ANNEX 4

REPORT OF THE WORKING GROUP ON STATISTICS, ASSESSMENTS AND MODELLING

(Cape Town, South Africa, 19 to 23 July 2010)

CONTENTS

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INTRODUCTION

Opening of the meeting

1.1 The fourth meeting of WG-SAM was held at the National Research Aquarium, Cape Town, South Africa, from 19 to 23 July 2010. The meeting was convened by Dr A. Constable (Australia) and local arrangements were coordinated by Mr J. Khanyile, Department of Environmental Affairs (DEA), South Africa. The meeting was opened by Dr M. Mayekiso, Deputy-Director General, DEA.

1.2 Dr Constable thanked Dr Mayekiso for his warm welcome, and the South African Government for hosting the meeting. Dr Constable also welcomed the participants (Appendix A), and, given the increasing number of young scientists, thanked Members for their support of the meeting and of the Scientific Committee's capacity building effort.

Adoption of the agenda and organisation of the meeting

1.3 The agenda, as amended, was adopted (Appendix B).

1.4 Documents submitted to the meeting are listed in Appendix C; WG-EMM-10/33 was included at the start of the meeting for consideration during the discussion on VMEs. While the report has few references to the contributions of individuals and co-authors, the Working Group thanked all the authors of papers for their valuable contributions to the work presented to the meeting.

1.5 In this report, paragraphs that provide advice to the Scientific Committee and its working groups have been highlighted. A list of these paragraphs is provided in Item 8.

1.6 The report was prepared by Drs S. Candy (Australia) and Constable, Mr A. Dunn (New Zealand), Drs C. Edwards (UK), C. Jones (USA), S. Kasatkina (Russia), S. Kawaguchi (Australia), M. Kiyota (Japan), S. Parker (New Zealand), D. Ramm (Data Manager), K. Reid (Science Officer), B. Sharp (New Zealand), D. Sologub (Russia), G. Watters (USA) and D. Welsford (Australia).

KRILL

Integrated assessment of krill

2.1 The Working Group agreed that the development of an integrated assessment for krill was highly desirable. The current approach using the GYM does not incorporate information

from all the data that are currently available; e.g. it does not address ongoing trends in the fishery, changes in the demography of krill (potentially associated with climate change) and does not include data from annual krill monitoring.

2.2 Dr Watters informed the Working Group that the US AMLR Program has committed resources to developing an integrated assessment of krill based initially on the data collected as part of the US AMLR Program in Subarea 48.1, but aiming to be sufficiently general so that data collected by other Members working in other subareas could be used to expand the scope of the work. These data include acoustic surveys, net tow samples, krill predator diet samples and indices of predator performance. In addition, at-sea distributions of predators may also be useful in indicating spatial differences in predation mortality.

2.3 The Working Group recommended that an integrated assessment for krill be developed with consideration given to the following issues:

(i) it should proceed in a stepwise fashion with increasing levels of complexity added over time;

(ii) it should be based on clearly defined stock hypotheses;

(iii) the utility of CPUE data from the fishery in assisting the calibration of the population model should be investigated, particularly in areas of Area 48 which have limited research survey data;

(iv) the assessment will need to include methods for accounting for different selectivity patterns associated with survey efforts, the fishery and krill predators;

(v) the information content or utility of different datasets and their exclusion or inclusion needs to be considered in an iterative cycle of data preparation, model fitting and model evaluation.

Krill observer program

Background and papers

2.4 WG-EMM requested that WG-SAM provide advice on:

(i) an appropriate estimation structure of an integrated krill assessment that might utilise observer-derived data on krill length, which could be used to evaluate the efficacy of the observer program;

(ii) how the accuracy and precision of quantities estimated in the observer program influence assessment outputs, and hence the extent to which different levels of observer coverage will improve assessments;

(iii) a provisional observer program that could be used in the interim and to help design the observer program in the longer term;

so that a well-designed program for systematic observer coverage in the krill fishery can be adopted at SC-CAMLR-XXIX in 2010 (SC-CAMLR-XXVIII, Annex 4, paragraph 3.60).

2.5 WG-SAM-10/10 presented some important factors related to the collection of krill size-frequency data that need to be considered in designing an observer program for the krill fishery. WG-SAM-10/17 reported on an analysis of krill mean length and fish by-catch for the Japanese krill fishery and examined the impact of observer coverage levels across different factors such as vessels, subareas and years on CVs. Agnew et al. (2010) presented another analysis of observer data and proposed appropriate levels of observer coverage based on data from Subarea 48.3.

Discussion

2.6 The Working Group recommended that WG-EMM should consider the following discussion in its deliberations on the krill observer program.

2.7 The Working Group noted that sampling the size structure of krill in the catch by the fishery (a primary task for scientific observers) helps to estimate size-specific fishing mortality rates, while inferences about the demographic structure from which that catch was taken would be developed from an integrated assessment model.

2.8 In discussion of Agnew et al. (2010) the Working Group agreed that, based on currently available data, observer coverage of 50% of vessels each year and 20% of hauls, with all vessels being observed at least once every two years, was sufficient to estimate mean krill length and total number of fish larvae by-catch in Subarea 48.3 with an acceptable level of precision.

2.9 The Working Group further agreed that while the levels of coverage described in paragraph 2.8 were appropriate for the current fishery in Subarea 48.3, which is a winter fishery, different levels of coverage in space and time are likely to be necessary for accurate estimation of parameters for other areas and at different times of year.

2.10 Since variation of krill population parameters may differ between areas and time of year, required observer coverage to achieve the precision of parameters of interest may also differ across area and time. Those areas with high variability may need higher coverage than other areas with low variability.

2.11 Considering the requirement for systematic observer coverage of 50% in 2010/11 for Area 48 (Conservation Measure 51-06), and noting that increased coverage is required in time–area strata where variability in the quantities being observed (e.g. krill length) is greatest, the Working Group recommended that WG-EMM develop a table indicating time–area strata where variability is highest and, thus, higher observer coverage is required. This table is expected to provide useful guidance for how a systematic program of observer coverage can be optimised to yield data that would be most useful in an assessment.

