

**SC-CAMLR-XIII**

**SCIENTIFIC COMMITTEE FOR THE CONSERVATION OF  
ANTARCTIC MARINE LIVING RESOURCES**

**REPORT OF THE THIRTEENTH MEETING  
OF THE SCIENTIFIC COMMITTEE**

**HOBART, AUSTRALIA  
24 - 28 OCTOBER, 1994**

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### **Abstract**

This document presents the adopted record of the Thirteenth Meeting of the Scientific Committee for the Conservation of Antarctic Marine Living Resources held in Hobart, Australia, from 24 to 28 October 1994. Major topics discussed at this meeting include: krill, fish, crab and squid resources, ecosystem monitoring and management, marine mammal and bird populations, assessment of incidental mortality and management under conditions of uncertainty. Reports of meetings and intersessional activities of subsidiary bodies of the Scientific Committee, including the Working Groups on Krill, on Fish Stock Assessment, for the CCAMLR Ecosystem Monitoring Program and on Incidental Mortality Arising from Longline Fishing, are appended.

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**REPORT OF THE THIRTEENTH MEETING  
OF THE SCIENTIFIC COMMITTEE**  
(Hobart, Australia, 24 to 28 October 1994)

OPENING OF THE MEETING

1.1 The Scientific Committee for the Conservation of Antarctic Marine Living Resources met under the Chairmanship of Dr K.-H. Kock (Germany) from 24 to 28 October 1994 at the Wrest Point Hotel, Hobart, Australia.

1.2 Representatives from the following Members attended the meeting: Argentina, Australia, Belgium, Brazil, Chile, European Economic Community, France, India, Italy, Japan, Republic of Korea, New Zealand, Norway, Poland, Russian Federation, South Africa, Spain, Sweden, United Kingdom of Great Britain and Northern Ireland and United States of America.

1.3 The Chairman welcomed to the meeting observers from Canada, Greece, Ukraine, the Antarctic and Southern Ocean Coalition (ASOC), the Intergovernmental Oceanographic Commission (IOC), the International Whaling Commission (IWC) and the Scientific Committee on Antarctic Research (SCAR) and encouraged them to participate in the meeting as appropriate.

1.4 A List of Participants is given in Annex 1. A List of Documents considered during the meeting is given in Annex 2.

1.5 The following rapporteurs were appointed to prepare the report of the Scientific Committee:

- Dr A. Constable (Australia), Fish and Crab Resources;
- Dr W. de la Mare (Australia), Krill Resources;
- Dr J. Croxall (UK), Ecosystem Monitoring and Management;
- Mr D. Miller (South Africa), Joint Meeting of the Working Groups on Krill and CEMP;
- Dr J. Bengtson (USA), Marine Mammal and Bird Populations;
- Drs K. Kerry (Australia) and J. Croxall, Assessment of Incidental Mortality;
- Dr G. Watters (USA), Management Under Conditions of Uncertainty about Stock Size and Sustainable Yield;
- Dr E. Sabourenkov (Secretariat), Publication; and
- Dr D. Agnew (Secretariat), all other matters.

## ADOPTION OF THE AGENDA

1.6 The Provisional Agenda had been circulated prior to the meeting. The Provisional Agenda was adopted without amendments (Annex 3).

## REPORT OF THE CHAIRMAN

1.7 During the intersessional period Members participated in a number of meetings. The Chairman expressed his thanks to South Africa for hosting the meetings of the Working Group on Krill (WG-Krill), the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP), Joint WG-Krill and WG-CEMP, and Flux Workshop (paragraphs 1.8 and 1.9), and to Conveners, Members, Rapporteurs and the Secretariat for ensuring their success.

1.8 WG-Krill met from 25 July to 3 August 1994, and was chaired by the Convener, Mr Miller. WG-CEMP also met from 25 July to 3 August 1994, and was chaired by the Convener, Dr Bengtson. A joint meeting of these two Working Groups from 27 July to 2 August 1994 was chaired by the Chairman of the Scientific Committee, Dr Kock. These meetings were held at the Breakwater Lodge, Cape Town, South Africa.

1.9 A Workshop on Evaluating Krill Flux Factors, chaired by Dr de la Mare, was held prior to the meeting of WG-Krill from 21 to 23 July 1994 at the Sea Fisheries Institute, Cape Town.

1.10 The Working Group on Fish Stock Assessment (WG-FSA) met in Hobart, Australia, from 11 to 19 October 1994, and was chaired by the Convener, Dr I. Everson (UK).

1.11 At its 1993 meeting, the Scientific Committee decided to establish an *Ad Hoc* Working Group on Incidental Mortality Arising from Longline Fishing (WG-IMALF) (SC-CAMLR-XII, paragraph 10.19). The first meeting of this *ad hoc* group was held on 21 and 22 October 1994 in Hobart, Australia, and was chaired by the Convener, Dr C. Moreno (Chile).

1.12 The report of WG-FSA is attached as Annex 4, that of WG-Krill as Annex 5, that of WG-CEMP as Annex 6, that of the Joint Meeting as Annex 7 and that of WG-IMALF as Annex 8. The report of the Workshop on Evaluating Krill Flux Factors is appended to the report of WG-Krill as Appendix D.



1.13 The Scientific Committee was represented as an observer at a number of international meetings during the intersessional period:

- 82nd Statutory Meeting of ICES, 22 to 27 September 1994, St Johns, Canada - Dr M. Sissenwine (USA);
- 1994 Annual Meeting of the IWC Scientific Committee, May 1994, Puerto Vallarta, Mexico - Dr de la Mare;
- XXIII Meeting of SCAR, 29 August to 9 September 1994, Rome, Italy - Dr Everson;
- Meetings of SCAR Groups of Specialists, 23 to 27 May 1994, Padua, Italy - Dr Croxall;
- Sixth SCAR Symposium on Antarctic Biology, 30 May to 3 June 1994, Venice, Italy - Dr Sabourenkov;
- SO-GLOBEC Implementation Meeting, June 1994, Bremerhaven, Germany - Dr Everson;
- SCAR-COMNAP *Ad Hoc* Antarctic Data Management Meeting, 29 August to 2 September 1994, Rome, Italy - Dr Agnew;
- FAO *Ad Hoc* Consultations on the Role of Regional Fisheries Agencies in Relation to High Seas Fisheries Statistics, 13 to 16 December 1993, La Jolla, USA - Dr Sabourenkov; and
- 3rd International Marine Debris Conference, 8 to 13 May 1994, Miami, Florida - Dr Sabourenkov.

1.14 The Chairman regretfully informed the Scientific Committee that Dr Rodion Makarov had died on 12 August 1994 in Moscow. Dr Makarov was a member of WG-Krill and had contributed a great deal to the work of the Scientific Committee through his studies on Antarctic krill biology, distribution and population dynamics. The Chairman also informed the Scientific Committee that two Chilean fishermen had lost their lives in a fire on board the Chilean longliner *Friosur V* whilst it was fishing for *Dissostichus eleginoides* in Subarea 48.3. The Scientific Committee extended its condolences to the families of Dr Makarov and the Chilean crewmen.

1.15 During the intersessional period, scientific observers from the UK, USA and Russia, operating under the CCAMLR Scheme of International Scientific Observation, were present on vessels fishing for *D. eleginoides* in Subarea 48.3.

1.16 The first issue of *CCAMLR Science* was published in October 1994 and was distributed to delegates at the current meeting.

## FISH RESOURCES

### FISHERY STATUS AND TRENDS

2.1 The only species targeted in commercial fisheries in the 1993/94 season were *D. eleginoides* and *Electrona carlsbergi* (SC-CAMLR-XIII/BG/1). A catch of 603 tonnes of *D. eleginoides* was taken by longlines in Subarea 48.3 in accordance with Conservation Measure 69/XII<sup>1</sup>. 942 tonnes were reported by longliners and 4 141 tonnes by trawlers in Division 58.5.1. 12 tonnes of skates and rays were reported in Subarea 48.3 as by-catch in the *D. eleginoides* fishery. A catch of 114 tonnes of myctophids in Subarea 48.3 in October 1994 was reported to CCAMLR just prior to the meeting. There were no reports of commercial catches of *Champscephalus gunnari* in Subarea 48.3, *D. eleginoides* in 48.4 or *Notothenia squamifrons* in Division 58.4.4, even though TACs had been set for these fisheries.

### REPORT OF THE WORKING GROUP ON FISH STOCK ASSESSMENT

2.2 WG-FSA met from 11 to 19 October 1994 at CCAMLR Headquarters in Hobart. The Convener of the Working Group, Dr Everson, presented the report of the meeting.

2.3 The Report of the Working Group is attached in Annex 4.

### Data Requirements Endorsed by the Commission in 1993

2.4 Various data were specifically requested by the Working Group in 1993 (SC-CAMLR-XII, Annex 5, Appendix D). Data submitted to the Secretariat in response to this request are listed in Annex 4, Appendix D.

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<sup>1</sup> An additional 43 tonnes were reported as having been taken by Russian longliners from October to January.

2.5 Haul-by-haul and length frequency data from the fishery for *D. eleginoides* in Subarea 48.3 were reported in accordance with Conservation Measure 69/XII. France reported fine-scale and length frequency data from the fishery for *D. eleginoides* in Division 58.5.1 and Subarea 58.6. Other biological data were reported from the various research cruises in the 1993/94 season. However, most data requested by the Working Group are still outstanding.

#### Fish Biology/Demography/Ecology and Other Information

2.6 WG-FSA welcomed the data made available by observers of the *D. eleginoides* fishery in Subarea 48.3. These data were considered under a number of agenda items of the Working Group meeting (Annex 4, paragraphs 3.7 to 3.12). Dr K. Shust (Russia) explained that a report from a Russian observer on a Bulgarian longliner, who only recently returned to Russia, will be submitted to CCAMLR as soon as it is available.

2.7 WG-FSA discussed papers dealing with various aspects of fish biology/demography/ecology relevant to stock assessments. Topics included age and growth, reproduction and early life history, trophic relationships and stock separation (Annex 4, paragraphs 3.26 to 3.35).

2.8 Dr E. Fanta (Brazil) reported that the SCAR *Ad Hoc* Working Group on Evolutionary Genetics of Antarctic Marine Organisms is proposing to meet in Brazil in March/April 1995. This group seeks, *inter alia*, to promote the coordinated investigation of stock separation. This is of considerable interest to CCAMLR with respect to identifying the origin of seabirds caught in longline fisheries, as well as stock identity in a number of exploited fish species.

2.9 A revised bathymetric map of the Elephant Island area and estimates of seabed areas around the islands have been added to the CCAMLR database on seabed areas. In addition, the Secretariat has developed software to calculate seabed areas in the Convention Area (Annex 4, paragraphs 3.37 and 3.38).

#### New Fisheries

2.10 CCAMLR has had no notifications that Members intend to initiate a new fishery under Conservation Measure 31/X.

## Assessments and Management Advice

2.11 Assessment summaries for the various fish stocks assessed by WG-FSA are presented in Appendix F of Annex 4.

### Statistical Area 48 (South Atlantic)

#### *Dissostichus eleginoides* (Subarea 48.3) (Annex 4, paragraphs 4.5 to 4.44)

2.12 Assessments of *D. eleginoides* in Subarea 48.3 were based on the re-analysis of the 1992/93 estimates of local densities, results of the 1994 depletion experiments in the fishery, examinations of annual CPUE data and length frequency distributions from commercial catches and estimated recruitment from survey data (Annex 4, paragraphs 4.8 to 4.25). The results provided no evidence of trends in the abundance or status of the stock and, as a consequence, no estimate of yield was made.

2.13 The Scientific Committee noted that the assessments conducted in 1993 using the De Lury method were superseded by the 1994 analysis - the analyses done in 1993 involved a number of errors and inappropriate choice of subsets of available data. Re-analysis of the full data set showed, contrary to the conclusions reached in 1993, that there was no evidence of stock depletion. The Working Group had concluded that the assumption of the model, that the level of immigration was very small, was invalid. As a result, no conclusion regarding stock size could be drawn from the 1992/93 CPUE data.

2.14 The results of a De Lury analysis of the CPUE data from the depletion experiments in 1994 were not conclusive. Hence, estimates of biomass were considered unreliable.

2.15 There were no demonstrable declines in CPUE over the last four years that could be attributed to fishing. Three alternative explanations for this were considered:

- (i) the stock may not have become depleted (Annex 4, paragraph 4.31) and, as a consequence, the catches may be sustainable at current levels;
- (ii) the relationship between stock size and CPUE may be weak. For example, the overall stock may be declining under fishing but movement of the fish into the fishing area may keep the CPUE relatively constant (Annex 4, paragraph 4.27); and

- (iii) a relationship between stock abundance and CPUE may exist but is masked by natural variation in the annual CPUE; the variability in performance of longline fishing may be such as to prevent an estimate of the decline in abundance before depletion has occurred (Annex 4, paragraph 4.31).

2.16 The Scientific Committee agreed that work needs to be carried out to determine whether constant CPUE in this fishery is a reliable indicator that the catch level is sustainable.

2.17 The Scientific Committee agreed that there is an urgent need to develop methods of assessing the biomass of *D. eleginoides* and endorsed the holding of a three-day workshop in association with the next meeting of WG-FSA. The Scientific Committee recommended that the workshop should go ahead, pending the submission of data and appropriate papers by 1 August 1995. The decision to hold the workshop will be taken by the Convener of WG-FSA, the Chairman of the Scientific Committee and the Data Manager. The Scientific Committee approved the following terms of reference for the workshop:

- (i) to review catch information, including trends in catches of individual vessels and including the location and extent of catches both inside and outside the Convention Area;
- (ii) to review and evaluate available information on stock identity over the entire range of the species and in particular the relationships between stocks in Subarea 48.3 and neighbouring areas;
- (iii) to review and evaluate methods of conducting surveys of stocks targeted using longlines;
- (iv) to review and evaluate methods of assessing the status of stocks and for determining appropriate yields, including the utility of CPUE data from the longline fishery in these assessments;
- (v) to determine the data required from the longline fishery; and
- (vi) to provide advice to the Working Group on stock identity and on stock survey and assessment procedures.

2.18 The Scientific Committee recommended that funds be made available to pay for two invited experts to participate in the workshop. The Scientific Committee noted that experience from other *D. eleginoides* fisheries outside the Convention Area would benefit the workshop.

2.19 The Scientific Committee was aware of reports of potentially large catches being taken from Subarea 48.3 and which were not recorded in official statistics. Also, catches outside but adjacent to the Convention Area may be from the same stock. The Scientific Committee agreed that the best information available on total catch should be used in stock assessments, provided the data are well documented and the sources reliable, as is common practice in many fisheries management authorities.

### Management Advice

2.20 The Scientific Committee agreed that, should fishing be conducted for *D. eleginoides* in the coming season, fishing effort should be distributed in such a way as to ensure that catch and effort data are able to contribute to assessments of the stock.

2.21 Some Members suggested that it would be beneficial to distribute effort throughout the subarea and over a period longer than a single reporting period, but consistent with periods fished in previous seasons.

2.22 The Scientific Committee noted the success of the scientific observer program in the 1994 fishery in providing important fisheries data for consideration by WG-FSA. Consequently, it recommended that all vessels participating in the fishery should have scientific observers on board.

2.23 The Scientific Committee recommends that, in addition to the required information already listed in the *Inspectors Manual* and according to Conservation Measure 71/XII, the following information should be requested from commercial fishing operations:

- (i) conversion factors from processed to whole weight;
- (ii) bottom depths at both start and end of a longline set;
- (iii) direction of haul;
- (iv) percentage of hooks baited;
- (v) amounts of discarded fish;
- (vi) design of longline gear (e.g., Spanish, traditional);
- (vii) an unequivocal measure of the depth at which hooks were set off the bottom; and

(viii) information allowing unique identification of individual vessels across years within the CCAMLR Database.

2.24 In addition, the Scientific Committee recommended that the Secretariat acquire from FAO, Member countries and Acceding States data on catches of *D. eleginoides* in areas adjacent to the Convention Area. The Scientific Committee also recommended that historical haul-by-haul data for this fishery be compiled together with information allowing unique identification of individual vessels across years (Annex 4, paragraphs 4.32 and 4.43).

2.25 With regard to catch levels for 1994/95, the Scientific Committee endorsed the Working Group's comments that 'In none of the data examined were there indications that the current and recent levels of catches had had any detectable effect on the fishery. However, given the concerns expressed previously about interpretation of longline CPUE and the probable high vulnerability of toothfish to overfishing, the Working Group agreed that a precautionary approach should be taken to the setting of any TACs until a reliable stock assessment has been completed.' (Annex 4, paragraph 4.40).

2.26 In the absence of a reliable stock assessment for the 1993/94 season, the Scientific Committee reviewed previous assessments and advice for this stock, and catches, TACs and conservation measures from previous years (Tables 1 and 2; paragraphs 9.65 to 9.68).

2.27 It was recognised that the estimates contained in Table 1 do not exclude the setting of a zero TAC as one of the options for the management of this fishery.

2.28 The advice arising from the assessments of last year, which indicated a significant depletion of the stock, was not considered because it was found to be invalid. The previous assessments have not been invalidated, but the Scientific Committee noted the need to treat them with caution because they each carry a suite of assumptions that may not have been addressed adequately (see footnotes to Table 1).

2.29 There was no agreement on how these assessments could be used to recommend a TAC because each new method had been applied in an effort to overcome the problems with previous methods.

Table 1: Assessments of yield (in tonnes) for the longline fishery for *D. eleginoides* in Subarea 48.3 provided by the Scientific Committee in previous years on the basis of a number of stock assessment methods and yield-per-recruit calculated at  $F_{0.1}$ .

Assessment Method	SC-VIII (1989)	SC-IX (1990)	SC-X (1991) <sup>1</sup>	SC-XI (1992) <sup>2</sup>	SC-XII (1993)
Area fished per hook				1790-5370 <sup>3</sup>	
Area fished per longline				750-1910 <sup>4</sup>	
Length-based cohort analysis			8819 <sup>5</sup>	assessment not completed <sup>6</sup>	
Trawl survey of young fish	240-1200 <sup>14</sup>	1200-8000 <sup>7</sup>	794-11700 <sup>8</sup>	assessment not completed <sup>9</sup>	
De Lury method - annual CPUE			481-8438 <sup>10</sup>	1130-1430 <sup>11</sup>	
De Lury method - local CPUE				920-1170 <sup>12</sup>	900-1700 (invalid) <sup>13</sup>

<sup>1</sup> no agreement on estimates to be used (SC-CAMLR-X, paragraphs 4.64 to 4.66)

<sup>2</sup> considerable uncertainty about stock size and its sustainable yield, stock biomass in excess of 45 000 tonnes considered unlikely (SC-CAMLR-XI, paragraph 3.79)

<sup>3</sup> estimates sensitive to the range of influence of each hook and the relationship between CPUE and stock biomass (SC-CAMLR-XI, Annex 5, paragraphs 6.165 to 6.170)

<sup>4</sup> estimates sensitive to effective width of area fished by a longline, extrapolation from local density to whole region, relationship between CPUE and stock abundance; further caveats in the estimates of biomass using this method described in SC-CAMLR-XI, Annex 5, paragraphs 6.160 to 6.165

<sup>5</sup> not tuned to independent data; run under the assumption that the fishing mortality in the most recent year was equal to longterm average fishing mortality (SC-CAMLR-X, Annex 6, paragraph 7.99)

<sup>6</sup> sensitive to M and K; see SC-CAMLR-XI, Annex 6, paragraph 6.141

<sup>7</sup> no direct estimate of biomass available (SC-CAMLR-IX, Annex 5, paragraph 160); biomass estimated from young cohorts with unquantifiable uncertainty attached to the results (SC-CAMLR-IX, Annex 5, paragraph 167); TAC recommended to be in lower part of the range (USSR expressed view that TAC should be in middle of range) (SC-CAMLR-IX, paragraphs 3.59 and 3.60)

<sup>8</sup> TACs derived from MSY rather than  $F_{0.1}$ ; CV of estimate used was great because of single large catch in 1991 (SC-CAMLR-X, Annex 6, paragraph 7.96); highest recent catch was close to lower estimates of biomass (SC-CAMLR-X, Annex 6, paragraph 7.97)

<sup>9</sup> problems using survey results; see SC-CAMLR-XI, Annex 6, paragraphs 6.167 and 6.168

<sup>10</sup> this estimate will be affected by the relationship between the start of the CPUE series and the pre-exploitation biomass which is unknown (SC-CAMLR-X, Annex 6, paragraphs 7.120 and 7.121)

<sup>11</sup> based on a single estimate of biomass, range is an exploration into effect on yield of different values of M (SC-CAMLR-XI, Annex 6, paragraphs 6.171 and 6.172); assumes no immigration or emigration and direct relationship between CPUE and stock biomass (SC-CAMLR-XI, Annex 6, paragraph 6.146); CPUE could not be calibrated for hook type (SC-CAMLR-XI, Annex 6, paragraph 6.148)

<sup>12</sup> requires re-examination; based on a single estimate of biomass, range is an exploration into effect on yield of different values of M (SC-CAMLR-XI, Annex 6, paragraphs 6.171 and 6.172); estimates sensitive to effective width of area fished by a longline, extrapolation from local density to whole region, relationship between CPUE and stock abundance (SC-CAMLR-XI, Annex 5, paragraphs 6.164 and 6.165)

<sup>13</sup> method invalidated by WG-FSA, 1994

<sup>14</sup> yield derived from Gulland formula  $Y = 0.5 M \cdot B_0$ . Range of  $B_0$  was FRG biomass survey (lower bound) and five times the FRG biomass survey (upper bound) (SC-CAMLR-VIII, Annex 6, paragraphs 115 to 120).



