Krill

Methods for Estimating Distribution, Standing Stock, Recruitment and Production

4.1 The Scientific Committee noted that WG-EMM has continued its work on refining the methodology for acoustic estimation of krill biomass (Annex 4, paragraphs 3.1 to 3.10 and Appendices D and E) and, because of the level of expertise on this topic present in the Working Group, the Scientific Committee suggested that it might also examine the results of acoustic surveys for fish such as one reported by Russia and considered by WG-FSA (Annex 5, paragraphs 4.145 and 4.146).

4.2 The results of a large number of acoustic surveys for krill covering parts of Areas 48, 58 and 88 were reported to WG-EMM in 1996 (Annex 4, paragraphs 3.12 to 3.41). Particularly noteworthy were the results of a very successful Australian survey in Division 58.4.1 which covered an area of 873 000 km^2 and produced a biomass estimate of 6.67 million tonnes with a CV of 27% (Annex 4, paragraphs 3.31 to 3.36). The Scientific Committee recognised the significance of this survey which was the first acoustic survey of a CCAMLR statistical division designed to produce an estimate of B_0.

4.3 Whilst recognising the quality of the biomass estimate produced by the survey of Division 58.4.1, the Scientific Committee noted that it would be desirable to repeat the survey at some point in the future so that some assessment of the variability of krill abundance in this area could be made.

4.4 The Scientific Committee also received details of an Indian survey carried out in Division 58.4.4 during 1996 to study fisheries potential in this area and, jointly with Polish scientists, to examine processing technology (SC-CAMLR-XV/BG/15). The Scientific Committee welcomed India's research efforts and encouraged Indian scientists to participate in the work of WG-EMM. The Scientific Committee looked forward to receiving detailed results of this research for consideration at WG-EMM.

4.5 The Scientific Committee noted the extremely high priority given by WG-EMM to a new synoptic survey of krill in Area 48 and endorsed the plans put forward by the Working Group to form a steering group to move this proposal forward (Annex 4, paragraphs 3.72 to 3.75 and 7.58(v)). The Scientific Committee looked forward to receiving a detailed proposal for this survey, including a timetable and the resources required from Members to accomplish the task.

4.6 It was agreed that in the light of advances in technology and from experience gained in the conduct of recent large-scale acoustic surveys, a synoptic survey of Area 48 would require much less in the way of resources than had been envisioned in the past (Annex 4, paragraph 3.72). The Working Group estimated that approximately 60 ship-days sampling would be required and the Scientific Committee noted that with the current number of nations operating research vessels in the South Atlantic, such a figure would be attainable.

4.7 Given the feasibility of a survey of this magnitude, the Scientific Committee advised the Commission that it saw the conduct of a synoptic survey of krill in Area 48 as being a task of the highest priority.

4.8 Accordingly, the Scientific Committee requested that the Commission ask the Secretariat to send a circular to all Members informing them of the urgent need for a synoptic survey of Area 48, the status of planning arrangements and the timetable for implementation.

4.9 Members should be encouraged to bring to the next meeting of WG-EMM information on whether they could contribute to such a survey which would be scheduled to occur in the 1998/99 season. This would allow a suitable lead time for detailed planning and discussion of the survey before its implementation.

Catch per Unit Effort

4.10 Analyses of the CPUE data from the krill fishery in Subarea 48.1 indicated that there had been a declining trend from the mid-1980s to the 1989/90 season, but that the CPUE had remained relatively constant since the 1990/91 season. These changes were considered to be related to changes in the timing and intensity of the fishery in Subareas 48.1 and 48.3 (Annex 4, paragraphs 3.42 to 3.47). The Scientific Committee encouraged the submission of more of these data to future meetings of the Working Group.

4.11 Progress had been made in the estimation of effort and the Scientific Committee noted that an exercise in the collation of a time budget for fishing operations had been completed by a scientific observer which confirmed the feasibility of this technique which had been suggested by WG-EMM (Annex 4, paragraphs 2.10 and 2.11). Further collection of such data and their submission and analysis were encouraged.

4.12 The Scientific Committee endorsed the Working Group's call for further submission of haul-by-haul data from defined fishing locations and noted the utility of this information in interpreting the behaviour of the fishery (Annex 4, paragraphs 3.28 to 3.30).

Recruitment

4.13 The Working Group had examined the evidence of long-term changes in krill recruitment and abundance in the Elephant Island area and was unable to determine whether the results represented fluctuations about a median level or whether they were indicative of a longer-term trend in overall abundance (Annex 4, paragraphs 3.48, 3.59 and 7.4 to 7.13).

4.14 Because only one long-term dataset had been analysed – that from the Elephant Island area – the Working Group was unable to determine whether the results from a restricted area in Subarea 48.1 were indicative of changes that might have occurred throughout the whole of Subarea 48.1 or even over a wider area.

4.15 Members were urged to examine the datasets in their possession and to analyse them for any long-term trends in abundance and recruitment (Annex 4, paragraphs 3.58 and 3.59). In particular, the analysis of data from the fishery over wide areas was encouraged.

4.16 It is likely that there are sufficiently long time series of length-density data from the Indian Ocean sector and Japanese and Australian scientists were encouraged to collaborate in the analysis of these data and to submit their analyses to the next meeting of the Working Group (Annex 4, paragraph 3.59).

4.17 If the observed changes in recruitment and abundance are merely fluctuations about a median level, then such variability is incorporated into the krill yield model currently used to set precautionary limits. If, on the other hand, the changes are a result of long-term changes in abundance and recruitment, then the current krill yield model may have difficulty reflecting the actual level of variability and will need to be modified.

4.18 The Scientific Committee recognised that it was desirable to examine the outputs of the krill yield model to determine whether they conform to the observed level of recruitment variability determined from samples in the South Atlantic and recommended that this work proceed.

4.19 Because of the fundamental nature of the questions raised by the variation in the observed recruitment indices, the Scientific Committee endorsed the Working Group's plan for a workshop to examine these changes in recruitment and abundance in Area 48 (Annex 4, paragraph 6.93) (La Jolla, USA, June 1997).