2.12 The Working Group further noted that the current instructions in the CCAMLR *Scientific Observers Manual* were not designed to account for vessel and haul coverage trade-offs. The Working Group advised that WG-EMM should consider whether the current level of haul sampling should be revised given different levels of vessel coverage.

2.13 In the analysis of observer coverage from the Japanese krill fishery, increased coverage across vessels caused the largest reductions in CV (increases in precision) for both krill mean length and fish by-catch (WG-SAM-10/17). The Working Group noted that the outcome of the analysis presented in WG-SAM-10/17 could have been influenced by the hierarchical structure of the model, suggested the use of linear mixed models to address this issue and encouraged reanalysis in which year, subarea and vessel effects are crossed while haul effects are nested within vessels.

2.14 The Working Group noted that while the analyses of Agnew et al. (2010) and WG-SAM-10/17 considered mean lengths of krill as the statistic of interest, it is likely that the overall population structure of krill in the catch would be of interest in an integrated assessment, and that this may require increased levels of sampling.

2.15 The Working Group recalled that the current requirement (in the *Scientific Observers Manual*) for sampling krill length frequencies by observers was determined through analysis of the overall length-frequency distribution (not the mean), using observer data collected in Subarea 48.3 (WG-EMM-08/45).

2.16 The Working Group agreed that estimating the total mortality of each length class of krill arising from fishing would require information on the landed catch, conversion factors, escape mortality and the mass-at-length of krill sampled during the period of fishing.

2.17 The Working Group also recalled its earlier agreement that an integrated assessment for krill would require a time series of data from the krill fishery (SC-CAMLR-XXVI, Annex 7, paragraph 3.13) and noted that any delay in acquiring data, such as length frequencies from systematic coverage of the krill fishery, would delay the implementation of an integrated assessment and the provision of updated management advice.

2.18 The Working Group also recalled that the best scientific advice remained that, in areas where appropriate levels of observer coverage has not yet been determined, 100% observer coverage in the short term was the best way to achieve systematic observer coverage (SC-CAMLR-XXVI, paragraph 3.10). An analysis of the data from Subarea 48.3 (Agnew et al., 2010) had also demonstrated that after about four years of coverage at higher levels, it was possible to decide on appropriate levels of observation over the longer term.

2.19 The Working Group agreed that it would not be in a position to provide more advice on designing the krill observer program until such time as new data are available and further statistical work to design the program has been undertaken.

Krill escape mortality

Background and papers

2.20 The Working Group recalled that the level of escape mortality in the krill fishery is a matter of concern for assessments and catch allocation schemes. At present, there are few available estimates of krill escape mortality, and these estimates are based on very little data. The Working Group noted that the Scientific Committee had recommended that there should be a concerted effort to estimate escape mortality in the krill fishery (SC-CAMLR-XXVIII, Annex 4, paragraphs 3.5 and 3.6). WG-SAM-10/6 was presented to address this task.

Discussion

2.21 The Working Group welcomed WG-SAM-10/6 in which the recommendations to the field study of the krill escape mortality, including data collection and processing, are shown. This document would be useful to facilitate the development of an operating manual that could be used to collect relevant data by scientific observers. Elaborating a standard approach to collecting data on escape mortality will ultimately improve estimation of this quantity.

2.22 The Working Group recommended that the issues of escape mortality assessment described in WG-SAM-10/6 should be further discussed by WG-EMM.

2.23 The Working Group also recommended continuing development of a manual for collecting standardised data on escape mortality assessment, noting that such a manual and its implications for the workload of scientific observers should ultimately be considered by ad hoc TASO.

Fishable biomass

Background and paper

2.24 It is important to understand how a potential subdivision of the precautionary catch limit for krill among SSMUs or other areas will affect fishery performance. One metric of risk to fishery performance would describe how the spatial distribution of fishable biomass (biomass that is of interest to the fleet) relates to overall biomass that might, for example, be estimated from the results of a research survey. WG-SAM-10/7 Rev. 1 presented the method for assessment of fishable krill biomass at different density thresholds by processing acoustic survey data.

Discussion

2.25 The Working Group noted that analyses presented in WG-SAM-10/7 Rev. 1 suggest that krill biomass available to the fishery is concentrated in small areas and constitutes only part of the total biomass concentrated within coastal SSMUs (SGW, SGE) in Subarea 48.3. The ratio between fishable biomass and total krill biomass may vary considerably by years and SSMUs, reflecting interannual fluctuations in the structure of the krill-density field, and estimation of fishable biomass should be considered relative to threshold krill densities that determine the efficiency of the fishery.

2.26 The Working Group recommended continuing investigation of the distribution of fishable biomass at the different threshold krill densities relative to fishery performance.

Use of acoustics data collected from exploratory krill fisheries
as relative indices of abundance

2.27 Although WG-EMM had asked the Working Group to advise on how acoustics data collected from exploratory krill fisheries (under the terms of Conservation Measure 51-04) could be used as relative indices of abundance, WG-SAM was not provided any information that could be used to form the basis of such advice. It was noted that WG-EMM had requested such advice under the expectation that during 2009/10, an exploratory krill fishery would occur in Subarea 48.6 and data would be available for analysis and consideration by WG-SAM. Exploratory fishing for krill in Subarea 48.6 has not occurred, and, therefore, the Working Group advised that it would reconsider this issue at a later date, after acoustics data from krill fishing vessels had been submitted for analysis.

FINFISH

Strategies for assessing data-poor fisheries

3.1 Robust assessments of toothfish stocks in Subareas 48.6 and 58.4 have been hindered by a lack of data that can be used to characterise the distribution, abundance and productivity of these stocks. Divisions in Subarea 58.4 have also been subject to significant IUU fishing (SC-CAMLR-XXVIII, Annex 5, Table 3). The Working Group noted that the Scientific Committee has expressed concern that the current approach to collecting data in exploratory fisheries outside the Ross Sea was unlikely to result in assessments in the near future, making it urgent to develop approaches that will deliver assessments within the next 3–4 years (SC-CAMLR-XXVIII, paragraphs 4.164 and 4.165).