Table 2: Catches and TACs applying to the longline fishery for *D. eleginoides* in Subarea 48.3.

Year	Catch (tonnes)	TAC (tonnes)	Conservation Measure
1990	8 311	-	
1991	3 641	2 500	24/IX
1992	3 703	3 500	35/X
1993	3 049	3 350	55/XI
1994	652	1 300	69/XII

*Champscephalus gunnari* (Subarea 48.3)  
(Annex 4, paragraphs 4.45 to 4.83)

2.30 No catches were reported for icefish, *C. gunnari*.

2.31 Two research surveys aimed at estimating the abundance of *C. gunnari* in Subarea 48.3 were conducted during the 1993/94 season, one by the UK and one by Argentina. The Working Group evaluated the methods used during these surveys and found that the results of the surveys were not comparable because different survey designs, sampling equipment and estimation methodology had been used (Annex 4, paragraphs 3.18 to 3.20). The Working Group decided to use the results of the UK survey for their assessment of this stock as it used the same methods as those employed in surveys of previous years. The survey series therefore provides an indication of trends in stock abundance.

2.32 The results of the UK survey indicated a very much lower standing stock of *C. gunnari* than had been expected using stock projections from the 1992/93 survey results. A number of explanations for the decline was considered in detail by the Working Group and these are summarised below:

- (i) uncertainty in the 1992/93 and the 1993/94 survey estimates - while this may contribute in part to the difference in the estimates, the Working Group agreed that other factors are likely to be important;
- (ii) unreported fishing mortality - there was no evidence to support this possibility;
- (iii) variability in recruitment - this would not fully explain the lower-than-expected abundance of age classes older than two years; and
- (iv) dramatic change in natural mortality - the Working Group agreed that interannual variation in *M* was likely and that *M* may increase with age.

2.33 The Working Group concluded that, as in 1991, there had been a genuine decline in standing stock of *C. gunnari* in Subarea 48.3. Both declines had occurred around times when krill, the staple food of *C. gunnari*, was scarce. Krill are also the dominant component in the diet of Antarctic fur seals and, since fur seals also eat fish, predominantly *C. gunnari*, they could have affected the *C. gunnari* stock. When krill are scarce, fur seals may change diet and feed predominantly on fish (Annex 4, paragraphs 4.73 to 4.77). The Working Group noted that the prey requirements of fur seals, particularly during periods of low krill availability, may need to be considered in future management advice for the *C. gunnari* fishery in Subarea 48.3.

2.34 The Scientific Committee accepted WG-FSA's assessment. Furthermore, the Scientific Committee endorsed the development of a longterm management plan for this fishery which would account for uncertainty in biomass estimates, variability in recruitment and variability in natural mortality with age and between years (Annex 4, paragraphs 4.78 and 4.79).

2.35 The Scientific Committee agreed that biomass surveys just prior to the meeting of WG-FSA would be beneficial for developing management advice based on information from the stock in the season to which that advice would apply.

2.36 The Scientific Committee endorsed the conclusions of the Working Group that, given the uncertainties outlined above, the calculation of yield on the basis of  $F_{0.1}$  as done in the past is no longer appropriate for this stock and that the escapement of the spawning stock should be high for the 1994/95 season (Annex 4, paragraphs 4.81 and 4.82).

#### Management Advice

2.37 The Scientific Committee recommends that the fishery for *C. gunnari* be closed for the 1994/95 fishing season.

2.38 The Scientific Committee endorsed the recommendation of the Working Group that a survey be carried out during the coming season to monitor the status of the stock and to provide more information for the development of the longterm management approach.

*Electrona carlsbergi* (Subarea 48.3)  
(Annex 4, paragraphs 4.84 to 4.93)

2.39 No new survey or fishery information for *E. carlsbergi* in Subarea 48.3 has been submitted to CCAMLR since the last meeting.

2.40 The Working Group undertook a new assessment of yield by applying a generalised version of the yield model being developed by WG-Krill. The Scientific Committee endorsed the application of this approach to *E. carlsbergi* because this species shares a number of population and trophic characteristics with krill (see Annex 4, paragraphs 4.86 to 4.90). In particular, this approach helps overcome the problem of formulating advice on the basis of biomass estimates derived from a survey older than the life expectancy of the fish. This is achieved by incorporating estimates of the pre-exploitation variability in biomass in the estimates of yield.

2.41 This approach uses stock projections to estimate yields for *E. carlsbergi* given the uncertainties in the characteristics of the stock and meets the objectives in Article II. This approach was endorsed previously by the Scientific Committee (SC-CAMLR-IX, paragraph 8.11). WG-Krill and WG-FSA have adopted three decision rules for determining yield (where  $Y = \gamma \cdot B_0$ ) (see paragraphs 5.18 to 5.26 for a detailed presentation of these rules).

2.42 The Scientific Committee endorsed the use of these decision rules for estimating  $\gamma$  for the *E. carlsbergi* fishery.

2.43 The Working Group agreed that, using the available biological information and pending refined estimates of the stock parameters and biomass, the estimate of  $\gamma$  of 0.091 for *E. carlsbergi* is the best available.

#### Management Advice

2.44 The most recent estimate of *E. carlsbergi* biomass was from a survey in 1987/88. This was used as the basis for calculating a TAC of 200 000 tonnes (Conservation Measure 67/XII) in 1993/94. Using these estimates of biomass and the new estimate of  $\gamma$  from the generalised krill yield model, the corresponding precautionary catch levels would be 109 000 tonnes for Subarea 48.3 and 14 500 tonnes for the region around Shag Rocks.

2.45 The Scientific Committee endorsed the advice of the Working Group on the need for a new biomass survey and for precautionary catch limits on the fishery (Annex 4, paragraphs 4.91 to

4.93). Consequently, it recommended that Conservation Measure 67/XII be retained indefinitely, but that some consideration should be given to a revision of the TACs in paragraphs 2 and 3 of the measure.

2.46 Dr Shust had some reservations about the analysis. He indicated that the role of *E. carlsbergi* as prey in Subarea 48.3 was uncertain. Thus, the level of escapement required in Decision Rule 2 (see paragraph 5.18) may be too high. Also, the parameters used in the yield model for this species are uncertain and need to be refined. On this basis Dr Shust stated that Conservation Measure 67/XII could be retained in its current form.

2.47 The view adopted by the Working Group and accepted by many Members of the Scientific Committee was that the uncertainties in the parameter and biomass estimates had been accounted for in the calculation of  $\gamma$ , and that this was in line with the general request that uncertainties be accounted for in stock assessments (CCAMLR-XII, paragraph 4.26; SC-CAMLR-XII, paragraph 3.96). In this case, the revised estimates of yield were appropriate, pending revision of the parameters (Annex 4, paragraph 4.91). It was noted that, for *E. carlsbergi*, Decision Rule 1 was the important rule for determining  $\gamma$ . Consequently, a revision of Decision Rule 2 would be unlikely to have any effect even though there is sufficient evidence to indicate the importance of myctophids to some predators.

2.48 In this case, Conservation Measure 67/XII would need to be revised to include the revised estimates of yield as precautionary TACs for Subarea 48.3 and Shag Rocks respectively.

*Notothenia gibberifrons*, *Chaenocephalus aceratus*,  
*Pseudochaenichthys georgianus*, *Notothenia rossii*,  
*Patagonotothen guntheri* and *Notothenia squamifrons*  
(Subarea 48.3) (Annex 4, paragraphs 4.94 to 4.103)

2.49 The Scientific Committee endorsed the advice of WG-FSA and recommended that all conservation measures for these species should remain in force.

Antarctic Peninsula (Subarea 48.1)  
and South Orkney Islands (Subarea 48.2)

*Champscephalus gunnari*, *Notothenia gibberifrons*,  
*Chaenocephalus aceratus*, *Pseudochaenichthys georgianus*,  
*Chionodraco rastrospinosus* and *Notothenia kempfi*  
(Subareas 48.1 and 48.2) (Annex 4, paragraph 4.116)

2.50 The Working Group reiterated the advice offered in 1993 that the fisheries in Subareas 48.1 and 48.2 should remain closed until a survey is conducted to provide more accurate estimates of the status of the stocks in these subareas.

#### Management Advice

2.51 The Scientific Committee endorsed the recommendations of the Working Group and recommended that the conservation measures in force for the above species should be maintained.

South Sandwich Islands (Subarea 48.4)  
(Annex 4, paragraph 4.117)

2.52 No catches were reported from this area.

#### Management Advice

2.53 In the absence of further information, the Scientific Committee recommended that Conservation Measures 70/XII and 71/XII should remain in force.

Statistical Area 58 (Indian Ocean Sector)

2.54 Catches from the 1994 season are shown in Table 9, Annex 4. Catches of *D. eleginoides* in Division 58.5.1 were taken in the directed French and Ukrainian trawl and longline fisheries. Catches in Subarea 58.6 were taken in a French exploratory trawl fishery around the Crozet Islands.

*Dissostichus eleginoides* (Division 58.5.1)  
Kerguelen Islands (Annex 4, paragraphs 4.131 to 4.135)

2.55 The fishery for this species continued in the 1993/94 season in the two traditional areas, a longline fishery on the western slope (942 tonnes) and a trawl fishery on the northern shelf (4 141 tonnes).

2.56 No other new data were provided.

2.57 French authorities have set a limit of 1 000 tonnes for the western area longline fishery in 1994/95.

2.58 A precautionary catch limit of 3 000 tonnes in the northern area for the trawl fishery has been set by French authorities for the 1994/95 season.

Management Advice

2.59 In the absence of any new data, the Scientific Committee endorsed the French conservation measures. These are consistent with the Working Group's previous advice that a longterm sustainable yield for the western area of the Kerguelen shelf is estimated at 1 400 tonnes, and that a precautionary approach should be taken with the northern area to prevent the spawning stock size falling to low levels before the stock has been adequately assessed.

2.60 The Scientific Committee endorsed the view of the Working Group that for proper assessment of these stocks, trawl surveys of the entire stocks would provide indices of abundance to model the stock dynamics and sustainable yield.

*Notothenia rossii* (Division 58.5.1)  
Kerguelen Islands (Annex 4, paragraphs 4.120 to 4.123)

2.61 More information has been submitted on the increase in juvenile *N. rossii* abundance. However, the Working Group noted that these data were for a part of the stock not on the fishing grounds and, therefore, not representative of the overall stock. The current biomass is very much less than the biomass before the fishery commenced.

### Management Advice

2.62 The Scientific Committee endorsed the recommendation of WG-FSA that the commercial fishery for *N. rossii* remain closed until a biomass survey demonstrates that the stock has recovered to a level that will support a fishery.

*Notothenia squamifrons* (Division 58.5.1)  
Kerguelen Islands (Annex 4, paragraphs 4.124 and 4.125)

2.63 No new data are available for this fishery.

### Management Advice

2.64 The Scientific Committee endorsed the recommendation of WG-FSA that the fishery for *N. squamifrons* on the Kerguelen Shelf remain closed.

*Champscephalus gunnari* (Division 58.5.1)  
Kerguelen Plateau (Annex 4, paragraphs 4.126 to 4.130)

2.65 The results of a recruitment study support the previously stated idea that the population is dominated by a single cohort that survives for three years. Other cohorts are present but in lower abundance. This is likely to be a result of variable recruitment.

2.66 At its last meeting, the Scientific Committee endorsed the recommendation of WG-FSA that fishing on the strong cohort being recruited should be delayed until the 1994/95 season, by which time it would have had the opportunity to spawn. Also, only restricted fishing in the 1994/95 season should be allowed, to enable sufficient escapement of fish to spawn a second time and because a declining trend in the strength of previous strong cohorts had been detected. The objective of the first part of last year's recommendation, i.e. no fishing in the 1993/94 season, was met. However, the Working Group could not recommend a catch limit for the 1994/95 season because no data on the biomass of this cohort were available.

2.67 The Scientific Committee endorsed the view of the Working Group that a proportion of the cohort should be allowed to survive another year to spawn a second time, in the hope that this will contribute to establishing a population with more than one strong cohort and a reduced variability in biomass.

### Management Advice

2.68 The Scientific Committee recommended that the fishery in the 1994/95 season be kept to a low level to allow the present strong cohort to spawn a second time.

Heard Island (Division 58.5.2)  
(Annex 4, paragraphs 4.147 to 4.159)

2.69 The results of three trawl surveys in the area since 1990 were reviewed by the Working Group.

2.70 The Scientific Committee endorsed the decision of the Working Group to determine precautionary catch levels using an approach similar to that adopted for *E. carlsbergi* in Subarea 48.3 (Annex 4, paragraphs 4.150 to 4.158). The Scientific Committee noted that these assessments will be refined following revision of the biological parameters for these stocks in the Heard Island area.

### Management Advice

2.71 The Scientific Committee recommends that a precautionary TAC be set for *C. gunnari* at 311 tonnes and a precautionary TAC for a trawl fishery on *D. eleginoides* at 297 tonnes.

Coastal Areas of the Antarctic Continent  
(Divisions 58.4.1 and 58.4.2)

2.72 No new information was available to WG-FSA to allow assessment of the stocks in these areas (Annex 4, paragraph 4.160).

Ob and Lena Banks (Division 58.4.4)  
(Annex 4, paragraphs 4.136 to 4.146)

2.73 The Scientific Committee welcomed the latest submission by Ukraine of data on catches from these banks (SC-CAMLR-XIII/BG/13). New stock assessments will be undertaken using these



data at the next meeting of WG-FSA. No new data were available for these banks at the recent meeting of WG-FSA.

2.74 Dr V. Yakovlev (Ukraine) informed the Scientific Committee that Ukraine wished to undertake the research proposed in recent years to survey fish stocks on the Ob and Lena Banks in November this year (WG-FSA-94/32). He welcomed the participation of observers from Members.

2.75 The Scientific Committee noted the details of the trawl survey proposal (see Annex 4, paragraphs 6.9 to 6.15 for details). The survey will be conducted using a commercially-sized bottom trawl with a mesh size (diamond mesh) of 40 mm in the codend. The duration of hauls will be 60 minutes. The Scientific Committee expressed particular concern at the use of a net monitor cable. The Scientific Committee noted that the vessel would be undertaking commercial fishing in addition to the research survey, and considered that this commercial fishing should not be exempt from conservation measures.

#### Management Advice

2.76 The Scientific Committee endorsed the advice of the Working Group that a biomass survey is likely to improve considerably assessments of the fish stocks on the two banks.

2.77 The Scientific Committee endorsed the Working Group's recommendations that:

- (i) the research trawl survey by Ukraine be conducted according to the information contained in Annex 4, paragraphs 6.9 to 6.15;
- (ii) a TAC of 1 150 tonnes for *N. squamifrons* (715 tonnes for Lena Bank and 435 tonnes for Ob Bank) as previously set in Conservation Measure 59/XI be reinstated for the seasons 1994/95 and 1995/96 combined;
- (iii) data reporting should follow the CCAMLR Database format and data recording should be in accordance with the requirements set out in Conservation Measure 64/XII. This information should include all species caught;
- (iv) in the event that the proposed survey is postponed by one year, the TAC recommended may need to be revised in the light of new assessments by the Working Group based on the revised catch figures provided in SC-CAMLR-XIII/BG/13;

- (v) the occurrence of seabirds close to the ship should be monitored and any incidental mortality, in particular that caused by the net monitor cable, must be reported;
- (vi) an international scientific observer should be present during these activities; and
- (vii) exemptions to conservation measures for research purposes should only apply at the designated research stations.

#### Management Under Conditions of Uncertainty Concerning Stock Size and Sustainable Yield

2.78 Discussions of this topic in WG-FSA are reported in Annex 4, paragraphs 4.161 to 4.164.

2.79 The Scientific Committee endorsed the approach of the Working Group to develop management options under conditions of uncertainty on a species-by-species basis. In particular, the Scientific Committee noted the moves by WG-FSA to consider options for a longterm management plan for *C. gunnari* in Subarea 48.3 (see paragraph 2.34). Also, the Scientific Committee noted that WG-FSA had applied the approach adopted by WG-Krill for krill to *E. carlsbergi* in Subarea 48.3 (paragraphs 2.41 and 2.42) and *C. gunnari* and *D. eleginoides* in Division 58.5.2 (paragraph 2.70). The techniques and models being used by the Working Group operate in such a way that calculated yields and catch limits usually decrease as uncertainty in any of the parameters increases.

#### Considerations of Ecosystem Management

2.80 The Working Group addressed a number of issues concerning ecosystem management: monitoring of coastal fish populations (Annex 4, paragraphs 5.1 to 5.3); incidental mortality of birds in longline fisheries (this topic was referred to WG-IMALF for discussion - Annex 4, paragraph 5.4); interactions among fur seals, *C. gunnari* and krill (Annex 4, paragraph 5.5); the by-catch of young and larval fish in the krill fishery (Annex 4, paragraphs 5.6 to 5.10); and interactions between the longline fishery and marine mammals (Annex 4, paragraphs 3.12 and 5.11).

2.81 The Scientific Committee welcomed two recent studies on the by-catch of young fish in krill catches. While these studies were not directly comparable, they both provided an opportunity to assess rates of by-catch in Subareas 48.1 and 48.3. The Scientific Committee noted the Working Group's conclusion that the largest by-catches in these studies occurred when the krill catch was

comparatively low. The Working Group concluded that, given the variability in estimates of by-catch, the rate of by-catch was likely to be of the same order of magnitude in Subareas 48.1, 48.2 and 48.3. This contrasts with information presented by WG-Krill (Annex 5, paragraph 3.12) that the by-catch around the South Shetland Islands was an order of magnitude less than the by-catch reported by the Ukrainian fishery in South Georgia. The Scientific Committee noted there is a need to account for spatial and temporal variability in the results when considering the scale of this problem.

2.82 The Scientific Committee endorsed the recommendation of WG-FSA that these studies be continued in the future following closely the instructions set out in the *Scientific Observers Manual*, and that they provide information on spatial, seasonal and diurnal differences in the by-catch of fish (Annex 4, paragraph 5.10).