Local Distribution

4.20 The Subgroup on Statistics and the Working Group had indicated that considerable research was required in the area of indices of local abundance and Members were requested to submit information to the Working Group of size composition, sex and maturity stage and energy content of krill (Annex 4, paragraphs 3.66 to 3.71 and Table 2). The Scientific Committee recognised these research priorities.

Future Work

4.21 The Scientific Committee endorsed the tasks identified by the Working Group as requiring further work (Annex 4, paragraph 7.58). These included the following items which directly relate to krill and which would be carried out informally by various members of WG-EMM:

(i) further coordination of research in the Antarctic Peninsula region;
(ii) further examination of uncertainty in acoustic surveys;
(iii) investigations into the use of multifrequency acoustic techniques in surveying; and
(iv) further work on the submodels within the overall ecosystem modelling framework.

General Advice Relating to Krill
(Annex 4, paragraph 8.3)

4.22 Given the difficulties experienced in surveying large statistical subareas and divisions, further consideration should be given to subdividing such areas into smaller management units (Annex 4, paragraph 3.41).

4.23 The updated *Scientific Observers Manual* should be published in 1997 as a matter of urgency.

4.24 The Subgroup on Statistics should meet in 1997 immediately prior to the meeting of WG-EMM. The terms of reference of the Subgroup on Statistics are provided in paragraph 5.38. The Convener will be Dr Watters.

4.25 A workshop is planned on the inter-relationship between the subareas in Area 48, including the study of changes in krill recruitment and abundance in subareas and the linkages between monitoring sites (see paragraph 4.19) (La Jolla, USA, June 1997).

4.26 The krill symposium identified in last year's Scientific Committee report is now to be held in 1998 or 1999. Dr M. Mangel of the University of California, Santa Cruz, USA, has offered to host this symposium and a full proposal will be put to the Scientific Committee in 1997 (Annex 4, paragraphs 9.1 to 9.4).

Management Advice
(Annex 4, paragraphs 8.1 and 8.2)

Area 58

4.27 The Scientific Committee endorsed the Working Group's calculation of a precautionary limit using the results from the krill biomass survey carried out in Division 58.4.1 (Annex 4, paragraphs 7.23 and 7.24) and recommended a precautionary catch limit of 775 000 tonnes per year for this division.

Area 48

4.28 The Scientific Committee recognised the urgent need for a synoptic survey in Area 48 and noted that it could not update its management advice for this area until such a survey had been conducted. Consequently, the Scientific Committee recommended that the existing management measures for Area 48 remain in force.

Fish Resources

Area 48

Antarctic Peninsula (Subarea 48.1)

4.29 The Scientific Committee noted that no new information on stocks in this subarea was available to WG-FSA. It also noted that a bottom trawl survey of Subarea 48.1 will be carried out by the German RV *Polarstern* in November and December 1996 (see Annex 5, paragraph 4.35).

Management Advice

4.30 In the absence of new information on stocks in this subarea, the Scientific Committee endorsed the advice of the Working Group that fisheries in Subarea 48.1 should remain closed in accordance with Conservation Measure 72/XII.

South Orkney Islands (Subarea 48.2)

Champsocephalus gunnari (Subarea 48.2)

4.31 The Scientific Committee noted that no new information was available to the Working Group on stocks in this subarea and that no new assessment had been undertaken at this year's meeting.

4.32 The Scientific Committee also noted the suggestion of Dr P. Gasiukov (Russia), made at the Working Group, that an experimental scientific fishery for *C. gunnari* should be permitted in this subarea following a similar approach to that adopted for *C. gunnari* in Subarea 48.3 for the 1995/96 season (Conservation Measure 97/XIV). Dr Gasiukov suggested a precautionary TAC of 1 500 tonnes, based on the approximate midpoint of the range of minimum (392 tonnes) and maximum (3 010 tonnes) MSY calculated for this stock by the Working Group in 1991 (SC-CAMLR-X, Annex 6, paragraphs 7.214 to 7.217). This proposal would depend on a research bottom trawl survey being carried out prior to the commercial fishery, and the presence of an international scientific observer on board each vessel fishing commercially.

4.33 The Scientific Committee recalled that the existing Conservation Measure (73/XII) requires a survey to be carried out, its results reported to and analysed by WG-FSA, and a decision made by the Commission, based on the advice of the Scientific Committee, before the finfish fishery can be reopened. This situation is analogous to that in Subarea 48.1.

Management Advice

4.34 In the absence of new information, the Scientific Committee was unable to provide advice on the reopening of the finfish fisheries in this subarea. The Scientific Committee therefore recommended that the finfish fisheries in Subarea 48.2 remain closed in accordance with Conservation Measure 73/XII.

South Georgia (Subarea 48.3)

Dissostichus eleginoides (Subarea 48.3)

4.35 The Scientific Committee noted the information provided by the Working Group on catch and effort data reported from this fishery in the 1995/96 season (Table 7). It had not been possible to make an estimate of the level of unreported catches at this year's meeting. However, the Scientific Committee noted that information provided intersessionally by the Chilean authorities indicated that there were no unreported catches by Chilean vessels in Subarea 48.3 during 1995/96.

Table 7: Estimated catches of *D. eleginoides* in Subarea 48.3 and adjacent Rhine and North Banks and TACs agreed by the Commission for Subarea 48.3 (tonnes).

Split-year	Fishing Season	TAC	Catch Reported to CCAMLR for the Fishing Season[1]	Catch Reported to CCAMLR for the Split-year	Estimate of Unreported Catch (split-year)	Best Estimate of Real Catches
1989/90				8156	345	8501
1990/91	2 November 1990 – 25 August 1991	2500	2200[2]	3639	565	4206
1991/92	2 November 1991 – 10 March 1992	3500	3150	3842	3470	7312[5]
1992/93	6 December 1992 – 5 February 1993	3350	2694	3089	2500	5589
1993/94	15 December 1993 – 15 September 1994	1300	537	460	6145	6605
1994/95	1 March – 10 May	2800	2635	3301	2870	6171
1995/96	1 March – 24 July 1996	4000	3871[3]	4362	?[4]	4362 + ?