3.2 The Working Group considered two items under this agenda item:

(i) reviewing the use of research hauls in exploratory fisheries for *Dissostichus* spp. in Subareas 48.6 and 58.4, completed as part of the Research and Data Collection Plan;

(ii) data collection and assessment strategies for data-poor fisheries.

Use of research hauls in exploratory fisheries for *Dissostichus* spp.

Background and papers

3.3 The Working Group noted that standardised CPUE data may assist with assessing distribution and abundance in data-poor fisheries in Subareas 48.6 and 58.4. Since 2008/09, vessels have been required to complete five research hauls in each of two strata (fished and unfished or lightly fished) to assist with developing a comprehensive picture of relative abundance within an SSRU.

3.4 The Working Group considered WG-SAM-10/4, which summarised the implementation of research hauls in the exploratory fisheries for *Dissostichus* spp. in Subareas 48.6 and 58.4 in the 2009/10 season. The Working Group noted that in most

instances, vessels had successfully completed research hauls within the allocated locations across fished and unfished/lightly fished strata. The Working Group further noted that some hauls could not be completed in some allocated locations due to sea-ice, and subsequently lines could only be set in ice-free areas, some of which were set in depths >2 500 m.

Discussion

3.5 The Working Group recalled its discussion on the allocation of the location of research hauls at its last meeting (SC-CAMLR-XXVIII, Annex 6, paragraphs 2.56 to 2.61). It reiterated its advice that this method continue to be used (ibid., paragraph 2.58), to maximise the utility and comparability of the data being collected.

3.6 The Working Group also considered ways to alleviate fishing vessels' difficulties in reaching allocated research haul locations in ice-bound areas. It agreed that the current single allocation of starting positions could be augmented in areas of sea-ice by providing each vessel with up to three random lots of start positions for the required research hauls in a given SSRU. These options would be provided by the Secretariat, on request from the Flag State or its vessel, immediately prior to the vessel's arrival at the SSRU. The vessel could then choose the option which best suited the local sea-ice conditions, and subsequent research hauls would be conducted using the current agreed procedure.

3.7 The Working Group also recalled its advice on the need to be able to standardise CPUE across gear types in order to allow robust comparison of CPUE within and between areas (SC-CAMLR-XXVIII, Annex 6, paragraphs 2.43 to 2.46).

3.8 The Working Group noted that, in calculating catch rates, it is important to consider the number of hooks retrieved as the measure of effort, rather than the number of hooks set, where large numbers of hooks or sections of line are lost. The Working Group noted that a field to record the number of lost hooks on lost line segments had been included on C1 forms in 2007/08 (SC-CAMLR-XXVI, Annex 5, paragraph 7.5).

3.9 The Working Group requested WG-FSA to review the data collected from research hauls to date to determine:

(i) Is there sufficient spatial and temporal overlap in research hauls such that a CPUE standardisation (accounting for, inter alia, the effect of vessel, gear type and line orientation to bathymetry) will be possible in the near future?

(ii) Is there further stratification of research hauls (e.g. to account for areas where sea-ice may be a problem) required to ensure data collected during research hauls can be used to estimate abundance, distribution and population dynamics of toothfish in Subareas 48.6 and 58.4 in the near future?

Data collection and assessment strategies for data-poor fisheries

Background and papers

3.10 The southern SSRU of BANZARE Bank (SSRU B, Division 58.4.3b) was closed in 2007 due to concerns about the status of these stocks and their ability to sustain fishing (CCAMLR-XXVI, paragraph 12.8). The Scientific Committee was unable to provide consensus advice of the status of toothfish in the open SSRUs of this division in 2009 (SC-CAMLR-XXVIII, paragraph 4.203).

3.11 Conservation Measure 41-07 required nominated Members to fish across four quadrants of a gridded survey area in Division 58.4.3b in 2009/10. Japan completed the southeast quandrant of the survey area. However, despite initially indicating their intention to do so, the other nominated Members were not able to participate in the survey.

3.12 WG-SAM-10/13 summarised data on *Dissostichus* spp. collected by the *Shinsei Maru No. 3* in a grid survey on BANZARE Bank (Division 58.4.3b) in 2009/10. WG-SAM-10/16 summarised data on *Dissostichus* spp. collected by the *Shinsei Maru No. 3* in the exploratory fishery on BANZARE Bank (Division 58.4.3b).

3.13 Ob and Lena Banks (Divisions 58.4.4a and 58.4.4b) were closed in 2002/03 due to the Scientific Committee's concerns regarding the low levels of the toothfish stock and the high level of IUU fishing (CCAMLR-XXI, paragraph 11.36).

3.14 Japan carried out a research survey on Ob and Lena Banks in 2007/08. It also conducted a modified survey across Ob and Lena Banks in 2009/10.

3.15 WG-SAM-10/14 summarised data collected by the *Shinsei Maru No. 3* in a grid survey of Ob and Lena Banks (Divisions 58.4.4a and 58.4.4b) in 2009/10. WG-SAM-10/15 summarised a proposal to continue survey work by the *Shinsei Maru No. 3* on Ob and Lena Banks (Divisions 58.4.4a and 58.4.4b) in 2010/11.

3.16 The Working Group recommended that WG-SAM-10/13 to 10/16 be considered in full by WG-FSA at its next meeting. The Working Group confined its discussions to the methodological elements of WG-SAM-10/13 and 10/15.

Discussion

3.17 The Working Group noted the distinction between the current management arrangements for the exploratory fishery on BANZARE Bank (Division 58.4.3b) and the closed fishery on Ob and Lena Banks (Divisions 58.4.4a and 58.4.4b). However, it considered that there were general points of discussion that would be relevant to research conducted in any data-poor fishery.

3.18 The Working Group noted that the survey design implemented in Conservation Measure 41-07 in 2009/10 had not been reviewed by any of the working groups. A lack of clarity on the objectives of the survey, and the lack of participation by Members in completing the sampling grid made it difficult to identify how the data resulting from this

survey would contribute to developing an assessment in this division. For example, some overlap between the areas of the survey grid allocated to vessels would have assisted with standardising the catch rate across the vessels participating.