Research Surveys (Annex 4, paragraphs 6.3 to 6.15)

#### Trawl Survey Simulation Studies

2.83 No new submissions were received by the Working Group. The Scientific Committee endorsed the comments made by WG-FSA on the need for more work on trawl survey simulation models and for the validation of models already submitted to WG-FSA to continue (Annex 4, paragraphs 6.1, 6.2 and 7.3).

#### Recent and Proposed Surveys

2.84 The UK has notified CCAMLR of its intention to undertake a fish survey in Subarea 48.3 in January/February 1995 using a design similar to those employed in previous years.

2.85 Argentina hopes to undertake, at some time between January and March 1995, a demersal fish survey in Subarea 48.3. If favourable ice conditions prevail, the cruise will also investigate krill in Subarea 48.2.

2.86 A Ukrainian demersal trawl survey of fish stocks on the Ob and Lena Banks is proposed to begin in November 1994. This is discussed above (paragraphs 2.76 and 2.77).

2.87 In response to the Commission's request (CCAMLR-XII, paragraph 6.10) to review the applicability of the 50 tonne catch limit for research prescribed by Conservation Measure 64/XII, the

Scientific Committee endorsed the advice of the Working Group that this limit appears applicable for crabs given the relatively tight provisions under Conservation Measures 74/XII and 75/XII.

#### DATA REQUIREMENTS

2.88 The Scientific Committee endorsed the list of data requirements specified by WG-FSA and set out in Annex 4, Appendix D.

2.89 In addition to these requirements, the Scientific Committee endorsed the requests of the Working Group that:

- (i) data collected by observers be submitted to the Secretariat in approved reporting formats whenever possible; and
- (ii) the format for reporting longline data to CCAMLR (Format C2) be updated to include the items identified in paragraph 2.23.

2.90 The Scientific Committee noted that the new submission date for STATLANT data, 31 August, had enabled the Secretariat to acquire all STATLANT data prior to the Working Group meeting, with the result that all catches could be reported to the group.

#### Software and Analyses Required for the 1995 Meeting (Annex 4, paragraphs 7.3 and 7.4)

2.91 The Scientific Committee endorsed the recommendations made by WG-FSA.

#### WORKING GROUP ORGANISATION

2.92 The Scientific Committee noted the discussion of WG-FSA on its function and terms of reference (Annex 4, paragraphs 7.5 to 7.8) and endorsed the view of WG-FSA that its terms of reference did not need to be changed at this time.

## CRAB RESOURCES

3.1 No fishing for crabs was undertaken in the 1993/94 season.

3.2 No new data for assessing the crab stock in Subarea 48.3 were available to WG-FSA (Annex 4, paragraph 4.105).

3.3 The Scientific Committee noted the continuing work on designing stock assessment procedures and a longterm management plan for crabs in Subarea 48.3 (Annex 4, paragraphs 4.108 to 4.110).

3.4 The USA and Sweden intend to conduct a survey of the crab stock in Subarea 48.3 in March 1995.

3.5 The Scientific Committee endorsed the recommendation of the Working Group that the following are high priorities for future research:

- (i) the use of time-release or biodegradable devices should be considered as a means of reducing the effects of ghost fishing should pots be lost from a line;
- (ii) a minimum mesh size should be adopted and/or an escape port included in pots (usually a metal ring set into the side of the pot) following research on mesh or port selectivity. This will serve to select only crabs of harvestable size more effectively and to reduce the number of potential discards, although it will also reduce the ability to monitor parasitic infection; and
- (iii) experiments should be conducted using pots with finer mesh or escape ports added to commercial pot lines in order to obtain more representative length frequency information from harvested stocks.

## MANAGEMENT ADVICE

3.6 The Scientific Committee recommended that the current TAC of 1 600 tonnes and the other regulations contained in Conservation Measures 74/XII and 75/XII should remain in force for the 1994/95 fishing season.

3.7 In the case of data reporting, the Scientific Committee believed that it would be most appropriate for data to be in haul-by-haul form. However, it noted that at this stage of the fishery's development the question of industrial confidentiality arose (SC-CAMLR-XII, Annex 5, paragraph 6.103).

## SQUID RESOURCES

4.1 No catches of squid were reported from the CCAMLR Convention Area in the 1993/94 season. The only catches of squid taken in recent years were reported from the 1989 season by the UK (8 tonnes).

4.2 Paper SC-CAMLR-XIII/BG/15 reported that the UK had received two enquiries about squid fishing in the Antarctic. The first, from Taiwan, concerned a proposal to fish for *Martialia hyadesi* in the waters off South Georgia and the South Sandwich Islands, and apparently resulted from experience of poor fishing conditions in the *Illex argentinus* fishery on the Patagonian shelf in the 1994 season. Prof. J. Beddington (UK) reported that since the preparation of SC-CAMLR-XIII/BG/15, a further enquiry had been received from a Taiwanese company. However, the Secretariat has not yet been approached on the matter.

4.3 The second enquiry was from a Spanish seafood company for information on *M. hyadesi*. The reason for this company's interest was the recent considerable variation in the catch rate of *I. argentinus* and the effects of this on the market.

4.4 Prof. Beddington informed the Scientific Committee that from the information available to the UK, he did not anticipate that a fishery for squid in the Convention Area would develop in the 1994/95 season. The Scientific Committee agreed that these developments and expressions of interest in fishing for squid in the Convention Area should continue to be closely monitored.

## RESEARCH

4.5 Paper SC-CAMLR-XIII/BG/15 reported that a UK research cruise around South Georgia in January/February 1994 had been partly devoted to cephalopod research. The results of this work will be reported to CCAMLR in the future. Paper SC-CAMLR-XIII/BG/15 also reported that in its 1995 South Georgia groundfish survey, the UK will evaluate the potential of a new longline system, developed by Japanese scientists for squid fishing, as a research sampling technique for *M. hyadesi*. These longlines are currently used in the Pacific *Ommastrephes bartramii* fishery.

4.6 Paper SC-CAMLR-XIII/BG/15 also included an abstract of a paper by Dr P. Rodhouse *et al.* on the growth, age structure and environmental history of *M. hyadesi* and noted that papers presented at the 1993 Symposium on Southern Ocean Cephalopods have now been published in *Antarctic Science*, 6 (2) (1994).

4.7 Prof. G. Duhamel (France) informed the Scientific Committee that squid caught during recent experimental surveys at the Kerguelen (Division 58.5.1) and Crozet Islands (Subarea 58.6) had been retained for identification, and that specimens had been sent to Dr Rodhouse for this purpose. Future surveys at Kerguelen will also include the identification of samples of squid caught in this area. The Scientific Committee encouraged this initiative.

## KRILL RESOURCES

5.1 The sixth meeting of WG-Krill was held in Cape Town (South Africa) from 25 July to 3 August 1994, and was chaired by the Convener, Mr Miller.

5.2 Monthly catch data were submitted in accordance with Conservation Measure 32/X from Chile, Japan, Poland and Ukraine. In addition, Chile has submitted a full set of haul-by-haul data.

5.3 The total catch of krill reported for the 1993/94 season in SC-CAMLR-XIII/BG/1 Rev. 1 is shown in Tables 3 and 4. It was reported that a non-member (Latvia) had taken a small catch in Statistical Area 48, but it was not known in which subarea the catch was taken.

Table 3: National krill landings (in tonnes) since 1985/86 based on STATLANT returns.

Member	Split-Year*								
	1986	1987	1988	1989	1990	1991	1992	1993	1994
Chile	3264	4063	5938	5329	4501	3679	6066	3261	3834
Germany	0	0	0	0	396	0	0	0	0
Japan	61074	78360	73112	78928	62187	67582	74325	59272	62322
Latvia									71
Republic of Korea	0	1527	1525	1779	4040	1211	519	0	0
Poland	2065	1726	5215	6997	1275	9571	8607	15911	7915
Spain	0	379	0	0	0	0	0	0	0
USSR**	379270	290401	284873	301498	302376	275495	0	0	0
Russia							137310	4249	965
South Africa									3
Ukraine							61719	6083	8708
Total	445673	376456	370663	394531	374775	357538	288546	88776	83818

\* The Antarctic split-year begins on 1 July and ends on 30 June. The column 'split-year' refers to the calendar year in which the split-year ends (e.g., 1989 refers to the 1988/89 split-year).

\*\* Although the formal date for separation of the former USSR was 1 January 1992, for comparative purposes statistics are compiled here for Russia and Ukraine separately for the complete split-year, i.e. 1 July 1991 to 30 June 1992.

Table 4: Total krill catch in 1993/94 by area and country. The catch for 1992/93 is indicated in brackets.

Subarea /Area	Chile	Japan	Latvia	Poland	Russia	South Africa	Ukraine
41.3.2				0 (2506)			
48.1	3834 (3261)	41251 (29665)		0 (4790)	(0)		(0)
48.2		7029 (10049)		6833 (2621)			(0)
48.3		13143 (13763)		1082 (5995)	965 (4199)	3 (0)	3455 (6083)
48.6		0 (33)					
48.?			71 (0)				
58.4.1		899 (5762)			(50)		
Total	3834 (3261)	62322 (59272)	71 (0)	7915 (15912)	965 (4249)	3 (0)	8708 (6083)

Subarea /Area	Total
41.3.2	0 (2506)
48.1	45085 (37716)
48.2	19115 (12670)
48.3	18648 (30040)
48.6	0 (33)
48.?	71 (0)
58.4.1	899 (5812)
Total	83818 (88777)



5.4 WG-Krill recommended that the *Statistical Bulletin* include details of total effort on the same temporal and spatial scales as catch data. In SC-CAMLR-XIII/BG/11 the Data Manager proposed a number of revisions to the format of the *Statistical Bulletin*, one of which would give effect to the recommendation of WG-Krill. The Scientific Committee recommended that future editions of the *Statistical Bulletin* report total effort in the format given in SC-CAMLR-XIII/BG/11.

5.5 A study of length frequency data from the Japanese commercial fishery was submitted to WG-Krill. The Scientific Committee encouraged the continued submission of length frequency and haul-by-haul information which is useful for assessing the overlap between the segment of the krill population exploited by the fishery and that by predators, as well as providing information on length at recruitment to the fishery.

5.6 Results of recent work by Japan on the by-catch of young fish in commercial krill trawls suggest an inverse relationship between the density of krill swarms and the by-catch of young fish. The Scientific Committee encouraged further work of this nature, but emphasised the need to follow the standard method for sampling fish by-catch during krill fishing set out in the *Scientific Observers Manual* (see also paragraph 2.81).

5.7 It was noted that attempts had been made to derive a composite index of krill abundance from the joint Chilean/US study using acoustic and fisheries data off Elephant Island. No information has been received on the practicality of collecting search time information at random times as described in SC-CAMLR-XII, Annex 4, paragraph 5.31. Pilot studies are encouraged despite the recognised difficulty of measuring search time information directly.

5.8 The Scientific Committee was informed that the fishing plans of Japan, Chile and Ukraine for 1994/95 were similar to the fishing operations of those countries last season. An Australian company is still interested in fishing for krill with one to four vessels, catching up to 80 000 tonnes per year, but it is uncertain whether this venture will proceed in the next year. India, in response to a request for information on reports that it had plans to undertake some krill fishing (see SC-CAMLR-XII, Annex 3, paragraph 3.12), informed the Scientific Committee that at present there were no plans to harvest krill. The Scientific Committee expressed its continued interest in knowing future plans with respect to potential krill catch levels and fishing areas.

#### ESTIMATION OF KRILL YIELD

5.9 A Workshop on Evaluating Krill Flux Factors was held immediately prior to the meeting of WG-Krill. The workshop calculated water and krill fluxes for a number of small regions within

Statistical Area 48 for which there are sufficient data. Data on krill distribution and abundance were available from FIBEX, and oceanographic flow rates were available from the Fine Resolution Antarctic Model (FRAM) and from German and Japanese geostrophic calculations. However, there is a lack of hydroacoustic and oceanographic data collected simultaneously over the same areas, and the geographical coverage of the existing data is limited. Nonetheless, the results showed that horizontal transport of krill is an important factor in the overall stock distribution and needs to be considered in the development of management advice for krill fisheries. The analyses provided a range of values which can be used to examine the flux of krill in relation to fishery and predator demands in particular regions.

5.10 The Scientific Committee considered that there were two important scales over which to consider the effects of krill flux. The first is the scale of statistical areas and subareas, where the question is how to take the flux of krill into account when calculating catch limits. The second scale is a much smaller one which relates to the flux of krill within the foraging ranges around predator colonies where these overlap with krill fisheries.

5.11 There are additional oceanographic data sets that could be used in refining the flux calculations, and the Scientific Committee encouraged further data submissions. In particular, there is a large body of drifter and buoy data (mainly collected by the USA) which would be very useful for indicating regions of rapid water transport with little eddy activity and areas of high eddy activity and drifter retention. The Scientific Committee agreed that repeated surveys of particular regions on a small scale (about 10 000 to 120 000 km<sup>2</sup>), such as carried out under AMLR and LTER, which include both biology and oceanography, were particularly useful, and that further studies based on direct current measurements were needed in key areas such as shelf and shelf-break regions. The development of coupled biological-oceanographic models is an area of research which will be kept under review by the Scientific Committee and its Working Groups.

5.12 Dr M. Naganobu (Japan) noted that there may be considerable aggregations of krill close to the sea bottom and that there may be a seasonal vertical flux of krill which could also be an important factor in the movement and concentration of krill. He reported that Japan would be conducting studies to investigate this hypothesis in the coming season.

5.13 WG-Krill had reviewed new work relevant to hydroacoustic investigations of krill, survey design and modelling studies on krill aggregation. Various aspects of krill acoustic target strength determination and survey design had been discussed. With respect to survey design, the Scientific Committee recognised the need to consider further the circumstances in which random or regular survey designs were to be preferred.

5.14 The Scientific Committee noted WG-Krill's endorsement of Australian plans to carry out a survey of krill biomass in Division 58.4.1. The Scientific Committee endorsed WG-Krill's view that if the survey were undertaken according to the design which had been submitted, the results would be suitable for providing a standing stock estimate to be used as the basis for setting a precautionary catch limit for this division.

#### KRILL YIELD CALCULATIONS

5.15 The population model and computer program used to calculate potential krill yield were updated during the year and the program verified by the Secretariat. The computer code has been updated to include the recruitment module reported to WG-Krill at its 1993 meeting (WG-Krill-93/13).

5.16 New estimates of recruitment variability were obtained using the proportion of recruits in the population estimated from length density data. Data available last year and new data which had been submitted in response to the request from the Scientific Committee were analysed to obtain new estimates of the average and variance in recruitment proportion. Mean recruitment proportions by age are similar, although variances of the individual estimates are much lower for 1-year-old as opposed to 2-year-old recruitment. Combined results tend to be dominated by estimates of 1-year-old recruitment since values were combined by inverse variance weighting.

5.17 Refinements to the model were planned to take into account probable correlation between growth and mortality, but submissions to WG-Krill indicated that no reliable information on the relationship between growth and mortality for crustacea was available. WG-Krill has identified two options for further investigations of the properties of the yield model with respect to potential correlations between these two variables (Annex 5, paragraphs 4.88 and 4.89).

#### CRITERIA FOR SELECTING APPROPRIATE VALUE OF $\gamma$ (Annex 5, paragraphs 4.92 to 4.98)

5.18 Over the past several years, the Working Group has been developing the krill yield model to calculate the proportion ( $\gamma$ ) of a survey estimate of the pre-exploitation krill biomass ( $B_0$ ) that can be set as a precautionary catch limit. At this year's meeting of WG-Krill and during discussions in the Joint Working Group, the following three decision rules were developed for determining the value of  $\gamma$  to be used in calculating a precautionary catch limit:

- (i) choose  $\gamma_1$ , so that the probability of the spawning biomass dropping below 20% of its pre-exploitation median level over a 20-year harvesting period is 10%;
- (ii) choose  $\gamma_2$ , so that the median krill escapement in the spawning biomass over a 20-year period is 75% of the pre-exploitation median level; and
- (iii) select the lower of  $\gamma_1$  and  $\gamma_2$  as the level of for calculation of krill yield.

5.19 To illustrate what the three decision rules mean, it is necessary to give some background on the krill yield model. The krill yield model uses computer simulations to determine the statistical distribution of the abundance of krill for a given level of exploitation over a period of 20 years. The model initially assumes a given biomass of krill, divided into a number of age classes. The model calculates the biomass year by year, by adding an amount for annual growth and deducting an amount corresponding to natural mortality. The biomass of each year's recruits is added and the effects of a constant annual catch of  $\gamma * B_0$  are deducted from the biomass each year. Variability in the simulated population biomass in each year arises because the recruitment to the population in each year is drawn from a statistical distribution which reproduces the statistical properties of the estimates of proportional recruitment obtained from length composition data collected during krill surveys.

5.20 A value for  $\gamma$  is selected by finding the value which results in the statistical distributions of the outcome of many repetitions of the simulation model meeting selected criteria. The model allows for uncertainty in estimates of unexploited biomass as well as uncertainty in estimates of key demographic parameters such as growth and mortality, by drawing values for each parameter from appropriate statistical distributions for each repetition of the model.

5.21 The model is run with  $\gamma = 0$  (i.e., no catches) to produce the distribution of spawning stock biomass, shown in Figure 1 as distribution A. The midpoint of this distribution is a number representing the median unexploited spawning stock biomass. If  $\gamma$  is given a value greater than zero, the simulated biomass is reduced by the effects of fishing.

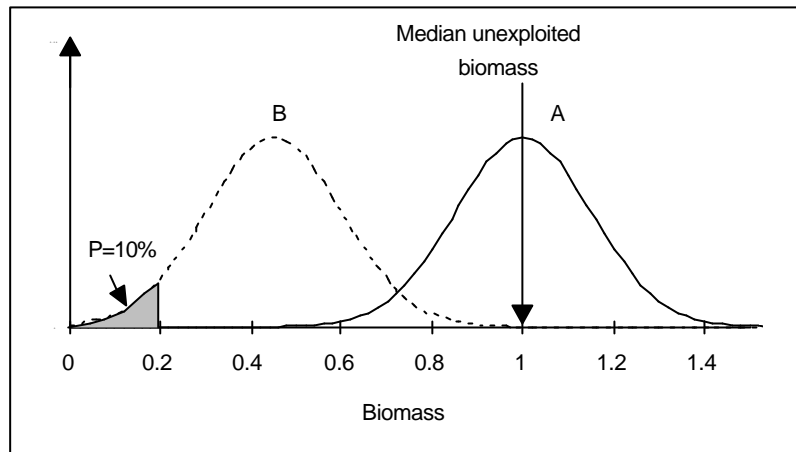
5.22 The selection of  $\gamma$  values used to date has taken into account two criteria. The primary criterion, or decision rule, has been the value of  $\gamma$  which leads to a 10% probability of the spawning biomass dropping below 20% of its pre-exploitation median level over a 20-year harvesting period. Applying this criterion requires the examination of the statistical distribution of the lowest population size (expressed in terms of spawning biomass) in any year over the 20 years of each simulation, collected over hundreds of replicates. This distribution is shown in Figure 1(a) as distribution B. The probability of attaining a lowest spawning stock biomass less than 20% of its pre-exploitation

level is estimated from the relative frequency of this event over the set of replications for a range of values of  $\gamma$ . The selected value of  $\gamma$  is that which has this relative frequency at 10%. This corresponds to the first decision rule.

5.23 This first decision rule was aimed at meeting the requirement for stable recruitment in the krill stock by not allowing the spawning biomass to drop to very low levels, where the chance for successful recruitment may be impaired. Although the probability of 10% is somewhat arbitrary, it is consistent with values used in managing other fisheries. This particular decision rule, however, is derived from a single-species approach. At last year's meetings, WG-Krill and the Scientific Committee had preliminary discussions on decision rules that afford some protection to krill predators in accordance with the provisions of Article II. This year, the second decision rule given above was derived as a first attempt to give some explicit effect to the requirements under Article II.

