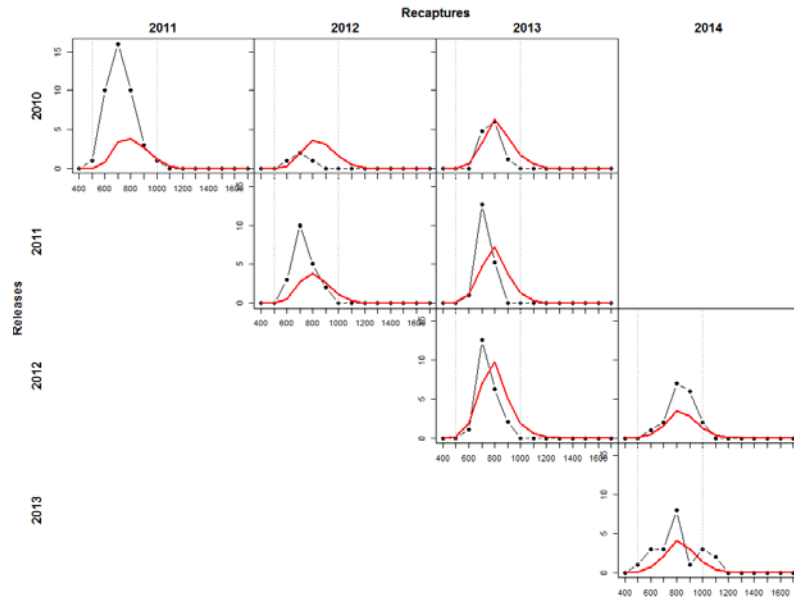
Figure 4: Observed (black) and expected (red) numbers of recaptures by release year and recapture length.
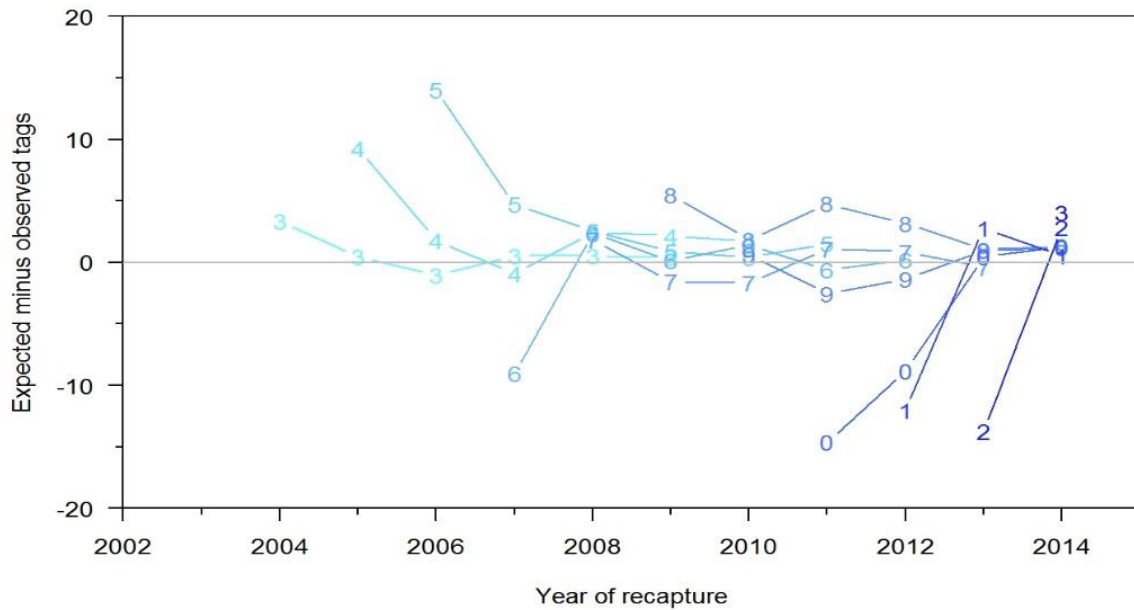
Figure 5: Residual fits to tag data.

LL profiles

Likelihood profiles

Profiles for B_0, catchability q, declining right-hand limb of selectivity functions where appropriate and other important parameters (i.e. estimated productivity parameters when estimated).