3.19 The Working Group recalled its advice that the best way to estimate stock size in data-poor areas was to carry out a tagging program (SC-CAMLR-XXVIII, Annex 6, paragraph 2.34). It also recalled that stock assessments had successfully been developed where focused tagging programs had been pursued, such as in Subareas 48.4 and 88.1 where tagging rates of up to 5 fish per tonne green weight caught had been achieved.

3.20 The Working Group recalled its previous advice regarding the characteristics of a well-designed research program (SC-CAMLR-XXVIII, Annex 6, paragraphs 2.34 to 2.40), and requested that WG-FSA also consider the following points in assessing any research survey design:

(i) research fishing operations should attempt to minimise the injury or mortality of all size classes of fish to provide the maximum number of fish suitable for tagging and release;

(ii) lines set should be of an appropriate length to ensure that lines do not overlap strata or extend across large bathymetric ranges.

3.21 The Working Group further recalled its advice that where the area being studied is large and the probability of recapture is low, research should concentrate effort on a subset of the management area. In such a case it would be important to recognise that estimates of abundance resulting from the work would be representative of the smaller area. The tagging effort might be extended more widely in future years, subject to review (SC-CAMLR-XXVIII, Annex 6, paragraph 2.35(i)).

3.22 The Working Group noted that there was currently no data to determine if tagged fish are more likely to survive the capture, tagging and release process from particular gear types (e.g. autoline, Spanish line or trotline). The Working Group requested that ad hoc TASO consider the feasibility of collecting such data.

3.23 The Working Group recalled its advice that other data would be required to perform a stock assessment, including reconstructing the legal and IUU catch history, analysing otoliths to determine catch-at-age and growth rates, and the collection of other biological data important to an assessment such as size-at-maturity (SC-CAMLR-XXVIII, Annex 6, paragraph 2.39).

3.24 The Working Group noted that WG-SAM-10/15 included a calculation of biomass on Ob and Lena Banks based on a comparison between relative catch rates and fishable seabed areas, and the biomass estimated in the assessment of Subarea 48.4 (SC-CAMLR-XXVIII, Annex 5, Appendix M). The Working Group noted that several implicit assumptions of this calculation (including similar catchability of autolines deployed at Subarea 48.4 and Spanish longlines deployed at Divisions 58.4.4a and 58.4.4b, similar size distributions in both areas and similar proportions of the total biomass that are mature in both areas) should be evaluated by WG-FSA in deciding if this method is appropriate for determining preliminary biomass estimates. The Working Group encouraged Members to consider simulation work to determine the effect that violating these assumptions may have on the biomass calculated.

3.25 The Working Group noted that in the absence of a robust method for estimating biomass in an area from longline catch rate alone, it is very difficult to estimate a precautionary level of research catch. Furthermore, without a minimum estimate of biomass, it is very difficult to determine a total number of tags to release, or a tagging rate, to achieve a biomass estimate with a target CV, following the method recommended by the Working Group in the past (SC-CAMLR-XXVIII, Annex 6, paragraph 2.35(i)), and implemented in WG-SAM-10/15.

3.26 The Working Group recalled that established methods exist for calculating abundance from trawl surveys, such as used for icefish in Subarea 48.3 and icefish and toothfish in Division 58.5.2 (SC-CAMLR-XXVI, Annex 5, Appendices O, R and S). When evaluating proposals for tag-recapture programs or longline surveys, such as in WG-SAM-10/15, the Working Group requested that WG-FSA consider the possibility of using a trawl survey to establish a preliminary biomass estimate that could then inform the design of a longer-term tagging program.

3.27 The Working Group agreed that its discussions in recent meetings had provided general advice on the methodologies that could be applied to collect data and develop robust assessments for data-poor fisheries in Subareas 48.6 and 58.4. The Working Group encouraged Members to continue to submit papers developing and evaluating methods of assessing data-poor fisheries; however, it considered that there was no need for a standing item on this topic on the Working Group's agenda.

Natural mortality of toothfish

3.28 WG-SAM-10/11 Rev. 1 described two models for estimation of *M* using catch-at-age and aged release–recapture data, the BODE (Baranov ordinary differential equation) and CCODE (constant within-year catch ordinary differential equation) models. The paper described the results of the application of the models using a realistic simulation framework involving multiple years of releases and all relevant cohorts. The paper concluded that the CCODE model performed better in general than the BODE model. In scenarios where non-domed selectivities were assumed, the CCODE model gave close to unbiased and reasonably precise estimates of *M*.

3.29 The Working Group noted that the CCODE model did not account for the fact that catch-at-age is not known exactly, but when applied in practise will be based on catch weight combined with the usual annual length frequency and otolith sampling. However, the Working Group also noted measurement and estimation error relating to weight-to-length conversion and ageing error adds uncertainty. The BODE model assumed the estimation errors are purely 'process' errors (i.e. model lack-of-fit) and hence does not decompose the total variance into the appropriate contributions from the different sources of error. Even though the catch weights in total represent a census which can be assumed to be known exactly, both BODE and CCODE models are approximations given the actual uncertainties in the catch-at-age data.

3.30 The Working Group noted that IUU catch is not accounted for by either model and it is not clear how this catch can be validly accounted for in these models.

3.31 The Working Group noted that the BODE model can give poor estimates of the total catch, and suggested that this might be addressed by modelling the catch-at-age as proportions, with the total catch used as a constraint.

3.32 The Working Group recalled that the estimates of *M* used for the *Dissostichus eleginoides* assessments in Division 58.5.2 and Subarea 48.3 are assumed to be 0.13 y^{-1}. The value was based on consideration of Beverton-Holt invariants presented in WG-FSA-05/18. The estimate of *M* used for *D. mawsoni* is also 0.13 y^{-1}, but this value was based on an analysis of catch-curve data from the Ross Sea fishery using the Chapman-Robson estimator (WG-FSA-SAM-06/8).

3.33 The Working Group noted the intention of Dr Candy to investigate each of the BODE and CCODE models in the estimation of *M* for Division 58.5.2 toothfish in order to evaluate the performance of these models in providing realistic estimates of *M* and the uncertainty of these estimates. The Working Group encouraged Members to investigate refinements to the data and methods for estimating *M*.