5.24 The second rule also leads to a value of  $\gamma$  which is determined by the statistical distribution of the spawning stock biomass at the end of the 20-year period used in each simulation. The criterion embodied in this part of the rule is illustrated in Figure 1(b). As before, A is the distribution of spawning stock biomass without fishing. C is the distribution of spawning stock biomass after 20 years of exploitation corresponding to a given  $\gamma$ . The selected value of  $\gamma_2$  is that which results in C having a median equal to 75% of the median of A.

(a)



(b)

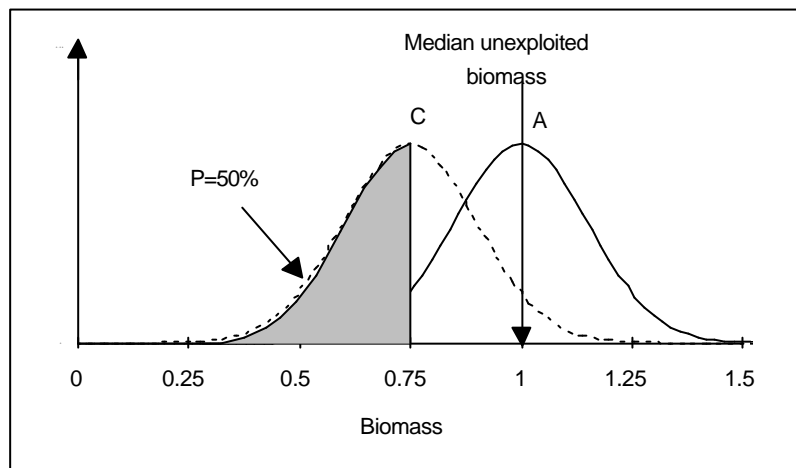


Figure 1: Distribution of biomass of krill under different management regimes.

A is the statistical distribution of biomass in any year for a population which has not been exploited. B in (a) is the statistical distribution of lowest spawning stock biomass over 20 years with catches  $\gamma_1 B_0$ . C in (b) is the statistical distribution of spawning stock biomass after 20 years of exploitation with annual catches  $\gamma_2 B_0$ .

5.25 The values of  $\gamma_1$  and  $\gamma_2$  will usually be different, and so the third decision rule chooses one of the two values. Whether  $\gamma_1$  or  $\gamma_2$  is the greater depends largely on the degree of variability in recruitment and the variance of the estimate of unexploited biomass  $B_0$ . Let the criteria corresponding to the values  $\gamma_1$  and  $\gamma_2$  be designated as the 'recruitment criterion' and the 'predator criterion' respectively. The lower of the two values is chosen because it means that the criterion corresponding to that part of the decision rule is just attained, and the criterion corresponding to the higher value of  $\gamma$  will be exceeded. Conversely, if the higher of the two  $\gamma$  values were chosen, the criterion corresponding to the lower  $\gamma$  value would not be met. There are two possible results for  $\gamma_1$  and  $\gamma_2$  as set out in Table 5 and four possible outcomes from choosing  $\gamma_1$  or  $\gamma_2$ . It can be seen that only by choosing the lower of  $\gamma_1$  or  $\gamma_2$  that the two criteria relating to recruitment or predator

requirements are met or exceeded. Choosing the higher value automatically leads to a failure to fulfil one or other of the two criteria.

Table 5: Outcome of choosing the higher or lower value of  $\gamma$  under conditions where  $\gamma_1 > \gamma_2$  or  $\gamma_1 < \gamma_2$ .

	Choose higher value of $\gamma$	Choose lower value of $\gamma$
$\gamma_1 > \gamma_2$	Predator criterion not met Recruitment criterion met	Predator criterion met Recruitment criterion exceeded
$\gamma_1 < \gamma_2$	Predator criterion met Recruitment criterion not met	Predator criterion exceeded Recruitment criterion met

5.26 The Scientific Committee agreed that use of the three decision rules is appropriate for determining precautionary catch limits for krill. It recognised that the levels used in the two criteria are somewhat arbitrary and they will need to be revised from time to time. The recruitment criterion of 10% probability of the lowest biomass being less than 20% of the unexploited level will need to be revised to take into account any information which becomes available on the relationship between stock and recruitment. A revision of the predator criterion of median spawning stock biomass at 75% of the unexploited level would require better information on the functional relationship between abundance of prey and recruitment in predator populations. The 75% level is chosen as the midpoint between taking no account of predators (i.e., treating the krill fishery as a single-species fishery), and providing complete protection for predators (i.e., no krill fishery). WG-CEMP has begun to develop some models to explore the possible form of these functional relationships. However, the Scientific Committee recognised that it will take considerable time to acquire the information needed to provide advice on revised values for either the recruitment or the predator criterion levels.

#### YIELD ESTIMATES (Annex 5, paragraphs 4.99 to 4.110)

5.27 Results from the krill yield model incorporating the updated estimates of average recruitment proportion and its variability are presented in paragraphs 4.99 to 4.110 of the report of WG-Krill (Annex 5). Given the unusually high variance in the set of estimates of proportions of recruits based on 1-year-olds, the values for  $\gamma$  were calculated using only the recruitment proportions from 2+ krill.

5.28 The first decision rule resulted in  $\gamma_1 = 0.149$  and the second decision rule  $\gamma_2 = 0.116$ . Full results (using 2+ recruitment) for both  $\gamma$  values are given in Table 6.

Table 6: Results of the krill yield model for the two decision rules.

Statistic		First Decision Rule	Second Decision Rule
		P = 0.10 $\gamma_1 = 0.149$	M = 0.75 $\gamma_2 = 0.116$
Probability of spawning biomass falling below 0.2 over 20-year harvest period	(Prob)	0.10	0.04
Median spawning biomass level at the end of 20 years	(Med)	0.68	0.75
Lower 5% -ile spawning biomass	(Low)	0.25	0.38

5.29 The Scientific Committee noted that the values of  $\gamma_1$  and  $\gamma_2$  lie between the values of 0.1 and 0.165 determined by WG-Krill in 1993. The third decision rule, indicating that the lower of the two values should be chosen, determines that a  $\gamma$  value of 0.116 should be used in calculations of precautionary catch limits.

5.30 The sensitivity of the results to size at 50% recruitment to the fishery was also investigated for variations of  $\pm 5$  mm in the distribution assumed for length at 50% recruitment ( $r_{50}$ ). The results showed that most changes in  $\gamma$  are not too substantial ( $\sim 10\%$ ) for the changes in  $r_{50}$  used in the tests. Although the Scientific Committee noted that there is some need to determine whether actual values of this parameter are likely to be covered by the ranges of the distributions used in the sensitivity tests, it was considered that the values currently used are likely to fall within the ranges used in the model.

ADVICE ON KRILL FISHERY MANAGEMENT  
(Annex 5, paragraphs 5.1 to 5.33)

Precautionary Catch Limits (Annex 5, paragraphs 5.1 to 5.26)

Estimates of Potential Yield (Annex 5, paragraphs 5.1 to 5.17)

5.31 WG-Krill examined the need for possible upward adjustment of survey estimates of  $B_0$  to account for flux. The Working Group developed an analysis which confirmed that such an adjustment may not be necessary if catch limits were to be calculated over a series of contiguous areas from a near-synoptic survey. This was the assumption used in calculating the existing overall precautionary limit for Statistical Area 48. The analysis showed that applying this assumption to the subarea survey estimates of  $B_0$  constituted a sufficiently conservative basis for management, provided that the regions for which precautionary limits were set did not contain more than one self-sustaining stock. This should allow catch limits to be set for all subareas for which biomass estimates



are available. This approach was applied to calculate the precautionary catch limits shown in column A of Table 7. The revised catch limit for krill in Statistical Area 48 is 4.1 million tonnes.

Table 7: Precautionary limits on krill catches in various areas, based on the formula  $Y = \gamma B_0$ , where  $\gamma = 0.116$ . Units are  $10^6$  tonnes. Two methods of calculating catch limits by subarea are given: (A) allocation proportional to biomass estimate for subarea; and (B) allocation on the basis of previous recommendation (see SC-CAMLR-XII, Annex 4, Table 5).  $B_0$  values are taken from SC-CAMLR-XII, Annex 4, Table 4.

Subarea/ Division	$B_0$	$Y = \gamma B_0$	Catch Limit by Subarea		1993/94 Catch
			A	B	
48.1	13.6}	3.57	1.58	1.39 (34%)	0.045
48.2	15.6} 30.8		1.81	2.01 (49%)	0.019
48.3	1.5}		0.18	1.07 (26%)	0.019
48.4	-		0	0.21 (5%)	0
48.5	-		0	0.21 (5%)	0
48.6	4.6		0.53	0.53	0.49 (12%)
Total 48	35.4	4.10			0.083
58.4.2	3.9	0.45			

5.32 Conservation Measure 46/XI specifies subarea maxima that currently apply in addition to the present overall precautionary catch limit of 1.5 million tonnes for krill in Statistical Area 48 (Conservation Measure 32/X).

5.33 Four views were put forward as to how the revised calculation of a limit of 4.1 million tonnes for Statistical Area 48 (see Table 7) should be treated and subdivided:

- the first view was that the revised precautionary limit of 4.1 million tonnes should replace the existing value of 1.5 million tonnes, and that it should be subdivided according to column A in Table 7;
- the second view was that the overall precautionary catch limit should be revised to 4.1 million tonnes, and that it should be subdivided according to column B in Table 7;
- the third view was that there was no need to revise either the 1.5 million tonne overall limit of Conservation Measure 32/X for Statistical Area 48 or the subarea maxima that currently apply in Conservation Measure 46/XI; and
- the fourth view was that the overall precautionary catch limit should be revised to 4.1 million tonnes, but that neither column A nor column B provided an acceptable basis for subdivision.

5.34 The first approach follows from the management strategy put forward in Appendix F of the WG-Krill report (Annex 5) which implies that the limits for subareas should be based solely on biomass estimates for those subareas (so that, *inter alia*, zero limits apply in subareas where there has as yet been no survey). Advocates of this approach queried the use of historic catch data as a guide towards subdivision, arguing that this was not a sound approach in the longer term, as the fact that a particular level of catch has been maintained over a limited period constitutes no guarantee that it is sustainable.

5.35 One reservation expressed concerning this approach was that it was unreasonable to reduce the existing limits for Subareas 48.4 and 48.5 from 75 000 tonnes to zero. Another was that the resultant decrease for Subarea 48.3 from 360 000 to 180 000 tonnes was inappropriate, as it was an artefact of the low coverage of this subarea achieved in the FIBEX survey used to provide the  $B_0$  estimate.

5.36 In response to these concerns, proponents of the approach in paragraph 5.34 argued that:

- (i) these low values provided an appropriate incentive to organise surveys of these subareas (for the first time, or on a more extensive basis than previously);
- (ii) the approach, consistently applied, obviated the need for considering only the results from near-synoptic surveys in setting precautionary catch limits - hence other surveys in, for example, Subarea 48.3 in addition to FIBEX, could be considered in refining the estimate of  $B_0$  for that subarea;
- (iii) the situation for subareas with zero limits (because of the absence of a prior survey) might be reconsidered in the context of limited allowances for exploratory fisheries; and
- (iv) further flux studies might provide evidence of a sufficiently large transfer of krill between, say, Subareas 48.2 and 48.3 to negate an hypothesis that these subareas contained effectively separate self-sustaining stocks, thus allowing them to be combined for the purpose of setting precautionary catch limits.

5.37 The second view showed agreement with the revision of the overall precautionary catch limit to 4.1 million tonnes. However, it considered that the matter of subdivision had already been discussed at length at previous meetings, and that the subdivision proportions for each subarea then agreed (SC-CAMLR-XII, Annex 4, Table 5) should be applied pending further detailed consideration

of this matter (since little time had been available to study the strategy advanced in Appendix F of the report of WG-Krill). These percentages are based on taking the average of the proportion of FIBEX survey estimates and the proportion of the historic catch in a subarea of Statistical Area 48 and adding 5%. The results of such a subdivision, and the percentages upon which it is based, are shown in column B, Table 7.

5.38 In support of this view Dr Naganobu stressed the following points:

- (i) the 1994 meeting of WG-Krill recognised the revised precautionary limit of 4.1 million tonnes as the best scientific value for Statistical Area 48 at this stage. It is therefore quite reasonable to accept the overall catch limit of 4.1 million tonnes;
- (ii) it is quite unreasonable to reduce without any scientific evidence the existing catch limits for Subareas 48.4 and 48.5 from 75 000 tonnes to zero, as shown in column A. The resultant decrease for Subarea 48.3 from 360 000 to 180 000 tonnes is also inappropriate, because the low coverage of this subarea was apparent in the FIBEX survey. If there had been a wider range survey than the FIBEX survey, he believed that values of biomass higher than the current figure would have been attained;
- (iii) the values in column A do not accord with the percentages adopted for the subdivisions in the context of the overall limit of 1.5 million tonnes for Statistical Area 48 which was agreed after lengthy argument. He therefore considered it appropriate to continue to allocate catch limits to subdivisions by percentages, not an overall catch limit and/or biomass; and
- (iv) Japan considers that in the approach proposed in paragraph 5.36(iii) and Annex 5, paragraph 5.9 (that the situation for subareas with zero limits - because of the absence of a prior survey - might be reconsidered in the context of limited allowances for exploratory fisheries), the imposition of such limits would be tantamount to restricting the area available for krill fishing.

5.39 A reservation concerning the application of the percentages in column B was that they were adopted for an allocation in the context of an overall limit of 1.5 million tonnes for Statistical Area 48. It was argued that these percentages had not been intended to extend to a higher figure for the overall precautionary catch limit, as was now under consideration.

5.40 The third view was that biomass estimates used in the krill yield model were based upon data:

- (i) collected in 1981 and therefore outdated and of no practical use; and
- (ii) possibly collected during a year when the krill biomass was high.

In addition, indications of the likely levels of fishing for the next season were considerably less than the trigger level of 0.62 million tonnes given in Conservation Measure 46/XI. Accordingly, there was no immediate need to revise either the subdivision maxima of Conservation Measure 46/XI or the 1.5 million tonnes overall limit of Conservation Measure 32/X for Statistical Area 48.

5.41 Dr Naganobu noted that although paragraph 5.40 mentions that there is no immediate need to revise 1.5 million tonnes in Conservation Measure 32/X because of likely low catch levels in the next fishing season, it is neither scientific nor reasonable not to do so since, following that logic, it would have been unnecessary to adopt Conservation Measures 32/X or 46/XI for the very same reason.

5.42 He furthermore stressed that WG-Krill had agreed that the revised catch limit represented the best scientific advice available and he therefore suggested that the 4.1 million tonne catch limit should be adopted by the Scientific Committee.

5.43 Dr T. Ichii (Japan) recalled that at last year's meeting the Scientific Committee was unable to agree on a recommendation for a revised catch limit even though the Scientific Committee had accepted a revised estimate for  $B_0$ . He was disappointed that the Scientific Committee was again unable to agree on a revised limit even though a revised value for  $\gamma$  was available. He was concerned that the lack of agreement would reflect badly on the credibility of the Scientific Committee.

5.44 The fourth view was that the overall precautionary catch limit could be revised upward to 4.1 million tonnes but that it was not possible at this stage to suggest an appropriate allocation to subareas.

5.45 Several Members stressed that the overall catch limit could only be revised upwards in conjunction with an appropriate allocation scheme designed to ensure that the overall catch would be distributed over the subareas (see paragraph 5.32).

REFINING OPERATIONAL DEFINITIONS OF ARTICLE II  
(Annex 5, paragraphs 5.21 to 5.23)

5.46 The Scientific Committee agreed that the development of the three decision rules for the selection of  $\gamma$  constituted significant progress on the refinement of operational definitions. In particular, the development of operational definitions that consider both predator and krill needs were welcomed. The Scientific Committee recommended the continued development of such operational definitions.

5.47 The Scientific Committee noted that the krill yield model has been refined and the key parameters of the model are now based on analyses of empirical data. The Scientific Committee noted that the revised overall precautionary catch limit for Statistical Area 48 has been obtained using empirical data and methods. A major problem now lies in the allocation of precautionary limits to subareas within Statistical Area 48. The two approaches proposed by WG-Krill each result in anomalies. The Scientific Committee was not able to offer any further advice at this time which would clarify the basic approach to be followed or provide possible means of resolving such anomalies.

DATA REQUIREMENTS (Annex 5, paragraphs 5.24 and 5.26)

5.48 The Scientific Committee endorsed the list of data requirements set out in Annex 5, Table 3.

5.49 WG-Krill received an offer from Chile to present data on haul start times and duration. The Scientific Committee agreed that these data would be useful. Analyses of parameters such as catch/towing hour could show seasonal trends. In addition, the data would be of use in fishery behaviour models. The Scientific Committee therefore recommended that such data should be presented to the next meeting of WG-EMM<sup>2</sup>.

ECOSYSTEM MONITORING AND MANAGEMENT

6.1 The ninth meeting of WG-CEMP was held in Cape Town, South Africa from 25 July to 3 August 1994 under the convenership of Dr Bengtson. The report of the meeting is attached as Annex 6.

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<sup>2</sup> At this meeting of the Scientific Committee it was agreed that the Working Groups on Krill and CEMP be merged into a new Working Group on Ecosystem Monitoring and Management (WG-EMM) (see paragraph 7.40).

## MEMBERS' ACTIVITIES

6.2 In previous years, summaries of the status of Members' activities - specifically their submission of data to CEMP on monitoring approved predator parameters and the nature of their research directed towards evaluating the utility of potential predator parameters - have been attached as an annex to the WG-CEMP report. This year, to save space in the final report of the Scientific Committee, this information is presented to the Scientific Committee as SC-CAMLR-XIII/BG/2.

6.3 The Scientific Committee welcomed the initiation of CEMP-related research by Italy and South Africa and Norway's commitment to start such work (Annex 6, paragraph 3.3). It regretted the absence of participants from several Members known to have recent or current programs of research on top predators of considerable relevance and interest to CEMP.

6.4 Dr Fanta reported that the Brazilian CEMP program had been temporarily suspended but would recommence in 1995/96. Dr E. Balguerías (Spain) stated that research on penguins undertaken by Spain at Deception Island is funded on a year-to-year basis of research grants and therefore the continuity required by the CEMP Program could not be maintained.

6.5 The Scientific Committee again encouraged Members to participate in CEMP meetings and activities. In particular, it invited representation and collaboration from France, Germany and New Zealand, all of which have longterm research programs of special interest to CEMP, offering the possibility of mutually beneficial interactions.

6.6 It was noted that the production of the WG-CEMP newsletter, endorsed by the Scientific Committee last year, was expected to be undertaken immediately following the current meeting of the Scientific Committee.

## MONITORING PROCEDURES

### Sites

6.7 A management plan for an Antarctic Specially Managed Area (ASMA) at Admiralty Bay, King George Island, submitted by Brazil and Poland had been approved by SCAR and, in accordance with agreed practice, was now being submitted to CCAMLR for comment.

6.8 In considering this proposal, the Scientific Committee recalled that an earlier draft of this document had been referred to WG-CEMP for consideration. Their comments were included in Appendix E of Annex 6.

6.9 The Scientific Committee noted that the proposal has been prepared in accordance with Annex V of the Protocol on Environmental Protection of the Antarctic Treaty and submitted to CCAMLR as would be required under Article 6(2) of Annex V once the Protocol came into force.

6.10 This is the first proposal of an ASMA to be developed and presented to CCAMLR. However, no criteria have been established by CCAMLR against which such proposals may be evaluated.