1 Form C2 except where indicated
2 From Statlant reports
3 From five-day catch reports
4 No new quantitative information was available to the Working Group to estimate unreported catches during 1995/96.
5 The best estimate of real catch for 1991/92 was erroneously given as 6 309.6 in Table 6 of last year's report (SC-CAMLR-XIV, Annex 5) due to an arithmetical mistake.

4.36 The Scientific Committee also noted information provided in Annex 5, paragraphs 4.48 to 4.59, regarding reports from CCAMLR observers, conversion factors, discards of *D. eleginoides*, baiting efficiency, non-reporting of zero catches, fish movements and environmental factors. In particular, the Scientific Committee endorsed the advice of the Working Group that:

(i) CCAMLR observers should collect further information on the values of conversion factors and methods of their estimation and application on board fishing vessels (Annex 5, paragraph 4.51);

(ii) the Scientific Observer Logbook be amended to include provision for the recording of discards of *D. eleginoides* (Annex 5, paragraph 4.52);

(iii) the estimation of loss rates of fish from hooks needs further investigation (Annex 5, paragraph 4.53);

(iv) consideration should be given to undertaking separate assessments for male and female fish in the future (Annex 5, paragraph 4.58); and

(v) the Secretariat be requested to investigate the possibility of obtaining meteorological information from Subarea 48.3 and other areas where there are fisheries for *D. eleginoides* (Annex 5, paragraph 4.59).

4.37 The Working Group had considered the use of catch-at-age analysis, applying such approaches as SPA (Sequential Population Analysis) or VPA (Virtual Population Analysis) as an alternative approach to estimating exploitation rates and spawning stock biomass of *D. eleginoides*. A background paper using this approach to study trends in the *D. eleginoides* stock between 1992 and 1996 was submitted to the Scientific Committee (SC-CAMLR-XV/BG/14) and had been reviewed by the Working Group. This analysis was undertaken using only data available in the CCAMLR database. The Scientific Committee noted the view of the Working Group that at this stage the analysis was preliminary in nature and that further developments could investigate the use of standardised CPUE data. The Scientific Committee encouraged further analyses using such models, because they have the potential to provide an independent assessment of the stock, which can be compared to the results of the generalised yield model.

4.38 The Scientific Committee recalled last year's recommendations for future work on the assessment of *D. eleginoides* in Subarea 48.3 (SC-CAMLR-XIV, paragraphs 4.48 and 4.51, Annex 5, paragraphs 5.72, 5.75 and 5.76 and Appendix E, paragraph 2.72) and noted the approach taken by the Working Group to address these recommendations. The work undertaken at this year's meeting of the Working Group focused on four main areas:

(i) revision of the length-density analysis undertaken at last year's meeting, using additional survey data;

(ii) consideration of the effects of varying the decision rule criteria applied in the generalised yield model;

(iii) revision of the stock simulations undertaken at last year's meeting, using the improved generalised yield model with various alternative input parameters, including revised parameters in the recruitment function; and

(iv) examination of methods of monitoring the status of the population, including analysis of trends in standardised CPUE and length samples taken from the fishery.

4.39 The details of the length-density analysis are provided in paragraphs 4.66 to 4.73 of the Working Group report (Annex 5). The Scientific Committee endorsed the view of the Working Group that the resulting recruitment function was the best information currently available on the recruitment of *D. eleginoides* for use in the generalised yield model for Subarea 48.3.

4.40 The Scientific Committee welcomed the refinements made to the generalised yield model since last year's meeting. A detailed description and explanation of the current method is provided in Constable and de la Mare (1996) and in Annex 5, paragraphs 3.65 to 3.69.

4.41 At last year's meeting, the Scientific Committee noted that the probability level (10%) in the γ_1 decision rule was not purely a scientific question and that the Commission may wish to consider this matter further. However, before this could be done, the Commission would require more information and advice from the Scientific Committee. To this end, the Scientific Committee tasked the Working Group with giving this issue detailed consideration at this year's meeting.

4.42 The Working Group undertook a series of test runs of the generalised yield model to explore the implications of variations in the decision rule criteria. The results of these runs are illustrated in Figures 2(a) and 2(b) and explained in paragraphs 4.77 to 4.80 of the Working Group's report (Annex 5). The Scientific Committee noted the advice regarding the relative effects on catch levels of departing from the γ_1 decision rule (i.e. that the probability during the projection period of the spawning stock biomass falling below 20% of its initial level should not exceed 10% – Annex 5, paragraphs 4.75 to 4.80 and Figures 2(a) and 2(b)). The Scientific Committee also noted that no specific decision rule criteria, other than γ_1 and γ_2 (the median status of the spawning stock biomass at the end of the projection period should not fall below 50% of the median pre-exploitation level), were considered at this year's meeting. However, the Scientific Committee endorsed the suggestion of the Working Group that more detailed consideration should be given to the critical level of spawning stock biomass in the γ_1 decision rule at its next meeting. If the Commission wishes to change the probability level or the ratio of median spawning stock biomass, the graphs in Figure 2(a) of Annex 5 should be used.

4.43 The Scientific Committee also noted results of a series of runs testing for the sensitivity of the results to changes in various input parameters, including the catch history, the size of fish selected in the fishery, von Bertalanffy growth parameters and natural mortality (M). The results of these sensitivity tests are presented in Table 13 and paragraphs 4.88 to 4.95 (Annex 5).

4.44 Following a request from Prof. Beddington for clarification of the way in which uncertainty in M had been represented, Dr de la Mare explained that each individual trial of the projection randomly selected a value of M in the range 0.12 to 0.2, sampled from a uniform distribution.

4.45 The final run of the yield model determined that a catch level of 5 000 tonnes was consistent with the γ_1 decision rule using a 10% probability level (see paragraph 4.42). At this level of catch, the ratio of median spawning stock biomass to the pre-exploitation level was 53%. The Scientific Committee noted that this catch level was an increase of 25% compared to the result from last year's meeting and agreed that a change from last year's result was to be expected for three principal reasons: refinements in the formulation of the yield model, revision of the recruitment function and changes in other input parameters (see Annex 5, Table 14).