Age- versus length-based harvest control rules

3.34 WG-SAM-10/12 compared age- and length-based HCRs for icefish in South Georgia, to determine whether the length-based approach could be reliably used to generate catch recommendations. An age-based operating model was used to generate a distribution of initial numbers-at-age to which an age-based HCR (which implemented the operating model and therefore reproduced the underlying population dynamics exactly) was applied. The initial numbers-at-age were also converted to numbers-at-length, and two length-based HCRs applied. The length-based methods used two different length-transition matrices described in Hillary (2010) and Punt et al. (1997).

3.35 The Working Group noted that estimates of catch limits from the age- and length-based HCRs were essentially the same in the first year, with the length-based methods more conservative in the second year. Both length-based HCRs (using the different length transition matrices) produced comparable results.

3.36 The Working Group concluded that the length-based approach, with the method described in Hillary (2010) of generating the length transition matrix, was suitable for determining catch limits.

3.37 The Working Group recommended that the code be validated and a worked example be provided and verified for WG-FSA-10. The worked example will be undertaken by the authors of WG-SAM-10/12, while Dr Candy volunteered to undertake the validation.

3.38 The Working Group noted that the method will be further evaluated as part of a wider study on management strategies in icefish in the near future.

Minimally realistic food-web modelling

3.39 The Working Group considered WG-SAM-10/21 describing the conceptual basis of work in progress to produce a minimum realistic model for investigating trophic relationships between *D. mawsoni* and its demersal fish prey on the Ross Sea slope, some of which are also caught as by-catch by the fishery. The model is intended as a tool to generate plausible hypotheses regarding trophic interactions between demersal fish, and to examine the potential for trophic impacts associated with changes in abundance arising from the fishery. The Working Group welcomed work to progress the model and encouraged its authors to seek collaboration with other interested Members.

VULNERABLE MARINE ECOSYSTEMS

VME modelling and evaluation tools

4.1 WG-SAM-10/19 described a spatially explicit Schaeffer production model designed to be used to simulate key processes of VME taxa population dynamics and bottom fishing effort, and to evaluate the effects of various management strategies. The paper included case studies using actual fishing effort distributions in the Ross Sea region, and projecting similar future effort patterns, to simulate impacts on VME taxa under different management strategies. VME taxa were distributed spatially with reference to hypothetical depth preferences and to the benthic bioregionalisation described in WG-EMM-10/30. Management strategy options considered in the case studies included no management and a move-on rule similar to that prescribed in Conservation Measure 22-07 but with alternate by-catch trigger thresholds and alternate areal closure sizes.

4.2 The Working Group welcomed the development of the model and recommended further development to evaluate strategies for avoiding significant adverse impacts on VMEs.

4.3 WG-SAM-10/9 described version 2 of Patch, a simulation model in R for evaluating spatial management strategies to conserve the structure and function of ecosystems, proposed as a potential tool to inform management within CCAMLR on strategies to avoid significant adverse impacts on VMEs. The paper includes a revised manual for Patch, the code for which is available from the Secretariat.

4.4 The Patch model has been considered previously by WG-FSA (SC-CAMLR-XXVIII, Annex 5, paragraph 10.11; WG-FSA-09/42) and WG-SAM (SC-CAMLR-XXVIII, Annex 6, paragraphs 4.8 to 4.19). The updated version described in WG-SAM-10/9 includes the following changes:

(i) a revised map with layers that can be used to influence the distribution and abundance of targets, patches, disturbance, activities and managers;

(ii) a reconfigured fishery model to enable better fleet dynamics;

(iii) a complete manual, including a user guide and programmer’s notes;

(iv) the use of programming objects to streamline programming of the different components.

4.5 The Working Group welcomed the continued progress in the development of Patch. It further noted that Patch is a very complex and flexible modelling package that may be applied to a wide range of ecological and management scenarios.

4.6 The Working Group recommended the development of case studies to assist Members in understanding the way in which Patch will operate with specific reference to bottom fishing impacts on VMEs. The Working Group recommended that specific case studies be developed and presented to WG-EMM and WG-FSA in order for them to be able to assess the use of specific parameters to represent plausible scenarios for management of VMEs and corresponding outputs.

4.7 The Working Group recommended, for both models (paragraphs 4.1 to 4.4), that simple case studies be prepared to illustrate the operation of the models consistent with expectations under extreme scenarios chosen to clearly illustrate the expression of particular input parameters. These will be useful to assist validation of the models.

4.8 The Working Group noted that because spatial correlations in ecology are scale-dependent, the cell size selected for use in simulation models of this kind is important if the model defines biological distributions as a function of cell attributes or in relation to other biological distributions.

4.9 The Working Group noted that WG-EMM is the appropriate body to provide guidance as to the particular spatial and ecological characteristics of VMEs, and that WG-FSA is the appropriate body to comment on interactions with fishing gear. The Working Group recommended that VME simulation methods such as those described in WG-SAM-10/9 and 10/19 should incorporate the advice of WG-EMM and WG-FSA in parameterising the models to characterise 'plausible scenarios'. WG-SAM suggested that WG-EMM and WG-FSA consider what scenarios and performance measures provide a sound basis for evaluating management strategies to avoid significant adverse impacts on VMEs.

4.10 The Working Group noted that the models described in WG-SAM-10/9 and 10/19 remain to be fully validated according to WG-SAM-09 (SC-CAMLR-XXVIII, Annex 6, paragraph 5.11).

4.11 The Working Group noted the advice of WG-SAM-09 (SC-CAMLR-XXVIII, Annex 6, paragraph 5.17) that, for models that have been developed to meet a specific request of the Scientific Committee or Commission on a short deadline, and for which there is insufficient time available for a full evaluation and validation, advice arising from the model should be commensurate with the level of evaluation and validation of the model. On this basis the Working Group recommended that the models described in WG-SAM-10/9 and 10/19 be further developed as a matter of priority, with emphasis on the provision of both plausible and illustrative case studies and necessary validation, to enable use of these models to inform WG-FSA-10 and SC-CAMLR-XXIX, commensurate with the level of model validation that is possible upon review by WG-FSA-10.