6.11 It was agreed to recommend to the Commission that assessment by the Scientific Committee of proposals for both ASMAs and Antarctic Specially Protected Areas (ASPAs) should include an evaluation of whether the proposals adequately:

- (i) describe the breeding distribution of seabirds and seals in the area and, at least for colonially breeding species, include points of their entry and departure from the sea;
- (ii) note the location of sites where monitoring studies for purposes of direct relevance to CEMP are being undertaken. This is irrespective of whether or not the sites have been formally protected under Conservation Measure 18/IX;
- (iii) ensure protection to research which contributes to the objectives of CCAMLR;
- (iv) describe areas in which birds and seals, associated with or breeding in the proposed management area, are known to forage;
- (v) draw to the attention of CCAMLR any other matters which may be relevant to the implementation of Article II of the Convention.

6.12 The Scientific Committee recommended that the Commission develop a formal procedure for consideration of proposals for ASMAs and ASPAs and decide how and at which stages they should be reviewed by CCAMLR. It suggested the requirement that any proposals for review by CCAMLR should be received by 31 March so that they may be considered by WG-EMM and then by SC-CAMLR at their next meetings.

6.13 An *ad hoc* group was asked to review the ASMA proposal from Brazil and Poland against the criteria set out in paragraph 6.11. They noted that not all of the information required had been presented. They also noted that there was no report of consultations with other parties, e.g., USA, Ecuador and Peru who are known to be conducting research in the area.

6.14 The Scientific Committee therefore recommended that the proposal be revised to include the information sought in paragraph 6.11.

#### Standard Methods

6.15 The Scientific Committee noted the revision of standard methods on breeding population size, breeding success and age-specific recruitment and survival in black-browed albatrosses, on age-specific recruitment and survival in penguins, on procedures for determining the sex of penguins and on methods involving banding and lavage (resulting from the workshop last year on seabird/researcher interactions). It noted that in response to the recommendation of WG-CEMP, the Secretariat had circulated these methods (in English only) to Members in advance of the 1994/95 field season. The Secretariat was thanked for its prompt and efficient response.

6.16 However, it was noted that changes agreed in previous years, especially those consequent on the incorporation of the gentoo penguin as a CEMP monitoring species, had not yet been incorporated and circulated. The Secretariat was requested to make these changes at the earliest opportunity and to circulate the revised texts to the *Ad Hoc* Subgroup on Monitoring Methods (currently Drs Bengtson, Croxall and W. Trivelpiece (USA)). Once approved, these additional changes should then be circulated together with the earlier ones in all languages of the Commission.

6.17 The Scientific Committee welcomed the agreement of the following scientists to prepare preliminary drafts of new standard methods for consideration by WG-EMM:

- time/depth recorder (TDR) deployment: Drs P. Boveng and Trivelpiece (USA), B. Culik and R. Wilson (Germany);
- TDR data collection: Drs I. Boyd and Croxall (UK); and
- Antarctic and cape petrels: Drs F. Mehlum (Norway) and J. van Franeker (Netherlands).



6.18 The Scientific Committee also supported the request made to the following persons to provide new text for potential incorporation into standard methods: Dr G. Robertson (Australia): penguin lavaging; Dr R. Veit (USA): procellariiform lavaging; Dr Kerry and Ms J. Clarke (Australia): penguin disease sampling.

6.19 It was noted that no progress had yet been made in developing standard methods for crabeater seals and Members with relevant experience were encouraged to prepare draft standard methods as soon as possible.

6.20 Last year the Scientific Committee endorsed WG-CEMP's development of initiatives designed to lead to standard methods for studying, recording and reporting on diving behaviour and foraging performance of penguins and seals using data collected by TDRs and related instruments. WG-CEMP has now developed its proposal in considerable detail (Annex 6, paragraphs 4.15 to 4.21) and recommended that a workshop be held in 1996 to develop as standard parameters indices of foraging effort which are likely to reflect intra- and interannual variation in prey availability. Subject to the approval of the terms of reference of this workshop, to be developed intersessionally by Dr Boyd and an *ad hoc* subgroup of WG-CEMP, the Scientific Committee accepted this proposal and agreed to make appropriate provision in the draft budget for 1996.

#### ENVIRONMENTAL MONITORING

6.21 The Scientific Committee commended the work of the Secretariat in compiling information on sea-ice distribution and extent in the vicinity of CEMP monitoring sites. It welcomed the detailed report in SC-CAMLR-XIII/BG/10 on progress to date and noted the recent dialogue with the IWC and other institutions also investigating Antarctic sea-ice characteristics based on archived historical data. The report indicated that additional - and possibly less costly - sources of relevant data might exist.

6.22 Rather than referring this matter to the WG-CEMP *Ad Hoc* Subgroup on Statistics as suggested in SC-CAMLR-XIII/BG/10, the Scientific Committee felt that the potential, for CCAMLR purposes, afforded by sources of sea-ice data which have recently become available, should be critically reviewed next year by the appropriate Working Groups of the Scientific Committee. To facilitate this, the Data Manager was asked to obtain CD-ROM data from the US Snow and Ice Data Centre to calculate sea-ice indices as currently defined by CEMP (SC-CAMLR-XI, Annex 7, paragraphs 4.30 to 4.32), to compare these with the indices calculated from the JIC charts and to report the results to the meeting of WG-EMM.

6.23 Pending the outcome of this review and re-assessment, the Scientific Committee agreed that the Secretariat should not undertake further extraction of sea-ice data from the JIC charts.

6.24 In addition, Dr Bengtson had been asked to consult with the Chairman of the Scientific Committee of the IWC (SC-IWC), Dr S. Reilly (USA) concerning the IWC initiatives on sea-ice data. Initial consultation indicated that further discussions would be fruitful and Dr R. Holt (USA) was asked to undertake these and report back to the WG-EMM meeting.

#### REVIEW OF MONITORING RESULTS

6.25 The Scientific Committee noted that 46 sets of data on designated monitoring species were submitted to CEMP by five Members for eight sites, including the first submissions from Italy (Annex 6, Table 1). However, the Scientific Committee echoed the concern of the Working Group that some Members, ostensibly undertaking active CEMP programs, were still not submitting data to CEMP. Furthermore, because no Member had submitted any historical data this year, gaps were increasing in the time series of data so far submitted to CEMP.

6.26 The Secretariat had, as requested, used the statistical methods specified in the CEMP standard methods to assess differences between years in the data submitted for each parameter at each site. In reviewing these assessments the Working Group:

- (i) raised queries concerning the appropriateness of some of the statistical tests used;
- (ii) requested investigation of other ways of presenting the results in order to assist the review process; and
- (iii) recommended that the Data Manager and the Subgroup on Statistics (currently Drs Boveng, P. Rothery (UK) and Lic. E. Marschoff (Argentina)) should address these issues intersessionally.

6.27 The Scientific Committee agreed that work aimed at identifying the most appropriate statistical analyses to be used to investigate interannual variation and trends in CEMP indices and the means of presenting the results of these analyses most clearly should be undertaken as a high priority before the 1995 meeting of WG-EMM. This work should be undertaken by correspondence, and, where circumstances allow, direct contact among Members of the statistics subgroup and the Data Manager. A one-day meeting of the subgroup to complete this work may be required immediately prior to the meeting of WG-EMM, depending on progress made intersessionally.

## ECOSYSTEM INTERACTIONS

6.28 The Scientific Committee noted that the discussion of this topic had taken place at the joint meeting of the Working Groups.

## ECOSYSTEM ASSESSMENT

6.29 Because of the problems in calculating the magnitude and significance of interannual differences in parameter values (see paragraph 6.26 above), the assessment procedure undertaken by WG-CEMP in 1994 (presented in Annex 6, Table 2) remained rather similar to those followed in 1992 and 1993, rather than the more quantitative summary envisaged in SC-CAMLR-XII, Annex 6, paragraph 6.37.

6.30 Nevertheless, the Scientific Committee found the summary tables very useful and welcomed the clear distinction in the tables between assessments based on data actually submitted to the CEMP database and those based on data collected annually by standard procedures but not submitted to CEMP.

6.31 The Scientific Committee noted the value of Annex 6, Table 2, in terms of the insight the data provide into predator population size and predator performance in 1993/94 (Annex 6, paragraphs 7.13 to 7.22).

6.32 In particular, the Scientific Committee noted the conclusions (Annex 6, paragraph 7.23) that very different patterns of predator performance and prey availability/abundance had apparently existed in the three subareas of Statistical Area 48 in 1993/94. It concurred with the Working Group that these contrasting situations offered an excellent opportunity for a concerted effort to investigate the biological and physical characteristics of the marine environment that existed in these three subareas in 1993/94.

6.33 Accordingly, WG-EMM was requested to investigate the best way that comparable, and, where appropriate, coordinated analyses of relevant data might be arranged and expedited. Members holding, or aware of the existence of, data relevant to this undertaking were asked to provide WG-EMM with details, if they had not already done so at the joint Working Group or in the report of their Member's activities for 1993/94.

## SCOPE OF CEMP

6.34 The Scientific Committee agreed last year that WG-CEMP should consider whether it was timely and appropriate now to consider expanding CEMP beyond its current exclusive focus on the krill-based system.

6.35 WG-CEMP reviewed briefly three areas of current research that had the potential to make valuable contributions to monitoring of and directed research on predators of fish species currently or recently subject to commercial fishing (Annex 6, paragraphs 9.3 to 9.7). These were:

- (i) work on blue-eyed shags, especially by Lic. E. Barrera-Oro and Lic. R. Casaux and colleagues, providing data on the relative abundance and other characteristics of several species of coastal benthic fish. This research had been further discussed by WG-FSA (Annex 4, paragraphs 5.1 to 5.3);
- (ii) current research at five sub-Antarctic island groups by Australia, France, South Africa and Sweden investigating the dynamics of interactions between king penguins and myctophids; and
- (iii) detailed work, principally by Australian, German and US scientists, on predators that are important consumers of *Pleuragramma antarcticum*, a selected species within the CEMP Program about which CEMP has rarely received any information.

6.36 In discussion, Members noted that research on king penguins and myctophids could potentially be coordinated with research on squid, which would also be valuable to the Scientific Committee.

6.37 It was also noted that interactions between Antarctic fur seals and *C. gunnari* were of considerable potential interest in relation to the dynamics and management of stocks of this icefish in Subarea 48.3 (Annex 4, paragraph 4.77).

6.38 The Scientific Committee noted the conclusions of WG-CEMP that it would be very valuable to widen the scope of CEMP to take full advantage of current work on these topics.

6.39 The Scientific Committee recollected its discussions of last year (SC-CAMLR-XII, paragraphs 8.11 to 8.13) concerning the advantages and disadvantages of expanding the scope of CEMP. It endorsed the statement of WG-CEMP that any expansion should be carefully planned and

should not dilute the considerable effort required to maintain the existing CEMP Program. It further noted the potential value of comparisons between krill-based and fish-based predator-prey interactions.

6.40 Consequently, recognising the interest in undertaking appropriate research and monitoring activities on selected predators of fish species that are or have been of commercial interest, the Scientific Committee agreed this topic should be considered at the next meeting of its Working Groups. It encouraged Members to submit outline proposals for research and monitoring activities.

6.41 Finally, the Scientific Committee noted Dr Bengtson's intention to retire as Convener of WG-CEMP. The Chairman, with unanimous endorsement, thanked him for five years of outstanding leadership of WG-CEMP, during which time the program had made great progress, attracting much international interest and furthering the ecosystem management goals of CCAMLR.

#### ADVICE TO THE COMMISSION

6.42 Members should be reminded of the importance of submitting current CEMP data annually and in a timely fashion, and of the requirement to submit all relevant historical data to CEMP as soon as possible.

6.43 Members undertaking long-term research programs relevant to CEMP, and especially France, Germany and New Zealand, should be particularly encouraged to participate fully in meetings and activities of WG-CEMP.

6.44 Subject to its approval of terms of reference of next year's meeting, the Scientific Committee recommended including funds in the provisional 1996 budget for a workshop to develop standard indices of foraging effort of seals and penguins (from TDR data) which are likely to reflect intra- and interannual variation in prey availability.

6.45 The Secretariat should be requested to circulate all approved revisions to existing CEMP standard methods in all languages of the Commission before the 1995/96 field season.

6.46 The Scientific Committee prepared specific recommendations to the Commission concerning the establishment of criteria against which proposals from SCAR for ASMAs and ASPAs should be assessed. These are set out in full in paragraph 6.11.

6.47 In respect of the current ASMA proposal from Brazil and Poland, the Scientific Committee drew the attention of the Commission to the fact that not all of the information required under the criteria proposed in paragraph 6.11 had been presented in the proposal. The Scientific Committee recommended appropriate revision (paragraph 6.14). Furthermore, there was no report of consultations with other parties (e.g., Ecuador, Peru, USA) known to be conducting research in the area (paragraph 6.13).

## REPORT OF THE JOINT MEETING OF THE WORKING GROUPS ON KRILL AND CEMP

7.1 The second joint meeting of WG-Krill and WG-CEMP was held in Cape Town, South Africa between 27 July and 2 August 1994. It was chaired by the Chairman of the Scientific Committee, Dr K.-H. Kock. The report of the meeting is attached as Annex 7.

7.2 The objectives of the meeting were set out at last year's Scientific Committee meeting (SC-CAMLR-XII, paragraph 15.4) and its primary objective was to facilitate interaction between WG-Krill and WG-CEMP on matters of common concern. Specific items chosen by the Scientific Committee for consideration are contained in SC-CAMLR-XII, paragraphs 8.14, 8.22 and 15.5. These include the development of models to evaluate various aspects of experimental harvesting regimes, a review of the scope of CEMP monitoring with respect to predators and prey, fine-scale fisheries data obtained within predator foraging ranges, indices of krill availability and year-class strength, the incorporation of predator-derived indices into the development of approaches to manage the krill fishery and the future organisation of the work of WG-Krill and WG-CEMP.

### PREY MONITORING (Annex 7, paragraphs 3.1 to 3.18)

7.3 The Scientific Committee endorsed the joint meeting's deliberations set out in Annex 7, paragraphs 3.1 to 3.18.

7.4 In particular, it was noted that with respect to the availability of krill biomass estimates within the Integrated Study Regions (ISRs), the boundaries for each of the three ISRs enclose a large area. These were originally chosen, *inter alia*, as regions where krill harvesting has taken place, krill surveys have been undertaken, and which were presumed to encompass important foraging areas for predators to be monitored (SC-CAMLR-V, Annex 6, paragraphs 11 and 12).

7.5 The Scientific Committee endorsed the joint meeting's conclusion that these boundaries were useful in the above context, but added that it may not be necessary to conduct surveys of krill biomass over the regions in their entirety (Annex 7, paragraph 3.10).

7.6 It also accepted that there are problems in comparing biomass estimates from different sized areas and that krill density is a more appropriate measure for such comparisons.

#### PREDATOR MONITORING (Annex 7, paragraphs 3.19 to 3.23)

7.7 The Scientific Committee noted the review of the important work being undertaken within CEMP.

#### ECOSYSTEM INTERACTIONS (Annex 7, paragraphs 4.1 to 4.40)

##### Distribution of Krill Fishing and Predators (Annex 7, paragraphs 4.1 to 4.13)

7.8 The Scientific Committee welcomed the work undertaken by Japanese scientists as the most detailed attempt so far to investigate interactions between penguins, fisheries and krill at an appropriate scale.

7.9 In respect of the reservations expressed about the above work, particularly the interpretation of the results (Annex 7, paragraph 4.3), the Scientific Committee welcomed the joint Japanese/US initiative, planned for the forthcoming austral summer, to investigate further potential interactions between predators, the fishery and krill in the Elephant Island region (Subarea 48.1).

7.10 The Scientific Committee further agreed that pursuing the question of potential predator-fisheries interactions at various scales is of great importance to CCAMLR (Annex 7, paragraph 4.4).

7.11 It is equally important that the collection of any data to examine such interactions should be accompanied by theoretical work aimed at establishing how such data can be used in management. Also, both theoretical work and data collection should proceed jointly. In particular, it is essential that data collection be evaluated in respect of additional observations necessary to resolve ambiguities in the interpretation of current data (Annex 7, paragraph 4.5).

7.12 The continuation of modelling studies at scales which examine the combined effects of fishing and krill flux on krill availability within predator foraging areas (Annex 7, paragraphs 4.6 and 4.37 to 4.39) was encouraged.

7.13 The Scientific Committee noted that further breakdown of flux calculations at finer scales more relevant for predators may be required. The importance of refining estimates of krill flux at the scales currently being used and through the acquisition of new data sets (Annex 7, paragraph 4.13), particularly at finer scales than at present, was recognised.

7.14 The Scientific Committee endorsed the joint meeting's suggestion that studies of predator foraging should be continued in order to investigate behavioural interactions between krill predators and their prey (Annex 7, paragraph 4.8). Such studies are also likely to be useful in improving quantitative definitions of predator-prey interactions.

7.15 In this connection, the Scientific Committee noted the Data Manager's development of a generalised index to describe overlap between predators and fishery and agreed that this work has been taken as far as possible at this stage (Annex 7, paragraphs 4.9 to 4.11). The Secretariat was requested to continue to calculate the catch of krill taken within the critical foraging period-distance.

7.16 The Scientific Committee further agreed that discussion of the full implications of studies of predator-fishery interactions should be carried forward.

#### Effect of Potential Precautionary Measures (Annex 7, paragraphs 4.14 to 4.17)

7.17 Reviewing the joint meeting's deliberations, the Scientific Committee commended the Data Manager on his efforts to develop a model setting out the perceived consequences of various management measures on the krill fishery. It agreed that further development of this model is unnecessary at this stage, but interested parties were encouraged to proceed with validation of the model and develop proposals for parameter re-definitions. The development of alternative models was also encouraged.

7.18 The Scientific Committee noted the concerns expressed about the relationship of the model to the operational requirements of fishing (Annex 7, paragraph 4.16). It recollected its request that fishing Members provide some indication of how they perceive some of the implications identified by the model in relation to their fishing operations (SC-CAMLR-XII, paragraphs 8.42 to 8.44). Fishing



nations were therefore requested to submit their views on this matter to the next meeting of the Working Group.

#### Krill/Predator Functional Relationships (Annex 7, paragraphs 4.18 to 4.40)

7.19 The Scientific Committee noted that the joint meeting had focused its attention on refining the Butterworth/Thomson model (WG-Krill-93/43 and 24) which aims to describe krill-predator functional relationships. Suggested improvements include refinement of input parameters (e.g., survival of juvenile krill), discussion of the mathematical formulation for functional relationships between predator survival and krill biomass in modelling density-dependence, mechanisms to deal with modelling error, possible effects of prey size selectivity on age-dependent natural mortality of krill and appropriate levels of krill escapement necessary to meet predator needs (Annex 7, paragraphs 4.21 to 4.32).

7.20 The Scientific Committee noted that work on most of these aspects of the Butterworth/Thomson model will be carried out during the forthcoming intersessional period.

7.21 The Scientific Committee noted that placing nominal bounds on the acceptable levels of escapement had proved to be useful in developing management advice. Usually this level is taken to be about 0.5 of the spawning population in a single species fishery context. However, this ignores dependent and related species within the provisions of Article II.

7.22 In the absence of quantitative assessment of predator responses to different levels of escapement, the Scientific Committee noted that the joint meeting had proposed a target escapement level of 0.75 which is intermediate between the 0.5 (traditional single species fishing level) and 1.0 (no fishing) 'extremes'. It agreed this target value could be revised in the light of new information both from the models currently being developed and from predator data (paragraph 5.18 and Annex 7, paragraph 4.32).

7.23 Particular note was taken of the possible effects of prey selectivity by predators on age-dependent natural mortality of krill along with the need for further investigation of the effects of predator consumption on the 2+ krill year class (Annex 7, paragraphs 4.34 and 4.35).

7.24 The Scientific Committee noted various other approaches to the modelling of predator/prey fisheries interactions considered by the joint meeting, particularly insofar as these attempt to relate prey flux with predator foraging demands at a local level (Annex 7, paragraphs 4.36 to 4.40), and in one case with environmental variability (position of the ice edge) as well. Further development of

these models was encouraged in the interests of improving the capacity for comparing results from different modelling approaches.