Looking for: Each dataset should decline to an obvious minimum value from at least one side for this dataset to make a substantial contribution to the scale estimation of the parameter. The likelihood contributions by the important data sources should show consistent trends.
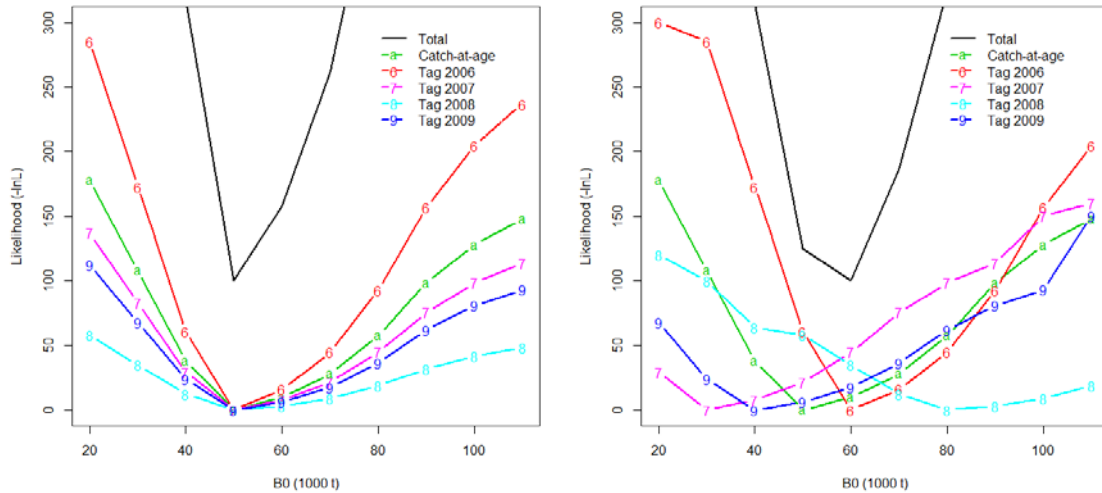
Figure 6: Illustrative example of likelihood profile for B_0 with a high yet unlikely (left) and low (right) level of agreement between different data sources about the most likely B_0 level.

MCMC

Model convergence

- Visual evidence of convergence at a stationary distribution:

  - Stationary loess estimate of MCMC samples

  - Absence of trends in running means

  - Geweke diagnostics to compare the means of different parts of a chain

  - Heidelberg and Welch diagnostic to evaluate whether the chain is sampled from a stationary distribution

  - Gelman and Rubin diagnostic for multiple chains.

Looking for: Plots should look like a 'hairy caterpillar' indicating good mixing behaviour and stationary chains. No correlation between parameters or correlations without substantial consequences for model fits.
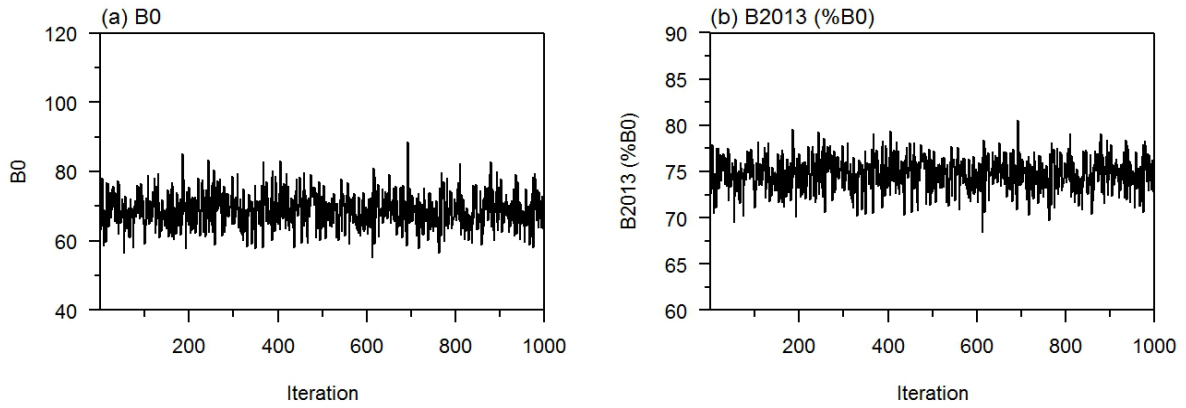
Figure 7: MCMC posterior trace plots for B_0 and stock status in 2013.