4.46 The Scientific Committee welcomed the refinements to the analysis using the generalised yield model made during the intersessional period and at this year's meeting of the Working Group.

4.47 The Scientific Committee endorsed the conclusion of the Working Group that the results of the yield model projection described in paragraph 4.45 provided a reasonable basis on which to set guidelines for the limits on total removals of *D. eleginoides* in Subarea 48.3 during the 1996/97 season.

4.48 The Scientific Committee endorsed the approach taken by the Working Group to standardise CPUE using a GLM (Annex 5, paragraphs 4.97 to 4.107). The aim of this analysis was to determine whether there were any annual trends in CPUE after accounting for the effects of any other factors/covariates that add to the variability in observed CPUE. Response variables considered were vessel type, month, area, depth and bait type. The GLM analyses followed the approach used at the 1995 meeting of the Working Group. Details of the methodology are provided in SC-CAMLR-XIV, Annex 5, Appendix G.

4.49 The Scientific Committee endorsed the conclusion of the Working Group that the GLM analyses indicated that there has not been an appreciable decline in standardised CPUE during the period 1992 to 1996. However, concern was expressed at the difficulties experienced by the Working Group during the analysis of the catch and effort data in the CCAMLR database. The data were checked for errors before the analysis was conducted in order to exclude records that were

spurious or incomplete. The raw dataset contained 5 163 records, but the final dataset contained only 2 740 records, 2 423 records being excluded from the analysis, principally due to missing data.

4.50 Prof. Beddington pointed out that the plot of unstandardised catch rates in Figures 5 and 6 of the Working Group's report (Annex 5) should include all data points, not just those remaining following the error checking described in paragraph 4.49. Dr Watters explained that this was not in fact the case and only the final dataset had been used.

4.51 The Scientific Committee expressed concern that the difficulties encountered by the Working Group meant that this year it had not been possible to undertake as full an analysis of the CPUE data as would have been desirable. Members were encouraged to resubmit historical haul-by-haul data which will be specifically requested by the Secretariat following a data audit.

4.52 The Scientific Committee noted the preliminary analysis of length frequency data described in Annex 5, paragraphs 4.109 to 4.113, and endorsed the proposal of the Working Group that the analysis of the length distribution of the catches should be pursued in the intersessional period, including completion and validation of the available dataset by the Secretariat.

Future Work

4.53 The Scientific Committee endorsed the areas of future work identified by the Working Group in Annex 5, paragraph 4.115.

Management Advice

4.54 The Scientific Committee noted that in spite of information in the Working Group's report from which it might be inferred that the level of unreported catches had probably fallen in 1995/96 (see paragraph 4.35), unreported catches continue to be a cause for concern and solving the problem of illegal catches remains a high priority.

4.55 The Scientific Committee recommended the continuation of the current provisions for reporting haul-by-haul and biological information from the fishery. In view of the problems experienced by the Working Group in the analysis of CPUE data, the Scientific Committee also strongly encouraged the reporting of existing haul-by-haul data from the longline fishery prior to 1992, and of information missing from the database for haul-by-haul data from 1992 to the present (paragraph 4.49). The Scientific Committee also recognised the continued importance to the

assessment work of the biological data and information collected by scientific observers, and recommended that the 100% observer coverage applied to this fishery over the past three seasons be maintained. The Scientific Committee also stressed the importance of timely submission to the Secretariat of data from observer trips, in the appropriate formats, to enable them to be made available for consideration by the Working Group (Annex 5, paragraph 3.16).

4.56 The Scientific Committee noted that, as at last year's meeting, the assessment of yield was based on the expectation that future catches will be taken only by longline vessels and recommended that the directed fishery for *D. eleginoides* in Subarea 48.3 should be restricted to longliners during the 1996/97 season.

4.57 The results of the projections using the generalised yield model indicated that an annual catch of 5 000 tonnes applied over a period of 35 years was consistent with the γ_1 decision rule. At this level of catch, the ratio of median spawning stock biomass at the end of the projection period to the pre-exploitation level was 53%. The Scientific Committee recommended that this should be the basis for setting the catch limit for *D. eleginoides* in Subarea 48.3 during the 1996/97 season.

4.58 Additional advice on the period of the fishing season is given in paragraph 3.46.

Champsocephalus gunnari (Subarea 48.3)

4.59 Despite a 1 000-tonne TAC for *C. gunnari* in Subarea 48.3 for the1995/96 season (Conservation Measure 97/XIV), there was no reported commercial catch of *C. gunnari*. There has now been no substantial reported commercial catch in Subarea 48.3 since March 1990.

4.60 Two research surveys were conducted in Subarea 48.3 during 1995/96: an acoustic survey by Russia in February 1996, using the RV *Atlantida*, and a bottom trawl survey by Argentina in March/April 1996, using the RV *Dr Eduardo L. Holmberg* (third in the series). The results of these surveys were reviewed by the Working Group (Annex 5, paragraphs 4.125 to 4.135). The Scientific Committee noted that this was the first time that standing stock estimates had been made for Channichthyidae using acoustic survey methodology.

4.61 The Scientific Committee endorsed the view of the Working Group that, due to the short nature of the time series of relative abundance from the Argentinian trawl survey, the questions surrounding the single estimate of abundance from the Russian acoustic survey which could not be resolved at the meeting, and the clearly identified need to develop a long-term management strategy, an assessment at this time was inappropriate.

4.62 Provision of this information in the specified form aids in the consideration of the results of surveys by the Working Groups. The Scientific Committee noted that considerable technical expertise on acoustic survey methodology was available in WG-EMM and recommended that the methods applied in acoustic surveys should be submitted to that Working Group, where they could be reviewed in more detail than would be possible at WG-FSA. The Scientific Committee recalled its advice on the information required from resource surveys, developed during the CCAMLR Workshop on the Design of Bottom Trawls held in 1992 (Draft Manual for Bottom Trawl Surveys in the Convention Area – SC-CAMLR-XI, Annex 5, Appendix H, Attachment E, section 7) and at the 1990 meeting of WG-Krill (SC-CAMLR-IX, paragraph 102).