#### ECOSYSTEM ASSESSMENT (Annex 7, paragraphs 5.1 to 5.34)

7.25 Having endorsed the joint meeting's deliberations on this topic, and on the development of prey, predator and fishery indices in particular, the Scientific Committee noted the difficulties identified by the meeting in this regard (Annex 7, paragraphs 5.1 to 5.22). Despite recent advances in the submission of fisheries data (Annex 7, paragraph 5.8), there was still a number of unresolved issues, particularly with regard to analysing fine-scale catch data from the former Soviet fleet (Annex 7, paragraph 5.9).

7.26 Although the Scientific Committee recognised that some expressions of CPUE, such as catch per towing time, may be useful in providing information about local concentrations of krill abundance, it acknowledged that it is not possible to use currently submitted CPUE data as one of the indices for assessment of prey abundance/availability in comparisons with predator indices derived from CEMP (Annex 6, paragraph 5.15). Consequently, the Scientific Committee agreed to encourage further development of fishery-based indices using catch information.

7.27 The Scientific Committee noted that, at least in the near future, the provision of prey abundance and availability indices relevant to the CEMP Program will depend extensively on fishery-independent information (Annex 6, paragraph 5.16).

7.28 The Scientific Committee reiterated that as far as CEMP prey monitoring surveys are concerned, a minimum requirement is for annual surveys of at least part of each ISR.

7.29 The Scientific Committee noted that the above conclusions indicate that evaluating changes in predator populations in relation to changes in prey, taking due account of environmental variability, and how together these may affect predators, prey, or both within the ISRs, may be more difficult than previously envisaged.

7.30 The Scientific Committee agreed that this topic should be reviewed at the earliest opportunity by WG-EMM (see paragraphs 7.40 and 7.41 below). It will be necessary to address questions of whether it is best to proceed in future by (Annex 7, paragraph 5.23):

- (i) attempting to increase the number and frequency of prey surveys in ISRs and to facilitate the acquisition of complementary environmental data;

- (ii) defining and developing more appropriate prey indices;
- (iii) developing a suite of different approaches to management measures involving predator/prey interactions, which do not necessarily require the close linkage of data from predators, prey and environment in the same way as hitherto attempted; or
- (iv) some combination of (i) to (iii) above.

7.31 The Scientific Committee agreed that to improve the development of an ecosystem-based management approach, it is necessary to improve current understanding of both the structure and dynamic functioning, including temporal and spatial variability, of the Antarctic marine ecosystem (Annex 7, paragraph 5.24).

7.32 Members were urged to submit proposals aimed at identifying variables most likely to indicate trends in important ecosystem components, especially for prey, hydrography and weather, on various spatial (e.g., areas/subareas, ISRs, fishing grounds) and temporal scales (e.g., interannual, intraseasonal).

7.33 WG-CEMP's past progress in addressing this issue specifically for predators was noted and the Scientific Committee agreed that it offers a useful basis on which to proceed (Annex 7, paragraph 5.26).

7.34 With respect to integrating predator, prey, environmental and fishery indices into ecosystem assessments and, ultimately, the formulation of management advice, the Scientific Committee acknowledged progress reported by both WG-CEMP and WG-Krill (Annex 7, paragraph 5.27).

7.35 In terms of CEMP Experimental Approaches (Experimental Fishing Regimes) as a means of investigating cause/effect relationships between the potential impact of fisheries and predator performance, the Scientific Committee agreed that these should not proceed without formalising the precise objectives of any experiment and thoroughly evaluating its feasibility. It was noted that Members had been requested to undertake such tasks, but no proposals or evaluations had been forthcoming (Annex 7, paragraphs 5.28 and 5.29).

7.36 The Scientific Committee also noted that continuing to measure and evaluate annual variations in predator, prey and environmental parameters increases the possibility of formulating well defined hypotheses to be tested by future experimental perturbations. Such measurements also serve to establish baselines against which to assess any detected changes in selected parameters. In

the meantime, sharp fluctuations in the natural variability of various parameters (e.g., local krill availability) can be considered as a form of natural experiment which may facilitate the development of suitable hypotheses for future work (Annex 7, paragraph 5.30).

7.37 The Scientific Committee concurred with the joint meeting's conclusion that given the difficulties which have become apparent in developing assessments using some combination of predator, prey and environmental data from those submitted to the CEMP database, and the likelihood that the situation will not improve markedly in the near future, greater priority should be given to considering how assessments of predator population status, trends, reproductive performance, diet and demography can contribute to the formulation of management recommendations for the krill fishery (Annex 7, paragraph 5.31).

7.38 The Scientific Committee noted that papers addressing the general issue of incorporating ecosystem assessments into management advice have been tabled at past CCAMLR meetings and encouraged Members to present these and other suggestions at the next meetings of the appropriate Working Groups.

#### ORGANISATION OF FUTURE WORK (Annex 7, paragraphs 6.1 to 6.12)

##### Re-organisation of the Scientific Committee's Working Groups (Annex 7, paragraphs 6.1 to 6.9)

7.39 The Scientific Committee had requested the joint meeting's advice on re-organisation of the Committee's work (SC-CAMLR-XII, paragraph 15.16).

7.40 The Scientific Committee agreed that in order to integrate better the work currently being undertaken by WG-Krill and WG-CEMP, these two Working Groups should be combined into a single group under one convener. The new Working Group will be called the 'Working Group for Ecosystem Monitoring and Management' (WG-EMM).

7.41 Recalling that Article II of the Convention requires the conservation of harvested populations, the maintenance of ecological relationships between harvested, dependent and related populations, the restoration of depleted populations and the minimisation of the risk of irreversible changes in the Antarctic marine ecosystem, the Scientific Committee agreed that the terms of reference for WG-EMM are to:

- (i) undertake assessments of the status of krill;

- (ii) undertake assessments of the status and trends of dependent and related populations including the identification of information required to evaluate predator/prey/fisheries interactions and their relationships to environmental features;
- (iii) undertake assessments of environmental features and trends which may influence the abundance and distribution of harvested, dependent, related and/or depleted populations;
- (iv) identify, recommend and coordinate research necessary to obtain information on predator/prey/fisheries interactions, particularly those involving harvested, dependent, related and/or depleted populations;
- (v) liaise with WG-FSA on matters related to stock assessment;
- (vi) develop further, coordinate the implementation of, and ensure continuity in the CCAMLR Ecosystem Monitoring Program (CEMP); and
- (vii) taking into account the assessments and research carried out under the terms of reference (i) to (v) above, to develop management advice on the status of the Antarctic marine ecosystem and for the management of krill fisheries in full accordance with Convention Article II;

Pursuing these terms of reference will require, *inter alia*, that WG-EMM:

- (a) develop assessment methods, including survey methods for predators and prey, and standard methods for monitoring dependent and related species together with environmental conditions;
- (b) continue efforts aimed at utilising the best available technology and at developing standard methods for the collection, recording, reporting and analysis of biological, environmental, fishery and other data pertinent to fulfilling the terms of reference;
- (c) develop models for predator and prey populations, their direct interaction with each other, and their potential interactions with fisheries and the environment;
- (d) coordinate relevant research activities; and

- (e) develop and evaluate approaches to managing krill fisheries, taking account of current and future patterns of harvesting.

7.42 The Scientific Committee also identified the following priority activities to be undertaken by WG-EMM (Annex 7, paragraph 6.10):

- further work on the determination of krill flux in Statistical Area 48, especially in relation to predators (Annex 7, paragraph 4.7) and with consideration of temporal as well as spatial variation;
- investigation of options for decision rules (in addition to those implicit in the bullet following) for the calculation of appropriate levels, distribution and timing of krill harvesting (Annex 7, paragraph 4.33);
- further work on the functional relationship between predators and prey, especially involving further determination of the parameters for and formulation of the Butterworth/Thomson model (Annex 7, paragraphs 4.25 to 4.30);
- further evaluation of the significance of localised interactions between krill harvesting and krill-dependent predators and identification of suitable approaches for further research initiatives and management measures; and
- review of the links between prey, predator and environmental data within the scope of the CEMP Program (Annex 7, paragraphs 5.22 to 5.25).

7.43 The Scientific Committee agreed that the important ongoing intersessional tasks and submission of data requirements identified by WG-CEMP (Annex 6) and WG-Krill (Annex 5, Tables 3 and 4), as well as those listed by the joint meeting (Annex 7, paragraph 6.8), should be carried out by WG-EMM. Tasks requiring work by *ad hoc* groups during the 1994/95 intersessional period include:

- (i) evaluation of proposals for new CEMP methods;
- (ii) evaluation of new statistics and methods of analysis of CEMP data;
- (iii) evaluation of any new proposals for CEMP site protection;
- (iv) development of standard methods for measurement of foraging performance of predators;
- (v) continuation of the analysis of krill flux;
- (vi) estimation of krill biomass and evaluation of acoustic methods, and

(vii) continuation of work on yield and functional relationship models.

7.44 The Scientific Committee noted that in order to address effectively the diverse range of tasks, WG-EMM will require wide participation by scientists in a variety of specialist fields (Annex 7, paragraph 6.9).

7.45 To facilitate the efficient and ongoing development of its advice to the Commission on krill harvesting and ecosystem assessment the Scientific Committee recommended that WG-EMM should meet in 1995 for about 10 days.

## MARINE MAMMAL AND BIRD POPULATIONS

### ANTARCTIC PACK ICE SEALS (APIS) PROGRAM

8.1 Dr Bengtson reviewed the past year's progress of SCAR's Antarctic Pack Ice Seals (APIS) Program. A planning meeting was held in May, 1994, during which time a Draft Implementation Plan for the APIS Program (SC-CAMLR-XIII/8) was developed. The SCAR Group of Specialists on Seals conveyed its thanks to CCAMLR for its financial support during 1993, which helped to fund this meeting.

8.2 The plan describes proposed research operations at three scales: circumpolar, regional, and sub-regional. It is planned that the APIS Program field activities will be conducted during five years (1995/96 to 1999/2000), with the 1998/99 season being targeted for coordinated, multi-ship operations on a circumpolar scale. Two of the focal areas for APIS Program field work are also integrated study regions for CEMP activities (Antarctic Peninsula and Prydz Bay).

8.3 The Scientific Committee welcomed the progress being made in developing the APIS Program and reiterated its support for the program, which is expected to provide information useful to the Scientific Committee's work. In particular, the proposed research on crabeater seals, a CEMP species selected for monitoring, will address topics of direct relevance to CCAMLR.

8.4 It was recalled that so far very little progress had been made in developing standard methods for monitoring crabeater seals as part of CEMP. The Scientific Committee recognised that one of the areas in which the APIS Program could benefit CCAMLR is through the specification of standard methods for studying pack-ice seals. Therefore, it was agreed that the Chairman would write to the Convener of the SCAR Group of Specialists on Seals requesting that group's assistance in drafting CEMP standard methods for crabeater seals.

8.5 The Scientific Committee agreed that CCAMLR should continue its support of the development and planning of the APIS Program, and it recommended that an amount of A\$2 500 be provided to SCAR in 1995. These funds would help to sponsor a planning meeting, provisionally scheduled for May or June 1995, that would focus on determining the scope and coordinating the logistic requirements of the program's field activities.

8.6 Dr Bengtson informed the Scientific Committee that because it was unlikely that he would be participating in future meetings of CCAMLR, he would no longer be able to serve as the liaison officer between the Scientific Committee and the APIS Program. The Scientific Committee thanked Dr Bengtson for his efforts to ensure good communication between these two groups, and nominated Dr Boyd as its new liaison officer with the APIS Program. It was recalled that Dr Boyd is well positioned to serve in this role given that he is active both in the APIS Steering Committee and in CEMP.

8.7 The Scientific Committee noted that it would be very helpful in maintaining effective communication with the APIS Program if the liaison officer would submit annual reports to the Scientific Committee concerning relevant developments and progress in the APIS Program. A report in respect of the APIS planning and development meeting was specifically requested.

8.8 Several Members informed the Scientific Committee that they were already undertaking pack-ice seal research leading up to the formal start of the APIS Program. The US noted that it would conduct aerial surveys and other studies of pack-ice seals during February-March 1995; scientists from Norway and the UK will collaborate in the cruise. This research was planned partly in response to the Scientific Committee's encouragement to Members to undertake such surveys as a matter of priority (SC-CAMLR-VII, paragraph 6.7; SC-CAMLR-IX, paragraph 6.4; SC-CAMLR-X, paragraph 7.11).

8.9 Australia reported that it was presently conducting crabeater seal research in the period leading up to the initiation of the APIS Program; one focus of this work would be on methodologies for future surveys. Chile stated that it plans to participate in the APIS Program, both through its national research program and through collaboration with scientists from other countries.

#### STATUS AND TRENDS

8.10 Dr Croxall reported that the IUCN (World Conservation Union) has produced new, draft objective criteria for identifying threatened species and for assigning them to specific categories of



threat (including near-threatened status). Designation of a species in one of these categories can be expected to have world-wide repercussions on conservation activities directed to such a species.

8.11 The first global application of these criteria has been to birds, and a book containing the relevant listings has just been published by BirdLife International<sup>3</sup>. Two bird species of special interest to CCAMLR are listed in the volume: wandering albatross, threatened; and grey-headed albatross, near-threatened. The Scientific Committee's attention was drawn to this development.

8.12 It was also noted that one of the objectives of the forthcoming International Conference on Albatross Biology and Conservation, to be held in Hobart in August 1995, will be to establish a mechanism for a more comprehensive and critical evaluation of the status of all albatross species. The results of this work could be of interest to the Scientific Committee in respect of its evaluation of the status and trends of marine mammal and bird populations.

## ASSESSMENT OF INCIDENTAL MORTALITY

### INCIDENTAL MORTALITY IN LONGLINE FISHERIES

9.1 The Chairman introduced this item by noting that, in response to the growing concerns about this topic and the increasing volume of material being presented for discussion at the Scientific Committee, it was decided last year to convene an *ad hoc* Working Group to review the situation. The terms of reference for this Working Group, set out in SC-CAMLR-XII, paragraph 10.19, were to:

- (i) review and analyse the data submitted in accordance with CCAMLR requirements on incidental mortality associated with longline fishing;
- (ii) review the efficacy of mitigating measures currently in use in the Convention Area, and consider improvements to them, taking into account experience both inside and outside the Convention Area;
- (iii) review data on the level and significance of incidental mortality arising from longline fishing to marine animals found within the Convention Area;
- (iv) prepare a summary of the above for the consideration of the Scientific Committee;

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<sup>3</sup> Collar, N.J., M.J. Crosby and A.J. Stattersfield. 1994. *Birds to Watch 2. The World List of Threatened Birds*. The official source for birds on the IUCN Red List. BirdLife Conservation Series No. 4. BirdLife International, Cambridge.

- (v) provide the Scientific Committee with advice for improvements to:
  - (a) the reporting requirements currently in use in the Convention Area; and
  - (b) the measures in use to avoid incidental mortality in longline fisheries within the Convention Area.

9.2 The meeting of WG-IMALF was held in Hobart, Tasmania, on 21 and 22 October 1994, under the convenership of Dr Moreno. The report of the meeting is attached at Annex 8.

9.3 The Convener noted that the meeting had been very well attended, with 32 participants from 12 Member countries. Forty papers were presented for consideration.

9.4 The Scientific Committee recorded its thanks to the Working Group for undertaking such an onerous task in such a short time. It welcomed the tabling of papers by Members such as Brazil and Uruguay, which were unable to send representatives to the meeting; it also appreciated the presence of representatives of fisheries authorities and organisations at the meeting.

#### Level of Incidental Mortality Arising from Longline Fisheries and its Significance for Marine Animals within the Convention Area

9.5 The Scientific Committee noted the review of reports of incidental mortality of seabirds arising from longline fishing in Subarea 48.3 since the start of the fishery there in 1986/87 (Annex 8, paragraphs 3.2 and 3.3).

9.6 The Scientific Committee recollected that, because of the very incomplete reporting of data on incidental mortality and the lack of information on the effectiveness of mitigation measures (SC-CAMLR-XII, paragraph 10.31), it had recommended last year to the Commission that scientific observers be placed on a high proportion of longline vessels fishing in the Convention Area (SC-CAMLR-XII, paragraph 10.32).

9.7 In response, the Commission had incorporated in Conservation Measure 69/XII, regulating the *D. eleginoides* fishery in Subarea 48.3 in 1993/94, the requirement that a scientific observer (appointed in accordance with the CCAMLR Scheme of International Scientific Observation) be aboard each vessel authorised to fish in the subarea.

9.8 The reports of the scientific observers from three of the four vessels which were authorised to fish in Subarea 48.3 were available for review by WG-IMALF.

9.9 Dr Shust regretted that because fishing by Ukraine/Bulgaria on the *RK-1* had only ceased on 15 September, there had been insufficient time to prepare and transmit the observer's report to CCAMLR. It would be submitted as soon as possible.

9.10 The Scientific Committee welcomed this information and the Secretariat was requested to ensure that the report was available for review by the appropriate working and *ad hoc* groups of the Scientific Committee.

9.11 The Scientific Committee endorsed the conclusions of the WG-IMALF review (Annex 8, paragraph 3.11) of the observer reports, specifically that:

- (i) the use of scientific observers had provided CCAMLR with the first adequate sets of quantitative data on incidental mortality of seabirds in the Convention Area and the first evidence of any kind of interactions involving cetaceans;
- (ii) the observers had produced excellent results, often under very difficult conditions, and had also managed to achieve and maintain good relations with the fishing masters and crew, without which such useful data could not have been collected;
- (iii) catch rates of seabirds were broadly similar to those reported for longline fisheries elsewhere (see Annex 8, Table 2 and paragraph 3.41). The current level of annual mortality of seabirds from longline fishing in Subarea 48.3 is likely to be in the order of a few hundred birds (over half of which, however, will be albatrosses). The levels of mortality, at least in some previous years when fishing effort was greater and few, if any, mitigating measures were used, could easily have been five or more times higher. Even current levels of mortality are likely to be having detrimental effects on some local albatross populations;
- (iv) setting lines only at night would reduce very significantly the catch of albatrosses. It will probably, however, result in larger numbers of white-chinned petrels being killed; further work on measures to prevent incidental mortality of petrels will be required;
- (v) streamer lines were shown to be highly effective in reducing seabird mortality. Some modification of the existing CCAMLR specification, to cater for the different types of longline fishing in the Convention Area, would be appropriate;

- (vi) discharge of offal during setting should continue to be prohibited; discharge during line hauling should be conducted on the opposite side of the vessel to hauling operations; and
- (vii) attention should be given to the problem of cetacean interactions.

9.12 Members commented on certain aspects of the WG-IMALF review of the observers' reports, specifically that:

- (i) because all catch rates of birds were based on observations during the hauling of lines, they will be substantial underestimates. This is due to the number of birds that are hooked and killed but not retained on the hooks; this proportion is about 30% in studies conducted outside the Convention Area; and
- (ii) the use of Mustad autoliners results in a proportion (perhaps 30%) of hooks not being baited. Thus the true number of hooks 'available' to catch birds is substantially lower than the numbers given in Table 2 of Annex 8, resulting in an underestimate of the real rate of catching birds.

9.13 The Scientific Committee noted the review of relevant data for Subarea 48.4 and Division 58.5.1 (Kerguelen). It noted that seabird mortality rates in the latter area (Annex 8, paragraphs 3.14 to 3.16) are broadly similar to those reported from Subarea 48.3.

9.14 It also noted the conclusion of WG-IMALF that, provided that the *D. eleginoides* fishery on the Kerguelen shelf is maintained at its current level and the enforcement of measures to reduce incidental mortality is maintained, there should be very limited impact from this source on local seabird populations.

9.15 The Scientific Committee noted with concern that in Subarea 48.3 there had been a very substantial increase in the numbers and proportions of albatrosses at their breeding colonies showing evidence of having interacted with local longline fisheries. These data could indicate mortality to albatrosses additional to those recorded from observations of hauled birds and from estimates of further mortality during setting.