VME impact assessment methods

4.12 WG-SAM-10/20 described a revised impact assessment framework that estimates the cumulative footprint and impact on VME taxa associated with New Zealand's bottom

longline fishery in the Ross Sea. The Working Group noted the differences in this updated framework relative to the previous version presented by New Zealand (WG-SAM-09/P1). These differences included:

(i) the impact assessment no longer uses distinct assumption sets to represent the upper and lower bound estimates of footprint and impact; instead it uses prior distributions to represent input assumptions about fishing gear movement in contact with the sea floor, and associated footprints and impacts on VME taxa;

(ii) the estimated footprint and impact indices are expressed as standard metrics;

(iii) the impact assessment is applied within spatial boundaries defined by the benthic bioregionalisation described in WG-EMM-10/30;

(iv) the impact assessment is applied at very fine spatial scales within which the assumption of no systematic relationship between fishing effort and VMEs is thought to be valid.

4.13 The Working Group noted the specific use of the terms 'footprint' and 'impact' in this framework. These are defined in WG-EMM-10/29 and are recommended to be considered further by WG-EMM.

4.14 The Working Group agreed that the Monte Carlo approach of sampling from distributions to represent input assumptions of the impact assessment framework constitutes an improvement over the previous method of using distinct assumption sets of point estimates to represent upper and lower bounds. However, the Working Group recognised that the nature of these distributions should be properly considered by WG-EMM.

4.15 The impact assessment formula, as described in the framework, is only applied to a single VME taxon; in this case, under an assumed 'worst-case' scenario for the most vulnerable taxon. However, the impact index can potentially be applied over multiple taxa or communities. The Working Group agreed that it would be useful to explore potential options for summarising impacts to multiple VME taxa or communities within an impact index.

4.16 The Working Group advised WG-FSA that the framework proposed in WG-SAM-10/20 could be used by individual Members as well as when WG-FSA needs to generate an overall cumulative impact assessment for a particular subarea or division across all Members notifying to participate in new and exploratory fisheries, given specific assumptions with respect to differences in gear configuration and performance.

4.17 The Working Group noted that the assessment in WG-EMM-10/20 examined cumulative historical spatial footprints of all longline deployments at a range of spatial scales and demonstrated that because effort distributions become sufficiently disordered at scales smaller than 10 km pixels, there is likely to be no systematic association between fishing effort and VME taxa at that scale.

4.18 The Working Group recommended that impacts calculated within small-scale pixels should in turn be summarised within biologically meaningful areas to determine if impacts in these areas may be different. It noted that plots of the frequency distribution of pixels in different impact categories would be a useful method for visualising the scales of impacts in different types of areas.

4.19 The Working Group recommended that standard metrics to express effort density, fishing footprint and impact (e.g. as in WG-SAM-10/20) should be used and expressed in common units. This would facilitate comparison between Members' preliminary assessments, as well as standardise inputs to simulation approaches such as those described in WG-SAM-10/9 and 10/19. The Working Group agreed that suitable metrics and units for longlines are as follows:

(i) effort density for longlines, expressed as km of line per km^2 of seabed area;

(ii) footprint index, the seabed area contacted by the fishing gear per unit effort, in units of km^2 of seabed per km of line;

(iii) impact index, the footprint index multiplied by proportional impact within the footprint.

GENERAL ISSUES

5.1 The Working Group welcomed the presentation of WG-SAM-10/P1 that described the application of the generalised age- and/or stage-structured seabird population dynamics modelling package (WG-SAM-08/P3 that had been previously considered by the Working Group (SC-CAMLR-XXVII, Annex 7, paragraphs 4.21 to 4.24)).

5.2 WG-SAM-10/5 described data quality assurance work under development in the Secretariat that included the use of species distribution metadata and trip report cards for both vessel and observer data. The Working Group agreed that all such developments to improve data quality were important. Furthermore, it suggested that the potential for routinely comparing fine-scale data and VMS data be examined as part of the data validation process.

5.3 WG-SAM-10/18 described a method for determining fishable areas for the seabed using scripted queries of a spatial database. The method uses the full resolution of a specified dataset and user-definable projection (currently South Pole Lambert Equal Area) to generate single polygons and calculate seabed areas for user-defined depth bins. The strength of the process is that subjectively derived contours are not needed and data are not aggregated to reduce the number of cells.

5.4 The Working Group agreed that this method would be useful for developing advice for Subareas 88.1 and 88.2, and noted that the data and method are available for the entire Southern Ocean. The Working Group encouraged specificity in presenting spatial data, especially in reporting the projection used for analysis.

5.5 The database (currently Gebco_2008 (rel. November 2009)) and the query script is currently available from New Zealand. The Working Group agreed that a formal repository for spatial bathymetric data is needed and recommended that the Secretariat identify appropriate organisations that may already have the infrastructure and expertise to store, manage and make available these types of data and functions, including the potential for future web interfaces. The Working Group further recommended that the Secretariat may be

the appropriate organisation to store metadata and derived GIS layers for routine mapping purposes (such as fishable-area polygons or subarea boundary files) to enhance data sharing and consistency among Members.

5.6 WG-FSA-09 (SC-CAMLR-XXVIII, Annex 5, paragraphs 10.15 and 10.16) had recommended that cumulative effort by gear type, SSRU or subdivision be used to inform the review of proposed bottom fishing activities under Conservation Measure 22-06. The Working Group reviewed software presented as part of WG-SAM-10/22. The R code utilises CCAMLR C2 data, incorporates GIS shapefiles and allows user-definable spatial scales to summarise data for several grouping variables.

5.7 The Working Group welcomed this substantial improvement on previous functions available to WG-FSA, noting that the software is very flexible and includes all of the grouping variables needed for display of fishing effort data, although some code to automatically link appropriate C2 data from different tables would enhance the ease of use.

5.8 The Working Group noted that one of the main purposes of generating effort plots is to visualise the spatial pattern in fishing effort density. It is therefore important, especially for large areas, to project plots to some appropriate projection space, such as an equal area projection. As the code is complex, help files for the functions developed would be useful, and the entire assemblage of functions could be built as an R library. The Working Group also noted that displaying fishing effort, especially for fine-scale analyses, may require plotting individual lines or line segments, or allocating lines or portions of lines to a given cell grid.