4.63 The Scientific Committee considered management advice for *C. gunnari* in Subarea 48.3 in the 1996/97 season before returning to the issue of a long-term management strategy for this species in this area.

Management Advice

4.64 The Scientific Committee noted that WG-FSA had not attempted a full assessment of *C. gunnari* at this year's meeting (see paragraph 4.61).

4.65 The Scientific Committee agreed that the development of a long-term management strategy for this fishery remains a high priority (see paragraphs 4.71 to 4.75).

4.66 The Scientific Committee noted that at last year's meeting the Commission stated that (CCAMLR-XIV, paragraph 8.26):

> 'should a similar situation to the current one prevail at the next meeting of the Commission, the fishery should be closed until the Scientific Committee has:
>
> (i) provided advice on a long-term management strategy for the stock; and
>
> (ii) provided advice on the reopening of closed fisheries;
>
> or has provided unanimous advice on an appropriate TAC for *C. gunnari* in Subarea 48.3.'

4.67 The Scientific Committee noted two different views expressed in the Working Group.

4.68 Drs P. Gasiukov (Russia), V. Gerasimchuk and E. Gubanov (Ukraine) considered that the two surveys undertaken in 1995/96 and surveys undertaken previously provided sufficient information on which to base recommendations for a TAC for *C. gunnari* in Subarea 48.3 during the 1996/97 season (Annex 5, paragraphs 4.159 to 4.163). Specifically, taking into account:

(i) the results of a comparison of biomass estimates and corresponding catches in the same year;

(ii) the successive increase in relative abundance from results of recent Argentinian surveys; and

(iii) the estimate of total biomass of around 43 000 tonnes by the Russian acoustic survey;

these members recommended that, bearing in mind the precautionary approach, the fishery for *C. gunnari* should be opened with a TAC of 13 000 tonnes. This value is the lower 95% confidence interval of the 1994 UK survey trawl survey biomass estimate.

4.69 The rest of the members of the Working Group considered that they were unable to provide advice on an appropriate long-term management strategy or TAC at the present time and that the situation regarding the assessment of *C. gunnari* remained substantially the same as at last year's meeting.

4.70 Advice on the reopening of closed fisheries in general is provided in paragraphs 6.1 to 6.12.

Development of Long-term Management Strategy for *C. gunnari* in Subarea 48.3

4.71 The Scientific Committee noted that the Working Group had identified a number of issues which need to be considered and tasks to be carried out before a long-term management strategy could be developed. These issues are discussed in Annex 5, paragraphs 4.137 to 4.154.

4.72 The Scientific Committee raised some concerns over paragraph 4.151 in the Working Group report (Annex 5), in which the Working Group expressed the need to understand the ecosystem processes occurring. Prof. Beddington pointed out that the ability to predict long-term krill

availability in the area was likely to remain poor, although the prospects for making short-term predictions were better.

4.73 Dr de la Mare explained that it was not the intention of the Working Group to suggest that all of the issues listed in paragraph 4.151 (Annex 5) had to be resolved before the long-term management strategy could be developed. The intention was rather to highlight areas where information would be needed for providing a basis for the structure of the ecosystem model and plausible bounds on input parameters.

4.74 The Scientific Committee agreed that this highlighted the need for the development of a feedback style of fishery management, based on real-time monitoring of the fishery and the links between *C. gunnari* and krill abundance.

4.75 The Scientific Committee agreed that it would require substantial resources to develop a long-term management strategy for this fishery and endorsed the conclusion of the Working Group that, for the reasons summarised in Annex 5, paragraph 4.155, the development of the strategy should nevertheless be given a high priority.

Chaenocephalus aceratus, Gobionotothen gibberifrons, Notothenia rossii, Pseudochaenichthys georgianus, Lepidonotothen squamifrons and *Patagonotothen guntheri* (Subarea 48.3)

4.76 Estimates of biomass and size composition for these species were available from the surveys by Argentina and Russia, but for similar reasons to those outlined for *C. gunnari* no assessment of these stocks was attempted by the Working Group.

Management Advice

4.77 The Scientific Committee endorsed the recommendation of the Working Group that, in the absence of a new assessment of these species, Conservation Measures 2/III, 3/IV and 95/XIV remain in force and that Conservation Measure 76/XIII be extended to the 1996/97 season.

Electrona carlsbergi (Subarea 48.3)

4.78 The Scientific Committee endorsed the recommendation of the Working Group that, in the absence of any new information on this species, Conservation Measure 96/XIV should be carried forward for the 1996/97 season.

South Sandwich Islands (Subarea 48.4)

Dissostichus eleginoides (Subarea 48.4)

4.79 The Scientific Committee endorsed the recommendation of the Working Group that, in the absence of any new information on this species, Conservation Measure 92/XIV should be carried forward for the 1996/97 season.

Bouvet Island (Subarea 48.6)

Dissostichus eleginoides (Subarea 48.6)

4.80 The Scientific Committee noted that notifications of the intention to conduct new fisheries for *D. eleginoides* in Subarea 48.6 for the 1996/97 season had been lodged by Norway and South Africa during the intersessional period. Management advice is given in section 8.

Statistical Area 58

4.81 Catches in Area 58 during the 1995/96 season consisted of 4 911 tonnes of *D. eleginoides*, 15 tonnes of *L. squamifrons* and 5 tonnes of *C. gunnari*, all taken in Division 58.5.1, and 3 tonnes of *D. eleginoides* taken in Subarea 58.6 (Annex 5, Table 21).

Ob and Lena Banks (Division 58.4.4)

4.82 Conservation Measure 87/XIII, allowing a catch of 1 150 tonnes of *L. squamifrons* on the two banks, lapsed at the end of the 1995/96 season. Subject to the Commission's conditions associated with this particular conservation measure (CCAMLR-XIII, paragraphs 8.52 and 8.53), Ukraine indicated its desire to undertake a research survey in the 1994/95 season on

L. squamifrons at Ob and Lena Banks following the plan endorsed by WG-FSA and the Scientific Committee (SC-CAMLR-XIII, paragraph 2.77). The Scientific Committee noted that no notification had been received from Ukraine for such a survey in accordance with Conservation Measure 64/XII. The Scientific Committee also noted that Ukraine has expressed an interest in undertaking a biomass survey in the area during the 1996/97 season.