9.16 The Scientific Committee welcomed the review of incidental mortality of seabirds which breed in the Convention Area, in longline fisheries for tuna outside the Convention Area (Annex 8,

paragraphs 3.22 to 3.30). This review summarised many of the data presented to the Scientific Committee in recent years.

9.17 Dr D. Robertson (New Zealand) drew attention to the existence of recent data from New Zealand which could supplement Table 2 of Annex 8. These data are also from the southern bluefin tuna longline fishery. In 1993 the data were from vessels either using streamer lines or fishing at night. In 1994 the data were from vessels required by regulation to use streamer lines whether or not fishing took place at night. The observed incidental catch rates for 1993 and 1994 (0.18 and 0.14 birds/1 000 hooks respectively) are both considerably higher than the rate recorded in Annex 8, Table 2 for 1992 in the New Zealand region.

9.18 Potential problems arising from existing and developing longline fisheries for *D. eleginoides* in southern Chile, the Patagonian shelf, the Falklands/Malvinas Islands and oceanic banks adjacent to the Convention Area were highlighted in Annex 8, paragraph 3.31.

9.19 The Scientific Committee noted the Working Group conclusions that the problem of incidental mortality of seabirds from the Convention Area clearly occurs in all three oceans bordering the Convention Area (Annex 8, paragraph 3.34).

9.20 The review of evidence of the effects of longline fishing outside the Convention Area on seabird populations in the Convention Area (Annex 8, paragraphs 3.35 to 3.40) was noted. This review also summarises many of the papers presented at recent meetings of the Scientific Committee.

9.21 The Scientific Committee welcomed the overall summary of many of the preceding studies and data in Annex 8, Tables 2 and 3. It agreed to include Table 2 in the report of the Scientific Committee (with some minor changes to aid clarity) and to incorporate the New Zealand data referred to in paragraph 9.17 (Table 8).

9.22 Dr M. de Poorter (ASOC) drew the meeting's attention to document CCAMLR-XIII/BG/14 (also Annex 8, paragraph 3.16) which reports an average of one to two birds killed per longline setting in the Ukraine fishery in the Kerguelen EEZ, and SC-CAMLR-XIII/BG/12 which mentions a total of 875 sets for this fishery in 1993/94. Combined, this gives an estimated total of 875 to 1 750 birds killed in this fishery in the Kerguelen EEZ in 1993/94.

Table 8: Catch rates of seabirds in various longline fisheries from data collected by observers both inside and outside the CCAMLR Convention Area. Rough estimates of total mortality are extrapolated from estimates of total effort. These estimates may involve substantial extrapolation, and hence may be subject to considerable uncertainty.

Region	Fishery	Season	Estimated Number of Hooks Observed	Number of Birds Observed Caught	Observed Incidental Catch Rate of Seabirds (No. per 1 000 hooks)	Estimated Total Effort in Fishery (Millions of hooks)	Annual Implied Total Seabird Mortality	Reference
South Atlantic off Brazil	Tuna	1990	18 597	71	3.82	-	2 650 <sup>1</sup>	WG-IMALF-94/4
South Atlantic off Brazil and Uruguay	Tuna	1994	55 624	280	5.03	-	-	WG-IMALF-94/17
Australia, SW of Tasmania	Tuna (Japanese)	1987	108 662	45	0.41	107.9 <sup>4</sup>	44 000	WG-IMALF-94/6
New Zealand (north)	Tuna (domestic)	1994	11 200	6	0.27	-	-	WG-IMALF-94/10
New Zealand (w/o mitigation)	Tuna (Japanese)	1988-91	1 269 000	304	0.24	10.4	2 500	SC-CAMLR-XII-BG/14
New Zealand (streamer lines + night-setting)	Tuna (Japanese)	1992	1 032 000	16	0.016	9.0	144 <sup>2</sup>	SC-CAMLR-XII-BG/14
New Zealand	Tuna (Japanese)	1993	1 226 000	215	0.18	4.8	839	D. Robertson pers. comm.
New Zealand	Tuna (Japanese)	1994	708 000	98	0.14	0.9	128	D. Robertson pers. comm.
Fisheries in CCAMLR Convention Area								
South Georgia (Subarea 48.3)	<i>D. eleginoides</i>	1991	9 000	6	0.67	5.2290	3 000	WG-IMALF-94/5
(single vessel)	“	1994	239 200	75	0.31	0.2392	75	SC-CAMLR-XIII-BG/9 Rev 1.
“	“	1994	25 860	5	0.19	0.2504	55	WG-IMALF-94/14
“	“	1994	206 720	98	0.47	0.2914 <sup>3</sup>	138	WG-IMALF-94/15 <sup>5</sup>
Kerguelen (Division 58.5.1)	“	1994	174 000	38	0.22	-	-	WG-IMALF-94/12

<sup>1</sup> Estimate calculated as birds per fishing day. Number of fishing days is an estimate only.

<sup>2</sup> Reported to be higher in 1993

<sup>3</sup> C. Moreno, pers. comm.

<sup>4</sup> All hooks south of 30°S

<sup>5</sup> Including data from experimental hauls set during the day

9.23 Prof. Duhamel drew attention to the fact that the estimate provided in CCAMLR-XIII/BG/14 was not based on data of the same type as those analysed by WG-IMALF.

9.24 The Scientific Committee noted the clear indications in Annex 8, Table 3 that, of species breeding in the Convention Area, albatrosses and white-chinned petrels are particularly at risk from longline fishing.

9.25 The Scientific Committee noted in particular the Working Group's conclusions that:

- (i) although considerable uncertainty exists concerning the estimates of implied total seabird mortality, it is known that substantial numbers of seabirds are killed each year;
- (ii) except for the very high catch rates of seabirds in the tuna fisheries off Brazil and Uruguay (where it is unlikely that any mitigating measures are in use), catch rates are broadly similar across fisheries despite the considerable differences in the near-surface longline gear employed in fisheries for tuna and the bottom lines used in the fisheries for *D. eleginoides*;
- (iii) the results from the Japanese tuna fishery in New Zealand waters (and also from similar Australian work) show that a substantial reduction in catch rates of seabirds can be achieved by setting longlines at night and by using bird-scaring streamer lines; and
- (iv) the greater part of seabird incidental mortality relating to birds breeding within the Convention Area arises from fisheries outside the Convention Area. However, catch rates of seabirds in longline fisheries within the Convention Area are comparable with those outside. Therefore, future expansion in any of these fisheries has the potential to lead to substantial incidental mortality unless the use of mitigation measures is continued and improved.

#### Data Reporting on Incidental Mortality Arising from Longline Fishing in the Convention Area

9.26 The Scientific Committee noted the deficiencies in data reporting identified by WG-IMALF (Annex 8, paragraph 4.2) and endorsed the comments that:

- (i) there is a need greatly to improve the collection of data and information on incidental mortality;
- (ii) reliable data will only be obtained from scientific observers;
- (iii) it would be essential to have observers on all longline vessels fishing in the Convention Area; and
- (iv) the range and nature of the tasks of the scientific observer (collecting both bird and fish data) are such that some prioritisation of tasks will be necessary. Even so, some tasks are unlikely to be within the ability of a single observer.

9.27 The Scientific Committee therefore endorsed the WG-IMALF recommendations that:

- (i) whenever logistically possible, two scientific observers should be present on each vessel. In this context, the Scientific Committee noted that one particularly helpful way of giving effect to this might be to share the duties between an international scientific observer and a scientific observer provided by the Member operating the vessel, as had been done successfully in 1992/93 and 1993/94 with the BF *Friosur V* in Subareas 48.4 and 48.3;
- (ii) priority tasks for scientific observers in relation to recording appropriate data on incidental mortality (Annex 8, paragraph 4.4) include:
  - (a) observation of both setting and hauling of lines and recording of appropriate details of fishing equipment, fishing techniques and the type and nature of the deployment of mitigating measures;
  - (b) retention of all specimens of birds caught, or, if impossible, retaining at least the head, leg and samples suitable for subsequent DNA analysis, together with any bands or other identifying markers;
  - (c) training in seabird identification;
  - (d) assisting with education and dissemination of information to fishermen on the problem of incidental mortality and its solutions. It was recognised that to carry out this task the observer would need to be equipped with appropriate documentation.



9.28 Accordingly the Scientific Committee recommended that:

- (i) the pilot edition of the *Scientific Observers Manual* be updated to include the following research priorities, relevant to incidental mortality, which could be addressed by scientific observers:
  - monitoring total incidental bird mortality by species, sex and age;
  - monitoring bird mortality per unit of fishing effort and relative vulnerability of different species;
  - collecting bird bands and reporting other study markings;
  - evaluating the efficacy of mitigation measures; and
  - investigating the practicalities of implementing different mitigation methods;
- (ii) in addition, a new appendix to the *Scientific Observers Manual* be prepared by the Secretariat to provide guidance to observers placed on longline vessels for the purposes of recording information relating to incidental mortality;
- (iii) reporting data on incidental mortality on form C2 be continued; and
- (iv) the Secretariat create data sheets in book format based on information set out in Annex 8, Appendix D for reporting observations conducted on board longline vessels by scientific observers designated under the CCAMLR Scheme of International Scientific Observation.

9.29 The Scientific Committee recognised that producing new data formats will not be possible in time for the 1994/95 fishing season. Development of these data formats would probably require close liaison with (and between) WG-IMALF and WG-FSA, as would evaluating priorities for the collection of data on fish and incidental mortality separately and together. The Scientific Committee therefore recommended that the list of data required be circulated among Members (Annex 8, Appendix D) in order to help standardise the collection of information by scientific observers in 1994/95.

9.30 In helping to provide material for observers to assist fishing vessels reduce incidental mortality, the Scientific Committee commended the collaboration between Australia and Japan which

had resulted in the production in 1994 of a book in Japanese entitled *Catching Fish not Birds: a Guide to Improving Longline Fishing Efficiency*. The Scientific Committee recommended that CCAMLR should consider requesting permission to revise the English language version of this text (WG-IMALF-94/20) to ensure its applicability to longline fishing for *D. eleginoides* in the Convention Area and then arrange its wide circulation in all languages of the Commission, and, if possible, in languages of nations currently undertaking longline fishing in the Convention Area.

#### Measures for Reducing and/or Eliminating Incidental Mortality Associated with Longline Fishing

9.31 The Scientific Committee welcomed the review by WG-IMALF of relevant information from Members working in the Convention Area (Annex 8, paragraphs 5.1 to 5.3), derived from experience of the scientific observers on vessels in Subarea 48.3 and from research in conjunction with the longline fishery around Kerguelen.

9.32 It noted the apparent efficacy of the method currently in use around Kerguelen, and also the comments of WG-IMALF that such a method would not be applicable to the types of longline fishing for *D. eleginoides* currently in use elsewhere in the Convention Area.

9.33 The Scientific Committee also welcomed the review of relevant experiences and observations from similar, but much more extensive, work outside the Convention Area (Annex 8, paragraphs 5.4 to 5.20).

9.34 It noted that the work referred to in Annex 8, paragraphs 9.29 and 9.30 indicated very clearly the need for some small, but potentially very important, modifications to the existing Conservation Measure (29/XII). The Scientific Committee also noted that while these modifications should very substantially reduce the number of albatrosses caught, they may increase mortality of petrels.

9.35 In general, however, the Scientific Committee observed that while improvements to such mitigating measures were desirable, only through more fundamental modifications to longline fishing techniques would lasting solutions to the problem be achieved. Examples of such modifications are the development by Australia and Japan of bait-casting machines and the development by Norway of methods for setting longlines under water.

9.36 In conclusion, the Scientific Committee recommended that scientific observers be placed on all longline vessels fishing in the Convention Area and that this requirement be incorporated into the appropriate conservation measures.

9.37 The Scientific Committee also recommended that Conservation Measure 29/XII be revised to:

- (i) ensure that the setting of longlines takes place only at night (i.e., between the times of nautical twilight);
- (ii) allow slightly greater flexibility in the design and deployment of streamer lines;
- (iii) request that every effort should be made to ensure that birds captured during longlining are released alive and that, wherever possible, hooks are removed without jeopardising the birds' lives; and
- (iv) ensure that the prohibition on dumping trash and/or offal during longline operations is maintained, with the addition of wording indicating that where this was impossible, any discharge should take place as far away as possible from the area of the vessel where longlines are being set or hauled.

9.38 In the revision of Conservation Measure 29/XII, existing provisions for rapid sinking of baited hooks and for the night-time use of the minimum ship's lights necessary for safety, be retained.

9.39 As regards deploying streamer lines effectively and helping to devise improvements to them, the Scientific Committee noted that WG-IMALF-94/19 provides a very clear statement of the principles involved in the construction and use of streamer lines. It recommended that this document be translated into all Commission languages and, if possible, into the languages of other Members currently fishing in the Convention Area, and circulated to Members with a request to make it widely available amongst the longline fishing fleets, including all the vessels operating in the Convention Area. All scientific observers should also be in possession of a copy of the document.

9.40 The Scientific Committee noted that the future development of improved methods to mitigate seabird mortality may require an experimental approach, augmenting and complementing data being collected by scientific observers aboard commercial vessels. Members were encouraged to undertake such work and to report the results to the Scientific Committee for review.

9.41 Lic. Marschoff noted that using longlines in an experimental program (as suggested in Annex 8, paragraphs 5.24 and 6.2) will result in some degree of interference with fishing activities. For example, during 1993/94 this potential problem was solved by the designation of a Special Area for Protection and Scientific Study.

9.42 The Scientific Committee noted that several papers tabled at WG-IMALF had drawn attention to the potentially important problem posed by interactions between longlines and cetaceans and that WG-IMALF had recommended that the Scientific Committee investigate how these interactions could be reduced.

9.43 The Scientific Committee recommended that a useful first step would be for the Secretariat to consult with the IWC, seeking its advice on this topic, information on relevant research into cetacean-fishery interactions and, particularly, details of research investigating techniques whereby such interactions can be reduced or eliminated.

9.44 Dr D. Torres (Chile) noted that FAO also had interests, and potentially relevant information, in this field; the Secretariat was asked to seek similar advice from this organisation.

9.45 The Scientific Committee recognised that however successful it is in reducing and/or eliminating incidental mortality of seabirds in longline fisheries in the Convention Area, there remains the substantial problem of the impact of incidental mortality on seabirds in areas outside the Convention Area (paragraphs 9.18 and 9.19). This is a problem CCAMLR cannot solve in isolation.

9.46 The Scientific Committee commended Japan for the initiatives already taken by its fishing organisations and authorities to reduce this problem; it encouraged Japan and other fishing Members to extend these practices as widely as possible and to continue devising improved solutions to the problem.

9.47 Accordingly, the Scientific Committee endorsed the recommendation of WG-IMALF that CCAMLR should exchange, with appropriate fisheries management authorities and international organisations, information on the state of Antarctic seabird populations affected by longline fisheries, incidental catches in these fisheries, and relevant data on fishing effort as well as CCAMLR experiences with mitigating techniques and with the formulation of conservation measures.

9.48 This exchange of information should involve all the international fishery organisations covering waters adjacent to the Convention Area as listed in Annex 8, Appendix E.

9.49 In this context, CCAMLR's attention was drawn to recent international efforts in formulating guidelines for responsible fishing, aimed at the sustainable use of the world's fisheries resources. In May 1992 a meeting on responsible fisheries was held in Cancun, Mexico, and in the same year the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil, agreed on the need to develop specific guidelines for responsible fishing and entrusted FAO with the development of a Code of Conduct for that purpose. A Technical Consultation on this subject was held in April 1994 and discussions will continue during the FAO Committee on Fisheries in March 1995. The work of CCAMLR on the regulation of fisheries is of high relevance to these international efforts and should be made known to FAO. It should also be noted that the UN Conference on Straddling Stocks and Highly Migratory Fish Stocks will continue, and hopefully be finalised, in 1995. Again, certain regulatory measures enacted by CCAMLR concerning high seas fishery and incidental catches of seabirds may be of considerable interest to that conference as an example of how some aspects of this problem are currently being tackled.

9.50 The Scientific Committee noted that WG-IMALF had identified a number of areas where further work was needed (Annex 8, paragraph 6.1), and proposed various actions in respect of some of these (Annex 8, paragraph 6.2).

9.51 Many of these initiatives have been addressed earlier in this report. However, the Scientific Committee also recommended that:

- (i) Members maintain or increase monitoring of seabird populations at risk from incidental mortality. The main species involved are albatrosses, for which quite extensive programs are in progress or under development, and to a lesser extent white-chinned petrels, for which there are currently no population monitoring programs; and
- (ii) WG-IMALF and WG-FSA should consider, as a matter of priority, the development of mechanisms facilitating the processing of specimens collected by scientific observers.

9.52 The Scientific Committee discussed how best to carry forward the work of WG-IMALF, particularly in the light of the heavy burden on the Secretariat of meetings already planned to be held in Hobart prior to the next meeting of the Scientific Committee.

9.53 It was agreed that a full meeting of WG-IMALF should not take place in 1995. In the intersessional period, the undertaking of initiatives identified above should be handled by an *ad hoc* subgroup instituted by the Scientific Committee and coordinated by Dr Moreno.

9.54 This subgroup will report on progress to the 1995 meeting of WG-FSA, for which the topic of incidental mortality in longline fisheries will receive attention as a special agenda item. Every effort should be made to ensure that scientists experienced in studies of incidental mortality can attend WG-FSA, at least when this subject is being discussed.

#### ADVICE TO THE COMMISSION

9.55 The Commission should note the conclusions of the Scientific Committee following its review of the reports of scientific observers on board longline fishing vessels in Subarea 48.3 under the terms of Conservation Measure 69/XII (paragraphs 9.11 and 9.12).

9.56 The Commission should also note the conclusions of the Scientific Committee on which species breeding in the Convention Area are principally at risk from longline fishing (paragraph 9.24), on catch rates of seabirds in tuna and *D. eleginoides* longline fisheries, on the success achieved by appropriate measures seeking to mitigate this incidental mortality and, finally, the conclusion that the greater part of seabird incidental mortality relating to birds breeding in the Convention Area arises from fisheries outside the Convention Area (paragraph 9.25).

9.57 Japanese scientists, at the time of the adoption of the report, reserved their position on the conclusions described above, since they had not analysed the papers and data submitted to WG-IMALF.

9.58 The Scientific Committee has made a series of recommendations:

- (i) concerning improving the collection of data on incidental mortality (paragraph 9.27);
- (ii) for related changes to the *Scientific Observers Manual* (paragraph 9.28); and
- (iii) for publications assisting scientific observers in explaining the problems of, and solutions to, incidental mortality of seabirds in longline fisheries (paragraph 9.30).

9.59 The Scientific Committee, after reviewing numerous papers tabled on the topic of measures for mitigating incidental mortality in longline fisheries, recommended that:

- (i) scientific observers be placed on all longline vessels fishing in the Convention Area and that this requirement be incorporated into the appropriate conservation measures (paragraph 9.36);

- (ii) Conservation Measure 29/XII be slightly revised, along the lines specified in paragraphs 9.37 and 9.38; and
- (iii) CCAMLR should make widely available to longline fishing vessels and observers a publication explaining how to construct, set and use streamer lines correctly (paragraph 9.39).

9.60 In seeking to reduce interactions between cetaceans and longline fishing in the Convention Area, the Scientific Committee recommended that the Commission consult with the IWC and FAO for advice (paragraphs 9.43 and 9.44).

9.61 In order to help reduce the mortality outside the Convention Area of seabirds breeding within the Convention Area, the Scientific Committee recommended that the Commission exchange information with all international fisheries organisations covering waters adjacent to the Convention Area and also with FAO and the UN (paragraphs 9.47 to 9.48).