5.9 The Working Group encouraged the author of WG-SAM-10/22 to update the functions and submit this for use by WG-FSA at its meeting this year.

OTHER BUSINESS

Independent review of the Secretariat's data management systems

6.1 The Working Group reviewed the proposal for an independent review of the Secretariat's data management systems (WG-SAM-10/8), noting that the goal of the proposed review is to provide assurance that CCAMLR's information assets are appropriately managed and protected, and that identified risks, including those which may arise from the Commission's growing needs, are managed and mitigated using an appropriate international standard as the benchmark. The Working Group also noted that the proposed review is part of the Secretariat's broad consideration of an information security policy.

6.2 The Working Group supported the proposed review and agreed that:

(i) the terms of reference of the review should be cast in the context of the Commission's future requirements;

(ii) the terms of reference may be broadened to identify opportunities for greater data integration, requirements for GIS-type systems and management of GIS-layer datasets, and consideration of whether Members could assist in bridging identified gaps;

(iii) the review should also identify the resources required to support its outcomes and the risks of not being able to implement those outcomes.

Performance Review

6.3 The Working Group recalled that the Scientific Committee had further considered the PRP report (SC-CAMLR-XXVIII, paragraphs 10.5 to 10.11), which included tasks to be considered by WG-SAM. These tasks were considered under 'Future Work' (Section 7).

FUTURE WORK

7.1 The Working Group recalled its purpose, including that derived from its origins as a subgroup of WG-FSA. It agreed that it had demonstrated there is value in bringing together the quantitative experts across the working groups of the Scientific Committee into a forum for developing, evaluating and validating more complex or non-standard methodologies to be used by the other working groups.

7.2 Although there is overlap with other working groups in order to provide context for its discussions on methods, the Working Group noted that its role is not to replace or duplicate the work of the other working groups. It also noted that not all quantitative issues need to be considered by WG-SAM when there is appropriate expertise available within a working group and the principles for adopting methodologies can be achieved.

7.3 The Working Group noted the increase in the range of tasks that were identified last year (SC-CAMLR-XXVIII, Annex 6, paragraph 6.1) as well as the ongoing discussion of the Scientific Committee on prioritising its work. Rather than considering the individual tasks, the Working Group discussed how best to provide an effective service to the other working groups and the Scientific Committee, a key aspect of which is to maximise the availability of appropriate quantitative expertise to continue its work. These may potentially include:

(i) greater clarity from other working groups when seeking advice from WG-SAM is required. This should include clear terms of reference rather than a simple recommendation that an issue be passed to WG-SAM for its consideration;

(ii) the setting of multi-year agendas to allow improved planning and preparation, noting that longer lead times can be advantageous in securing resources for such work;

(iii) clear prioritisation of, and setting of the agenda for, the work of WG-SAM during the meeting of the Scientific Committee;

(iv) flexibility in meeting scheduling such that WG-SAM might have a reduced requirement to give advice in some years, compared to other years when, for example, methods need to be reviewed in time for use by WG-FSA in 'assessment years'.

7.4 Some of these issues may be resolved, including variable emphasis on issues from one year to another, by holding meetings of all the working groups simultaneously, but interleaved (as is current practice in the IWC), and could provide a method for creating greater synergies between WG-SAM and the other working groups. It was agreed that this proposal could be considered further by the Scientific Committee, noting that there were potential costs and benefits associated with such a proposal.

7.5 The Working Group agreed that the prioritisation of items for consideration by WG-SAM at its next meeting should take place at the Scientific Committee in order that the comments and recommendations of WG-EMM and WG-FSA can be accommodated.

ADVICE TO THE SCIENTIFIC COMMITTEE

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

8.2 The Scientific Committee is requested to consider whether the format of the report needs to be changed in order to be able to extract an executive summary of recommendations or whether the current format is acceptable.

8.3 The Secretariat was asked to prepare options of different report formats (e.g. SC-CAMLR-XXVIII, Annex 6, paragraph 1.8) that the Scientific Committee could consider.

8.4 WG-SAM has provided advice to WG-EMM on the following items:

(i) krill integrated assessment (paragraph 2.3)
(ii) scientific observer programs for krill fisheries (paragraphs 2.6 and 2.19)
(iii) krill escape mortality (paragraphs 2.22 and 2.23)
(iv) krill fishable biomass (paragraph 2.26)
(v) VMEs (see paragraph 8.6 below).

8.5 WG-SAM has provided advice to WG-FSA on the following items:

(i) strategies for data-poor fisheries for *Dissostichus* spp. (paragraphs 3.6, 3.9, 3.19 to 3.26);

(ii) HCRs for *Champsocephalus gunnari* (paragraphs 3.36 and 3.37);

(iii) VMEs (see paragraph 8.6 below).

8.6 WG-SAM has provided advice to WG-EMM and WG-FSA on the following items:

(i) VME modelling and evaluation tools (paragraphs 4.6, 4.7, 4.9 and 4.11)
(ii) VME impact assessment methods (paragraphs 4.14 to 4.16, 4.18 and 4.19).

8.7 WG-SAM referred WG-IMAF to the seabird population dynamics modelling package (paragraph 5.1).

8.8 WG-SAM has provided general advice on the following items:

(i) bathymetric data (paragraphs 5.4 and 5.5)
(ii) plotting spatial data (paragraph 5.9)
(iii) review of the Secretariat's data management systems (paragraph 6.2).

8.9 WG-SAM's advice to the Scientific Committee on its future work program and its relationship with other working groups is provided in paragraphs 7.1 to 7.5. These issues require broader consideration by the Scientific Committee of the timing, agenda and priorities of all working groups.

ADOPTION OF THE REPORT AND CLOSE OF THE MEETING

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

9.2 In closing the meeting, Dr Constable thanked the participants for their contributions to the meeting and their work during the intersessional period, the subgroup coordinators for facilitating discussions, and the rapporteurs for bringing together a short focused report. He also thanked Dr Mayekiso and his local organising team for providing a beautiful venue and excellent facilities for the meeting, and the Secretariat for its support.

9.3 Dr Agnew (Scientific Committee Chair), on behalf of the participants, thanked Dr Constable for his excellent work in convening the meeting and leading the discussions.