Management Advice

4.83 The Scientific Committee recommended that Conservation Measure 87/XIII be extended to cover the 1996/97 season provided that a biomass survey is undertaken and that this survey is of the design approved by the Scientific Committee in 1994 (CCAMLR-XIII, paragraphs 8.52 and 8.53).

Kerguelen Islands (Division 58.5.1)

Dissostichus eleginoides (Division 58.5.1)

4.84 The 1995/96 commercial fishery consisted of a French trawl fishery in the northern and eastern sectors, which took 2 574 tonnes and 1 029 tonnes respectively, and a Ukrainian longline fishery in the western sector, which took 1 003 tonnes. There was also a joint French/Japanese exploratory deep-sea longline cruise, which took 263 tonnes. None of these catches exceeded the catch limits imposed by French authorities (Annex 5, paragraphs 4.199 to 4.202).

4.85 A GLM was used to standardise CPUE data from the French and Ukrainian trawl fisheries (Annex 5, paragraphs 4.203 to 4.211). This analysis identified vessel, year and month as significant sources of variation in the data, but it supported the view that there had not been a decline in trawl catch rates.

4.86 The results of the GLM analysis in Annex 5, Figure 7, indicated a rise in CPUE between 1992 and 1993 seasons, and a maintenance of that approximate level since then. Although not analysed by the Working Group, there is no indication of an increase in fish recruitment to explain this. WG-FSA was requested to analyse length composition of the catch to investigate this question. Prof. Duhamel suggested that CPUE is indicating increased fishing efficiency rather than the status of the stock abundance.

4.87 As trawl fisheries target a limited age range of fish, CPUE does not give comprehensive information on the state of the spawning stock biomass. Recommendations are sought from WG-FSA on methods to improve the monitoring of the stock in this division as well as other areas.

4.88 One such method would be to use recruitment estimates based on trawl surveys for this area, as used for Subarea 48.3 and Division 58.5.2. At the moment, no such survey data exist for Division 58.5.1.

Management Advice

4.89 The French authorities have allocated TACs to the two trawling sectors for the 1996/97 season of 2 500 tonnes for the northern sector and 1 000 tonnes for the eastern sector. A catch limit of 500 tonnes has already been established for longlining in the western sector for the period October to December 1996, and the number of vessels limited to two. The level of catch by longlining in the first six months of 1997 is not expected to increase, and will be in line with the 1993 recommendations of WG-FSA.

4.90 For the western sector longline fishery, no further analysis of *D. eleginoides* has been undertaken. There has been no decline in the trend of CPUE in recent years (WG-FSA-93/15 and subsequent data), so the Scientific Committee recommended that the estimate of long-term sustainable yield, established during the 1994 meeting at 1 400 tonnes per split-year, be retained.

4.91 For the northern sector trawl fishery, the GLM analysis has not detected a significant decline in CPUE in recent years. The Scientific Committee therefore recommended that the TAC of 2 500 tonnes set by the French authorities be endorsed. This is a slight decrease from the 2 800 tonnes set in the previous year.

4.92 Given the uncertainty over the applicability of using CPUE analysis to monitor the stock when only a small part of it is susceptible to the fishery, the Scientific Committee recommended that WG-FSA should consider other ways of assessing fisheries such as this. In particular, it encouraged the collection of trawl survey data on *D. eleginoides* in this division so that an estimate of recruitment can be made.

4.93 For the eastern sector, for which 1995/96 was the second year of fishing, the limit of 1 000 tonnes set in 1995/96 by the French authorities was considered an appropriate precautionary catch limit for 1996/97.

4.94 The Scientific Committee felt that the GLM analysis of factors affecting CPUE in trawl fisheries is a useful technique, and recommended the continued reporting of catch and effort data on a haul-by-haul basis. In addition, efforts should be made to acquire haul-by-haul data from the Ukrainian authorities concerning their longline vessels in the division.

Champsocephalus gunnari (Division 58.5.1)

4.95 There was no commercial fishing for this species in the 1995/96 season, although a small number of trawls were made by a commercial vessel to gain information about the new cohorts entering the population (Annex 5, paragraphs 4.218 to 4.220). The 1994 year class appears abundant, but at present is below the legal size of 25 cm total length under French regulations and will remain so during a large part of the 1996/97 season, so no fishery is expected to occur. A survey will be carried out in 1996/97 to assess pre-recruit biomass (1994 year class).

Management Advice

4.96 The Scientific Committee reiterates its advice from last year (SC-CAMLR-XIV, paragraph 4.83) that the Kerguelen shelf fishery for *C. gunnari* in Division 58.5.1 be closed until at least the 1997/98 season, when the cohort born in 1994 will have had an opportunity to spawn. The Scientific Committee recommends that before this cohort is fished, a pre-recruit biomass survey be conducted in the 1996/97 season to evaluate the strength of the cohort at age 2+. These data should be evaluated at the 1997 meeting of WG-FSA, and an appropriate level of catch recommended.

Notothenia rossii (Division 58.5.1) – Management Advice

4.97 No new data on this species are available. The Scientific Committee therefore reiterated its advice that the fishery for *N. rossii* remain closed until a biomass survey demonstrates that the stock has recovered to a level that will support a fishery (SC-CAMLR-XIV, paragraph 4.78).

Lepidonotothen squamifrons (Division 58.5.1)

4.98 Exploratory fishing was carried out in the traditional fishing areas for this species by French trawlers, and length frequency and CPUE data were collected. The distribution of *L. squamifrons* concentrations was found to be unchanged, but results are very dependent on the time at which the survey is undertaken. A specific survey will be necessary to estimate the biomass and potential yield (Annex 5, paragraphs 4.224 to 4.226).