Parameter estimates

MCMC values of the parameters estimated by the model, and how they compare to their priors and estimation bounds.

Looking for: Does distribution of estimate follow that of the prior, distribution of estimates is narrower than that of the prior (but not unrealistically precise), estimates do not hit bounds.
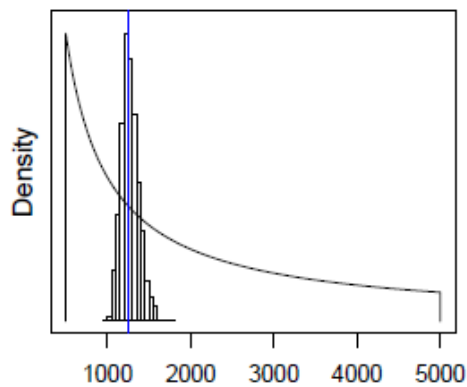

Figure 8: Estimated fishing selectivity functions with 95% credible intervals obtained from the MCMC samples.

Model-derived estimates with MCMC intervals

Selectivity functions
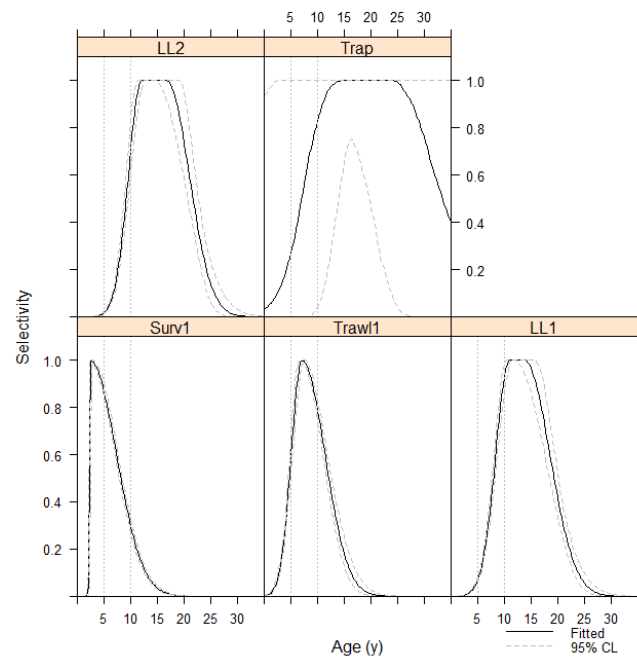
Figure 9:   Estimated selectivity functions with 95% credible intervals obtained from the MCMC samples.

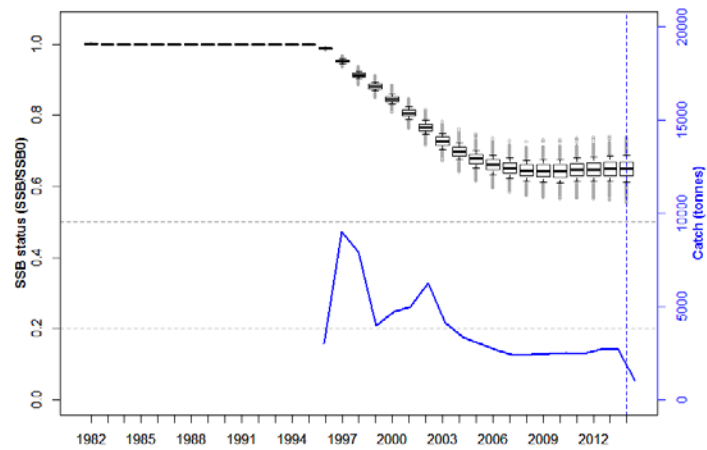*Annual spawning, total biomass and stock status*