REFERENCES

Agnew, D.J., P. Grove, T. Peatman, R. Burn and C.T.T. Edwards. 2010. Estimating optimal observer coverage in the Antarctic krill fishery. *CCAMLR Science*, 17: 139–154.

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APPENDIX A

LIST OF PARTICIPANTS

Working Group on Statistics, Assessments and Modelling
(Cape Town, South Africa, 19 to 23 July 2010)

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APPENDIX B

AGENDA

Working Group on Statistics, Assessments and Modelling
(Cape Town, South Africa, 19 to 23 July 2010)

1. Introduction
   - 1.1 Opening of the meeting
   - 1.2 Adoption of the agenda and organisation of the meeting

2. Krill
   - 2.1 Krill integrated assessment
   - 2.2 Krill observer program
   - 2.3 Krill escape mortality
   - 2.4 Krill fishable biomass
   - 2.5 Use of acoustics as relative index of abundance

3. Finfish
   - 3.1 Strategies for data-poor fisheries (toothfish)
   - 3.2 Natural mortality of toothfish
   - 3.3 Age- versus length-based harvest control rules
   - 3.4 Minimally realistic food-web modelling

4. Vulnerable marine ecosystems
   - 4.1 VME modelling and evaluation tools
   - 4.2 VME impact assessment methods
   - 4.3 Evaluation of management strategies for VMEs

5. General issues
   - 5.1 Seabird assessments
   - 5.2 Data quality
   - 5.3 Bathymetric data
   - 5.4 Plotting spatial data

6. Other business
   - 6.1 Review of data management system
   - 6.2 Performance review

7. Future work
   - 7.1 Long-term work plan
   - 7.2 Other issues – agenda

8. Advice to the Scientific Committee

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

APPENDIX C

LIST OF DOCUMENTS

Working Group on Statistics, Assessments and Modelling
(Cape Town, South Africa, 19 to 23 July 2010)

WG-SAM-10/1	Draft Agenda and Draft Annotated Agenda for the 2010 Meeting of the Working Group on Statistics, Assessments and Modelling (WG-SAM)
WG-SAM-10/4	Deployment of research hauls in the exploratory fisheries for *Dissostichus* spp. in Subareas 48.6 and 58.4 in 2009/10 Secretariat
WG-SAM-10/5	Further improvements in data quality (short note) Secretariat
WG-SAM-10/6	Recommendations on estimating krill escape mortality during fishing operations: the problems and approaches V.K. Korotkov and S.M. Kasatkina (Russia)
WG-SAM-10/7 Rev. 1	Assessment of fishable krill biomass on the basis of the acoustic surveys results using geostatistical methods S.M. Kasatkina and P.S. Gasyukov (Russia)
WG-SAM-10/8	Proposal to commission an independent review of the Secretariat's data management systems Secretariat
WG-SAM-10/9	Update on Patch v2: a simulation program in R for evaluating spatial management strategies to conserve structure and function of ecosystems A.J. Constable (Australia)
WG-SAM-10/10	Factors to consider in designing a systematic observer program for the krill fishery S. Kawaguchi and A. Constable (Australia)
WG-SAM-10/11 Rev. 1	Estimation of natural mortality using catch-at-age and aged mark-recapture data: a simulation study comparing estimation for a model based on the Baranov equations versus a new mortality equation S.G. Candy (Australia) (*CCAMLR Science*, submitted)

WG-SAM-10/12	Comparison of age- and length-based harvest control rules for the South Georgia icefish (*Champsocephalus gunnari*) fishery C.T.T. Edwards, R.M. Hillary, R.E. Mitchell and D.J. Agnew (United Kingdom)
WG-SAM-10/13	Preliminary reports on stock status and biological information on toothfish obtained from the scientific research survey by *Shinsei Maru No. 3* in 2009/10 in the SE sector of Division 58.4.3b K. Taki, M. Kiyota and T. Ichii (Japan)
WG-SAM-10/14	Preliminary reports on abundance and biological information on toothfish in Divisions 58.4.4a and 58.4.4b by *Shinsei Maru No. 3* in the 2009/10 season K. Taki, M. Kiyota and T. Ichii (Japan)
WG-SAM-10/15	Research plan for toothfish in Divisions 58.4.4a and 58.4.4b by *Shinsei Maru No. 3* in 2010/11 Delegation of Japan
WG-SAM-10/16	Distribution and population structure of *Dissostichus eleginoides* and *D. mawsoni* on BANZARE Bank (CCAMLR Division 58.4.3b), Indian Ocean, Antarctic K. Taki, M. Kiyota, T. Ichii and T. Iwami (Japan) (*CCAMLR Science*, submitted)
WG-SAM-10/17	Analysis of observer coverage for Japanese krill fishing vessels T. Okuda, M. Kiyota and H. Okamura (Japan)
WG-SAM-10/18	A bathymetric data framework for conservation in the Ross Sea region S.J. Parker, B. Wood, S.M. Hanchet and A. Dunn (New Zealand)
WG-SAM-10/19	Development of methods for evaluating the management of benthic impacts from longline fishing using spatially explicit production models A. Dunn, S.J. Parker and S. Mormede (New Zealand)
WG-SAM-10/20	Revised impact assessment framework to estimate the cumulative footprint and impact on VME taxa of New Zealand bottom longline fisheries in the Ross Sea region B.R. Sharp (New Zealand)
WG-SAM-10/21	Towards a Minimum Realistic Model for investigating trophic relationships between Antarctic toothfish and demersal fish in the Ross Sea, Antarctica M.H. Pinkerton, S. Mormede and S.M. Hanchet (New Zealand)

WG-SAM-10/22	*plotImage* – software for producing augmented image plots of spatially referenced data J.P. McKinlay (Australia)

Other documents

WG-SAM-10/P1	Fisheries risks to the population viability of black petrel (*Procellaria parkinsoni*) R.I.C.C. Francis and E.A. Bell (New Zealand) (*New Zealand Aquatic Environment and Biodiversity Report*, 51 (2010), ISSN 1176-9440)

Additional Information

Letter from ICES – Invitation to join a strategic initiative on stock assessment methods (SISAM)