Management Advice

4.99 In the absence of a new assessment, the Scientific Committee recommended that the Kerguelen Shelf fishery for *L. squamifrons* should remain closed.

Heard Island and McDonald Islands (Division 58.5.2)

Dissostichus eleginoides (Division 58.5.2)

4.100 In 1994 and 1995, WG-FSA had assessed the potential yield of *D. eleginoides* in Division 58.5.2 in a manner similar to assessments of krill yield. This was because the only information available was two estimates of biomass from trawl surveys in previous years. These assessments determined the proportion of the estimated biomass that satisfies the two decision rules used by the Commission (see SC-CAMLR-XIII, paragraphs 5.18 to 5.26, for a discussion on the application of these two rules). The resulting recommended TAC in both assessments was 297 tonnes, and Conservation Measure 78/XIV specifies this figure as the TAC for *D. eleginoides* in Division 58.5.2.

4.101 This year, WG-FSA reassessed this stock using improved techniques developed in 1995. This involved applying the generalised yield model described in Annex 5, paragraphs 3.65 to 3.69, to estimates of recruitment derived from two trawl surveys described in WG-FSA-96/38. This was essentially the same method employed for *D. eleginoides* in Subarea 48.3 (Annex 5, paragraphs 4.67 and 4.68), although different input parameters, principally the age-specific selectivity function, were used to take account of the fact that the catches will be taken by trawling. The catch limit that satisfies the decision rules is 3 800 tonnes. Full details of the analysis are given in Annex 5, paragraphs 4.228 to 4.234.

4.102 The Scientific Committee welcomed the refinements to the analysis using the generalised yield model.

4.103 The reason for the increase in the catch limit over the previous estimate of sustainable yield of 297 tonnes involves two factors: the refinement to the generalised yield model and the use of the new estimate of recruitment, rather than total biomass, in the calculations. The explanation of this difference lies in the assessment of recruitment, which revealed that the biomass estimates used in the previous assessments were underestimates of the stock biomass because the trawl surveys had sampled mostly the younger age classes.

4.104 The Scientific Committee noted that the Commission has previously decided that this fishery does not constitute a new or exploratory fishery (see CCAMLR-XIII, paragraph 6.1 and Conservation Measure 78/XIII). The Scientific Committee reaffirmed that the available information was sufficient to determine, in accordance with paragraph 1 of both Conservation Measures 31/X and 65/XII, that this fishery should not be classified as either a new or exploratory fishery.

4.105 Dr Croxall noted that consideration of the potential impact on dependent and related species of fisheries for *D. eleginoides* in other areas had not been able to incorporate data on the occurrence of *D. eleginoides* in predators' diets. In the Heard Island area, however, there is some evidence that *D. eleginoides* occurs in the diet of elephant seals; they could consume quite substantial quantities of fish even if these formed a small proportion of their diet.

4.106 Dr de la Mare informed the Scientific Committee that there are some as yet unpublished data on the frequency of occurrence of *D. eleginoides* in elephant seal stomachs, amounting to 21 otoliths among about 1 500 squid beaks. Seals take relatively small *D. eleginoides*, so that the overlap with the fishery is incomplete. The abundance of small fish would not be reduced by a fishery unless the spawning stock biomass was dramatically reduced, and the Commission's decision rules are designed explicitly to prevent this.

Management Advice

4.107 The results of the projections using the generalised yield model applied to assessments of recruitment indicated that an annual catch of 3 800 tonnes was consistent with the two decision rules used by the Commission. The Scientific Committee recommended that this should be the basis for setting the catch limit for *D. eleginoides* in Division 58.5.2.

4.108 The Scientific Committee noted that the assessment of yield was based on the expectation that future catches will be taken only by trawling and recommended that the directed fishery for *D. eleginoides* in Division 58.5.2 should be restricted to trawling during the 1996/97 season. Use of other types of fishing gear such as longlines would change the age structure of the catch. It was recognised that the catch level applied for longlining is likely to be greater than that for a trawl fishery but the Scientific Committee did not consider such catch levels. Should there be an interest in longlining in Division 58.5.2 in the future, then the assessment using the generalised yield model can be adjusted to take this into account.

4.109 The Scientific Committee recommended that because the locations of fishable aggregations are not yet known, it would be appropriate to apply some effort limitations during the expansion of the fishery.

4.110 The Scientific Committee recognised the importance to the assessment work of biological data and other information collected from Division 58.5.2. The information can be collected both by scientific surveys and through a scientific observer program. In view of the need for information, the Scientific Committee recommended that at least one observer be on board each vessel.

Champsocephalus gunnari (Division 58.5.2) – Management Advice

4.111 Conservation Measure 78/XIV established a TAC of 311 tonnes for *C. gunnari* in Division 58.5.2 on the basis of results from Australian biomass surveys. There is no new information available to suggest any change to this figure. In the light of experience with the fishery for this species in Division 58.5.1 (SC-CAMLR-XIV, Annex 5, paragraphs 5.146 to 5.152), the Scientific Committee recommended that the fishery for *C. gunnari* in Division 58.5.2 should also avoid taking fish smaller than the size at first spawning (about 28 cm total length).

General

The Definition of 'Fishing Ground'

4.112 The Scientific Committee considered the response of WG-FSA to the Commission's request (CCAMLR-XIV, paragraph 8.5) in relation to the definition of fishing grounds given in the WG-FSA report (Annex 5, paragraphs 4.1 to 4.4).

4.113 The Scientific Committee agreed that the term 'fishing ground' is confusing and should not be used but replaced with a specific geographical definition.

4.114 The Working Group noted that, in their present form, the conservation measures which aim to control by-catch could give rise to practical problems in demanding that a fishing ground be abandoned when the by-catch is greater than a given percentage of the total catch, even though the catch itself may be very small.

4.115 The Scientific Committee deemed this to be a problem within the scope of SCOI. The problem is the need to establish additional criteria in the monitoring of the by-catch which are easily applied by fishermen and where compliance can be ascertained.

Future Work

4.116 When considering the future work for WG-FSA, the Scientific Committee noted the substantial increase in the workload to be performed by the Working Group in forthcoming years, and the consequent increased workload for the Secretariat.