Figure 10:   Estimated *SSB* status (black) and historical catch time series (blue).
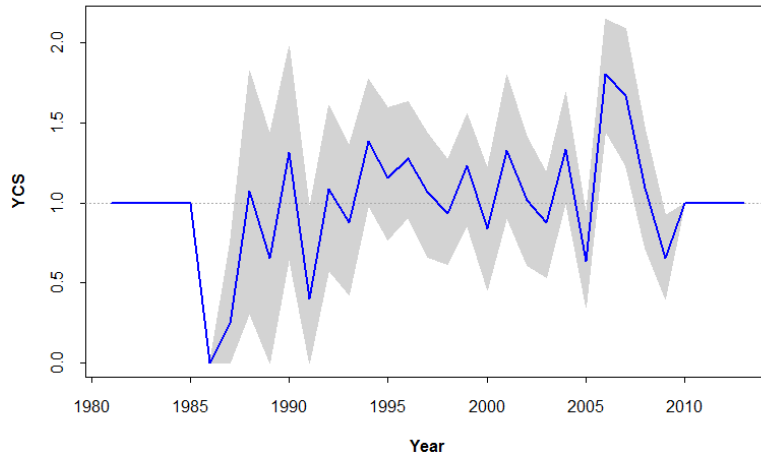
Year-class strength

Figure 11: Estimated year-class strength (YCS) with 95% credible intervals obtained from the MCMC samples.

Annual harvest rates or proxy

Total catch relative to vulnerable biomass (or spawning biomass as a proxy).
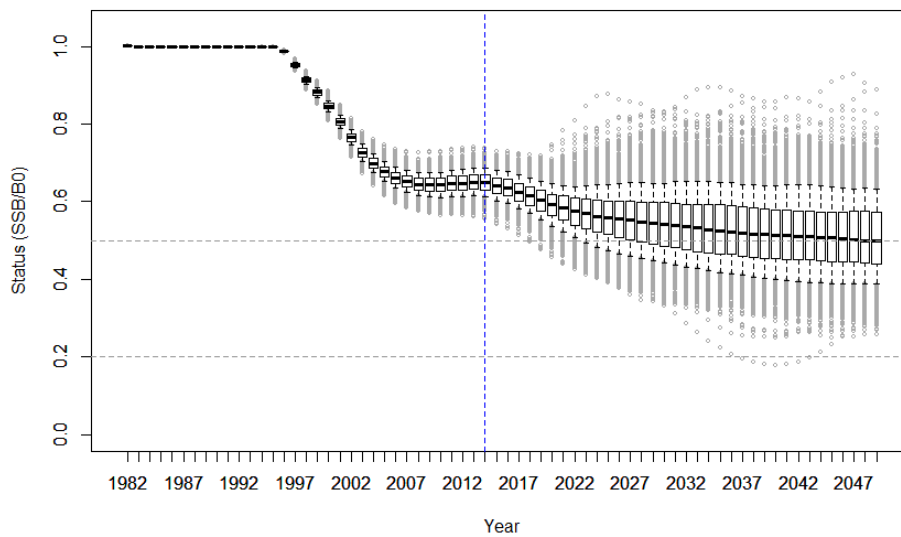
Stock projections

Figure 12: Projected *SSB* status relative to SSB_0 using MCMC samples and future random lognormal recruitment from 2011 to 2049 with annual constant catches.
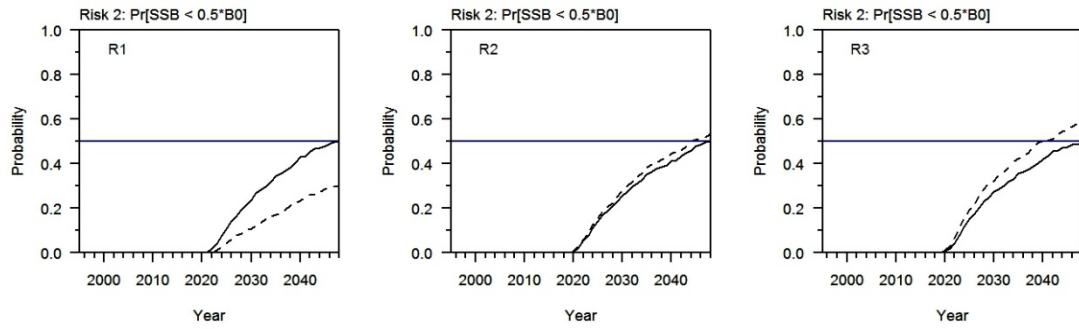
Figure 13: Estimated risks for three models under the CCAMLR decision rules for probability that SSB $< 0.5\ B_0$ with the current catch limit (dashed lines) and maximum catch that meets the decision rule criteria for each model (solid lines).