4.117 The Scientific Committee endorsed the details of the future work required by WG-FSA, presented in Annex 5, paragraphs 9.2 to 9.7.

Crab Resources

4.118 The Scientific Committee noted that a single US fishing vessel, *American Champion*, had fished for crabs in Subarea 48.3 during the 1995/96 fishing season. The vessel targeted *P. spinosissima* with *P. formosa* being returned to the sea.

4.119 The *American Champion* acted in accordance with the experimental harvest regime set forth in Conservation Measure 90/XIV. The vessel initiated Phase 2 of the experimental harvest regime on 4 November 1995 (the provisions of Phase 2 require vessels to concentrate fishing effort in three squares each measuring approximately 26 n miles^2). The *American Champion* completed Phase 2 of the experimental harvest regime on 20 November 1995 and continued standard commercial operations until 29 January 1996, when it stopped participating in the fishery.

4.120 The *American Champion* has surrendered its US-issued permit to fish for crabs in Subarea 48.3. American Seafoods South America (the company which manages *American Champion*) does not currently consider this fishery to be economically viable.

4.121 In accordance with the Ten-day Catch and Effort Reporting System set forth in Conservation Measure 61/XII, catch and effort data for both the 1994/95 and 1995/96 crab fishing seasons have been submitted to the Secretariat (Annex 5, Table 19). A total catch of 479 tonnes was taken during these two seasons.

4.122 Data on the by-catch of *D. eleginoides* during the 1994/95 and 1995/96 fishing seasons were also provided to the Secretariat (Annex 5, Table 20), and the Scientific Committee noted that the by-catch in the 1995/96 season was lower than that in the 1994/95 season.

4.123 The decreased by-catch during the 1995/96 season probably resulted from changes in the availability of *D. eleginoides* to the crab fishing gear and not from physical changes in the design of the gear itself.

4.124 The Scientific Committee noted that several analyses of data collected during the experimental harvest regime had been presented to WG-FSA, including a review of the current minimum size limit for *P. formosa*. WG-FSA reviewed these analyses (see Annex 5, paragraphs 4.174 to 4.179) and came to three conclusions:

(i) data collected during Phase 1 of the experimental harvest regime indicate that estimates of local crab abundance should not be extrapolated to the whole of Subarea 48.3 solely on the basis of depth-specific seabed area (extrapolations must consider area-specific differences in crab density);

(ii) results from Phase 2 of the experimental harvest regime suggest that there is not much scope for using depletion estimators to estimate local abundances of *P. spinosissima*; and

(iii) there is not a sufficiently strong biological reason to revise the current size limit on *P. formosa* (90 mm carapace width) set forth in Conservation Measure 91/XIV.

4.125 The Scientific Committee agreed that the experimental harvest regime set forth in Conservation Measure 90/XIV had provided valuable information and endorsed the views of WG-FSA in this regard (Annex 5, paragraphs 4.181 to 4.184). In particular, the Scientific Committee agreed with the following points:

(i) the wide geographic distribution of fishing effort required by Phase 1 was useful for learning about the distribution of *P. spinosissima*, determining where the areas of high crab abundance are located, and providing information about whether the crab fishery was likely to be economically viable;

(ii) the implementation of Phase 2 had successfully shown that local depletion estimators cannot be used for estimating the abundance of *P. spinosissima* and that Phase 2 of the experimental harvest regime should be redrafted so that vessels are not required to conduct depletion experiments during this phase; and

(iii) the experimental harvest regime has, to date, been successful at controlling development of the crab fishery.

4.126 Noting that data collected from the experimental crab fishery did not provide a basis for estimating crab abundance and also that the crab fishery does not currently appear to be economically viable, the Scientific Committee endorsed WG-FSA's opinion that it was not necessary to make an assessment of the crab stocks in Subarea 48.3.

4.127 Dr Holt concluded the discussion on crab resources by thanking the Scientific Committee and WG-FSA for assistance in developing the experimental harvest regime and helping to ensure that the crab fishery developed in a controlled fashion.

Management Advice

4.128 Since the crab stock was not assessed and since the US and the UK have indicated that some fishing companies may still be interested in participating in the crab fishery (paragraph 2.17), the Scientific Committee recognised that a conservative management scheme is still appropriate for this fishery. In particular, the Scientific Committee noted that the fishery should continue to be controlled by direct limitations on catch and effort, as well as by limitation on the size and sex of individual crabs which may be retained in the catch. In this regard, the Scientific Committee noted that Conservation Measure 91/XIV contains such limitations and endorsed WG-FSA's recommendation that this measure should continue to be applied to the crab fishery in Subarea 48.3.

4.129 In light of the conclusions presented in paragraphs 4.125(i) and (ii), the Scientific Committee agreed that the experimental harvest regime set forth in Conservation Measure 90/XIV should be revised in accordance with the following specific recommendations:

(i) Phase 1 of the experimental harvest regime should remain in force;

(ii) Phases 2 and 3 of the experimental harvest regime should not remain in force in their present form, but the regime should include provisions for requiring approximately one month of experimental fishing effort during the second season of a vessel's participation in the fishery. The details of appropriate revisions to Phases 2 and 3 should be considered by WG-FSA if any new vessels initiate participation in the crab fishery; and

(iii) the experimental harvest regime should include provisions for the placement of scientific observers on the fishing vessels.

Squid Resources

4.130 Results from a research cruise conducted in Subarea 48.3 in June 1996 using a Korean squid jigging vessel had been discussed by WG-FSA (Annex 5, paragraph 3.56) (paragraph 2.19).

4.131 The Scientific Committee noted that notification to initiate a new fishery for *M. hyadesi* in Subarea 48.3 had been received from the Republic of Korea and the UK (paragraph 2.20). This was considered under Agenda Item 8 (see paragraphs 8.2 and 8.3). Arising from this, the Scientific Committee noted that an assessment based on predator food consumption had been considered by WG-FSA. The Scientific Committee agreed that this approach should be reviewed at WG-EMM.