9.62 The Scientific Committee agreed that WG-IMALF need not meet in 1995. It established an *ad hoc* subgroup, coordinated by Dr Moreno, to ensure progress is made with the agreed intersessional tasks and to report to the 1995 meeting of WG-FSA (paragraphs 9.53 and 9.54).

9.63 Dr de Poorter expressed the view that it would be helpful to the Commission's deliberations if, in addition to the total number of birds accidentally killed in the past season, the Commission was informed of the effects of bird mortality that would be achieved by the different actions it might consider taking. This could include an estimate of the decrease of total mortality and the potential increase in petrel mortality resulting from adopting the mitigative measures identified by WG-IMALF, as well as the effects on bird mortality in the event of closure of the fishery.

9.64 Dr de Poorter further stated that it would be useful to specify a time frame for an in-depth review of the effectiveness of additional mitigative action.

9.65 Dr Holt noted that WG-IMALF had reviewed information concerning the incidence of bird, especially albatross, mortality in the *D. eleginoides* longline fishery. He suggested that the Commission might wish to consider these impacts when determining an appropriate catch level for this fishery. In fact, consideration of these impacts may include setting a catch level at the lowest or lower end of the range of levels being considered.

9.66 Dr Moreno stated that it was inappropriate to relate the problems of incidental mortality to the process of determining TAC levels. This statement is based on the fact that most incidental mortality of seabirds occurs outside the Convention Area, and the existence of mitigating measures which are currently being used to decrease the rate of mortality within the Convention Area. He was convinced that the most important issue is to educate fishermen in order to achieve longterm success in applying mitigating measures in all fisheries.

9.67 Dr de la Mare agreed that it was inappropriate to make a direct connection between TACs and the level of bird mortality. However, he considered that there was a need to provide information to the Commission on the likely consequences, for example in terms of estimates of bird mortality, of management measures directed towards the fishery. This would be particularly appropriate where a range of alternative measures was proposed so that the Commission might take bird mortality into account when considering the alternatives. The measures considered may be not only TACs, but other regulations possibly involving fishing areas and seasons.

9.68 Dr Robertson noted that in addressing the issues of incidental mortality of seabirds, the Scientific Committee has so far been careful to propose mitigating measures which will not have an impact on the TACs of target species.

9.69 Lic. Marschoff indicated that gathering information on incidental mortality would become useless if it did not result in adequate conservation measures being adopted; these measures might well include the setting of TACs based on by-catch considerations, as has been done in the past by the Commission.

9.70 Mr Miller emphasised that in addressing incidental mortality, CCAMLR was, to a large extent, inheriting a problem whereby far greater mortality was occurring outside than inside the Convention Area. Consequently, CCAMLR has a strong duty to inform other organisations and nations fishing outside the Convention Area of the magnitude of the problem of incidental mortality of seabirds across the Convention's boundaries. Therefore, the Commission should be proactive in promoting awareness not only of its activities in respect of the above, but also in enhancing efforts aimed at addressing incidental mortality of species found in the Convention Area on a global basis.

#### INCIDENTAL MORTALITY IN TRAWL FISHERIES

9.71 The Commission adopted Conservation Measure 30/X in 1991 which prohibited the use of net monitor cables in the Convention Area from the beginning of the 1994/95 fishing season.



9.72 Mr Z. Cielniaszek (Poland) informed the Scientific Committee that Poland intended to operate one vessel in the 1994/95 season and asked the Scientific Committee to support its request to the Commission to defer the introduction of the conservation measure for one season. Poland maintained that the ship it planned to use was old, and since this would be its last season of operation it would be uneconomic to replace the net monitor with one which does not use a cable. Poland would continue, however, to deploy the cables in accordance with the procedure set out in Annex 6 of CCAMLR-X. This has resulted in no cases of bird or mammal mortality being observed, a situation reflected in the report of Poland (CCAMLR-XIII/BG/7).

9.73 The Scientific Committee noted, however, that no other reports had been presented on incidental mortality caused by net monitor cables in trawl fisheries within the Convention Area.

9.74 The Scientific Committee recalled that such mortality in New Zealand trawl fisheries went unreported until scientific observers had been placed on board fishing vessels (SC-CAMLR-X/BG/4).

9.75 In the absence of relevant data from the Convention Area, the Scientific Committee could not assess the probability of incidental mortality of seabirds occurring. It was therefore unable to comment on the proposal from a scientific point of view, although it noted that the net monitor cable arrangement used by Poland was unlikely to cause substantial mortality of albatrosses. The Scientific Committee was, however, concerned at the prospect of creating exemptions from conservation measures and recommended that if an exemption were to be granted then this should be conditional on a scientific observer being placed on board.

9.76 The Scientific Committee noted that Ukraine proposed to undertake trawling on the Ob and Lena Banks using vessels equipped with net monitor cables (see paragraphs 2.74 to 2.76).

9.77 Japan reported in CCAMLR-XIII/BG/23 that two penguins, two unidentified seabirds and two Antarctic fur seals were caught and brought on board krill fishing vessels. Most of them, except for two unidentified birds, were caught alive and released immediately. Coordinates and dates provided show the birds were taken in the region of the South Shetland Islands in March to May and the fur seals were taken in June near South Georgia. This is the first report of incidental catches of marine mammals and birds in active trawl fishing gear in the Convention Area.

#### MARINE DEBRIS

9.78 Members' reports on the assessment and avoidance of incidental mortality and impacts of marine debris on biota in the Convention Area have been received from Australia, Brazil, Japan,

Russia, Poland, South Africa, UK and USA (CCAMLR-XIII/BG/6, 24, 23, 28, 7, 5, 20 and 15). Reports dealing with mortality and loss of longline equipment are discussed in paragraphs 9.5 to 9.25.

9.79 Dr Croxall presented SC-CAMLR-XIII/BG/3 which reports that surveys of Antarctic fur seals entangled in man-made marine debris were carried out for the fourth consecutive winter and sixth consecutive summer at Bird Island, South Georgia. In the 1993 winter the number of entangled seals was only 39% of the record 1992 total, but still five times the numbers in 1990 and 1991. Nearly all animals were juveniles, half had severe injuries and the proportion of females (40%) was the highest yet reported. The proportion of animals entangled in packaging bands was the lowest ever (24%) and less than one-half that in 1992. Fishing net fragments and especially string and bags were common entangling materials. In the 1993/94 summer the number of seals entangled (23) was the lowest ever and a 70% reduction on the previous year, thereby reversing the upward trend since 1990. For the first time more animals were entangled in net fragments (35%) than in packaging bands (30%), the decrease in the latter mirroring the records of the preceding winter. However, 68% of animals affected were female (previous highest 40%); combined with the highest proportion of adults and of severe injury yet reported, grounds still remain for concern.

9.80 Dr Croxall introduced SC-CAMLR-XIII/BG/4 which reported the first observations of oiled albatrosses at South Georgia. He noted that as with the oiled penguins reported in 1993, also from South Georgia (SC-CAMLR-XII, paragraph 10.29), evidence suggests that at least one of the birds became contaminated locally.

9.81 Paper SC-CAMLR-XIII/BG/4 also recorded the ingestion of plastics by albatrosses and giant petrels and reported a six-fold increase over the previous year of the incidence of fishing line and hooks associated with, regurgitated by and impaled in seabirds (see Annex 8, paragraphs 3.18 to 3.21). Paper CCAMLR-XIII/BG/5 reported the occurrence of a tuna longline hook close by a wandering albatross nest at Marion Island.

9.82 The Scientific Committee noted with concern the apparent increase in the number and variety of environmental threats to birds and seals.

## MANAGEMENT UNDER UNCERTAINTY ABOUT STOCK SIZE AND SUSTAINABLE YIELD

10.1 The Scientific Committee recalled the Commission's request for work to continue on the development and implementation of methods for estimating TACs under conditions of uncertainty about stock sizes and sustainable yields (see CCAMLR-XII, paragraph 4.26). The Scientific

Committee agreed that both WG-Krill and WG-FSA have made significant, practical advances in this regard; uncertainty has been incorporated into a number of stock assessments.

10.2 With respect to krill, the Scientific Committee reiterated its conclusion made in 1993 (see SC-CAMLR-XII, paragraph 3.97) and noted that the principles of management under uncertainty continue to be incorporated in the assessment and management of this stock.

10.3 With respect to fish, the Scientific Committee noted that WG-FSA has made significant progress in dealing with uncertainty in the assessments of various fish stocks. In particular, the Scientific Committee recognised that uncertainty had been considered during the assessments of *C. gunnari* (Subarea 48.3), *E. carlsbergi* (Subarea 48.3), *C. gunnari* (Division 58.5.2), and *D. eleginoides* (Division 58.5.2) (Annex 4, paragraphs 4.65 to 4.70, 4.78 to 4.83, 4.150 to 4.159, 4.161 to 4.164).

10.4 The Scientific Committee agreed that more work needs to be done on accounting for uncertainty in the assessment and management of fish stocks. There is scope for incorporating additional methods for dealing with uncertainty into the current assessment models. For instance, an estimate of the variability in pre-exploitation biomass could be taken into account for *C. gunnari* in Division 58.5.2 (Annex 4, paragraph 4.158).

10.5 The Scientific Committee noted that a longterm management strategy for *C. gunnari* in Subarea 48.3 (Annex 4, paragraphs 4.78 and 4.79; paragraph 2.34 of this report) will have to deal with uncertainty in many population dynamics parameters. In particular, it should take account of the potential for occasional, large increases in natural mortality of this stock (Annex 4, paragraphs 4.71 to 4.77).

10.6 The approach adopted by CCAMLR is a sensible strategy for coping with unpredicted changes in the ecosystem. It was noted that the observation system implemented in Subarea 48.3 (Annex 4, paragraph 3.7) could be a useful mechanism for collecting data on large-scale changes in the Antarctic marine ecosystem.

10.7 The Scientific Committee reiterated its view that ‘under conditions of increasingly poor data availability, management measures would most appropriately start to follow options from a choice of precautionary low catch levels’ (SC-CAMLR-XII, paragraph 3.98). In this context, it was noted that the techniques and models currently used to incorporate uncertainty in the stock assessments operate in such a way that estimated yields and catch limits usually decrease as uncertainty in model parameters increases (Annex 4, paragraph 4.164).

10.8 The Scientific Committee agreed that the topic of management under uncertainty should remain as a separate agenda item for its 1995 meeting.

## SCIENTIFIC RESEARCH EXEMPTION

11.1 The Scientific Committee had been asked by the Commission to review the appropriateness of the 50 tonne catch limit for scientific research exemption, specified in Conservation Measure 64/XII, for krill, crab and squid (CCAMLR-XII, paragraph 6.10).

11.2 The Scientific Committee endorsed the following comments of WG-Krill and WG-FSA on this topic:

- For krill, Members using commercial types of trawl should submit information on the levels of catches which could be taken in research cruises (Annex 5, paragraph 5.26). This information should be reviewed at the next meeting of WG-EMM.
- For crab, the 50 tonne catch limit appears sensible given the relatively tight provisions of Conservation Measures 74/XII and 75/XII (Annex 4, paragraph 6.8).

11.3 Given the limited information on the abundance of squid in the Convention Area, the Scientific Committee had no advice to offer in respect of squid.

11.4 Some members of WG-FSA suggested that the six-month lead in time required for notification of intended survey activity (CCAMLR-V, paragraph 60) was restrictive (Annex 4, paragraph 6.7). The Scientific Committee encouraged the review of this requirement at the next meeting of WG-FSA.

## NEW AND EXPLORATORY FISHERIES

12.1 CCAMLR has not received any notification of intention to conduct new or exploratory fisheries in the 1994/95 season. However, the USA notified its intention to fish for crabs in Subarea 48.3 in accordance with Conservation Measure 74/XII, which classifies this fishery as exploratory.

12.2 Dr Holt informed the Scientific Committee that although CCAMLR had been notified of this intention, the US did not pursue this exploratory fishery in the 1993/94 season. A company holds a

US permit and has notified its intention to fish in the present fishing season (1994/95), but it is still uncertain whether it will fish or not.

## CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION

### OBSERVATIONS IN THE 1993/94 SEASON

13.1 In the 1993/94 season three Members, in fulfilment of the conditions of Conservation Measure 69/XII, placed international observers on vessels operating in the *D. eleginoides* fishery in Subarea 48.3: UK (on vessels from Korea and Chile), USA (on a Russian vessel) and Russia (on a Bulgarian vessel).

13.2 In introducing the report of the US observer on the FV *Maksheevo* (7 February to 18 April 1994; SC-CAMLR-XIII/BG/9 Rev. 1), Dr Holt expressed the gratitude of the US to the Russian captain for the professional way in which the observer was treated, and acknowledged the assistance of UK colleagues with logistic organisation. He noted that although some results were reported in SC-CAMLR-XIII/BG/9 Rev. 1, analysis of observer samples (in particular otolith readings) was continuing. The report was considered by both WG-FSA and WG-IMALF.

13.3 The report of the UK observers on FV *Ihn Sung 66* (15 December 1993 to 7 February 1994; SC-CAMLR-XIII/BG/14) was introduced by Dr G. Parkes (UK). Three observers had participated, two being present on the vessel at any one time, and although the observers did not speak Korean, they were able to communicate in Spanish with the captain. On behalf of the UK he thanked Korean colleagues for their cooperation, but noted that the observer had found that the captain was not fully informed of his obligations under Conservation Measure 69/XII, especially with regard to the experimental protocol, and that the observers had found working conditions difficult. The principal results of the observations had been presented to WG-FSA and WG-IMALF (WG-FSA-94/22, WG-IMALF-94/15 and 16). Otolith and scale samples taken for age determination had not yet been processed.

13.4 Dr D.-Y. Moon (Republic of Korea) acknowledged that difficulties had been experienced in communicating with the vessel and its company, but that this situation would be improved in future arrangements.

13.5 Reports from the UK observers on the BF *Friosur V* (Chile) had been presented to WG-FSA (WG-FSA-94/31) and WG-IMALF (WG-IMALF-94/15 and 16). A Chilean observer was also present on this cruise and this had markedly increased the quality of the observations.

13.6 Dr Moreno noted that the presence of two observers on a ship was generally desirable to complete the heavy workload requested of observers, and suggested that the Chilean/UK experience of a local observer on board the *Friosur V* in addition to international observers could be used in other situations to reduce the workload on observers, enable increased coverage of observed events and increase cooperation between crew and observers.

13.7 Dr Robertson noted that the conversion factor of 0.69 for the headed and gutted fish on the Korean vessel was different to the factor of 0.5 noted in paragraph 4.7 of the WG-FSA report (Annex 4) for the Chilean vessel, and highlighted the need to obtain reliable conversion factors for CCAMLR fisheries. The Scientific Committee Chairman advised that the factor 0.5 was for fillet weight to green weight, hence the difference. Members were urged to submit information on conversion factors to the Secretariat.

13.8 It was reported that observers had found the *Scientific Observers Manual* very useful, but as was the case last year, they had used the forms in the manual as a guide only and had actually used their own forms (SC-CAMLR-XII, Annex 4, paragraph 4.3).

13.9 The Scientific Committee agreed that at the time of entering into a bilateral arrangement, some consideration should be given to establishing provisions for analysing data and samples collected by observers. It was recalled that the most important consideration was that data and samples from observer programs should be analysed in a timely fashion, so that results could be presented to the relevant Working Groups as early as possible. In cases where neither the host nor the observing Member could process the results in sufficient time, other Members might be able to find the resources to do the work.

#### ADVICE TO THE COMMISSION

13.10 The Scientific Committee recalled its decisions regarding the technical aspects of recording data on incidental mortality (Annex 8, paragraph 4.4). It recommended that, whenever logistically possible, two scientific observers should be present on each vessel for the purpose of recording such data (paragraph 9.27).

13.11 The Scientific Committee recommended that the Commission ensure that Members entering into an Observer Arrangement take steps to make certain that the crews of their fishing vessels are well aware of the responsibilities of hosting an observer, and the requirements of those observers in the execution of their duties, and also to ensure that the conditions available on the vessels are satisfactory.

13.12 To ensure that data collected by observers are analysed and reported to relevant Working Groups in a timely fashion, the Scientific Committee recommended that:

- agreement on the fate of data and samples, and the arrangements for their analysis, should be considered by the parties to the arrangement at the initiation of observer arrangements; and
- where neither host nor observing Member is able to process samples in a timely fashion, consideration should be given to sending them elsewhere for processing.

13.13 The Scientific Committee asked the Working Groups to consider what would be the best cooperative arrangements to ensure that samples are analysed in a timely fashion when they cannot be worked up by either party to an observer arrangement. A list of institutions able to perform such work would be helpful in this regard.

13.14 To facilitate access to observer data, it was recommended that all data acquired as part of an observer program should be lodged with the Secretariat. In this regard, the Scientific Committee endorsed the suggestion in Annex 4, paragraph 3.11 and recommended that:

- all data from observer programs which could be entered into existing CCAMLR databases (in particular, the longline, research, length composition, age composition, age-based biological databases) should be submitted to CCAMLR;
- a copy of all other data from observer programs should also be lodged with the Secretariat where it would be held as hard copy only; and
- these data would be subject to the CCAMLR rules on data access (Annex 10).

13.15 Regarding the *Scientific Observers Manual*, the Scientific Committee recalled its discussions in paragraph 9.28 under items regarding observer information and agreed that:

- the priority list for observations of incidental mortality (Annex 8, paragraph 4.5) should be added to the list of research priorities given on pages 5 and 6 of the *Scientific Observers Manual*;
- consideration of revisions to the section on data collection and sampling requirements for observers (page 7), which should contain some indication of the relative priorities for data collection, should be deferred to the next meeting of the Scientific Committee. In the interim, the Working Groups were requested to consider relevant priorities for data collection and proposals for changes to this section of the *Scientific Observers Manual*; and
- pending these and other technical additions a new version of the *Scientific Observers Manual* should be considered for 1996.

## COOPERATION WITH OTHER ORGANISATIONS

14.1 The Scientific Committee recalled that it had requested that a flow chart be prepared describing CCAMLR's relations with other organisations. This chart is in the final stages of preparation and will be distributed to Members in the intersessional period.

### FUTURE COOPERATIVE RESEARCH

14.2 During the present meeting representatives of five countries (Brazil, Germany, Japan, Republic of Korea, USA) reviewed their marine research activities in the Antarctic Peninsula area during the 1994/95 season (Annex 7, Table 1a).

14.3 Data collection procedures were discussed in order to ensure standardised methods for hydroacoustic surveys, krill and zooplankton net sampling, phytoplankton standing stock estimates and oceanographic measurements. Data formats were agreed in order to facilitate processing and analysis of biological data that will be collected during the surveys. Guidelines on sampling procedures and data storage will be prepared by Dr V. Siegel (EEC) and distributed to participants. Potential queries were drawn up for the workshop and a preliminary list will be attached to the guidelines.



14.4 Scientists involved in the planned research activities were invited by Germany to attend a Data Analysis Workshop in Hamburg from 17 to 20 July 1995 immediately prior to the meeting of WG-EMM in Italy.

SCAR

14.5 The report of the CCAMLR Observers to SCAR (Drs Croxall and Everson) was presented in CCAMLR-XIII/BG/18.

14.6 Following discussions held at the meeting of the Group of Specialists on Environmental Affairs and Conservation (GOSEAC) (Santiago, Chile, May 1994), the Scientific Committee noted the following items of interest to CCAMLR:

- GOSEAC presented a working paper on environmental monitoring to XVIII ATCM in Kyoto. The Secretariat was requested to obtain a copy of this paper from GOSEAC for consideration by WG-EMM; and
- GOSEAC noted the intention of IUCN to hold a workshop on human impact in the Antarctic, and that IUCN has established an Antarctic Advisory Committee with the stated priorities of addressing questions of protected areas, the liability regime and CCAMLR. The Scientific Committee requested that the Secretariat establish links with this Committee through its chairman, Prof. B. Davis (Hobart).

14.7 CCAMLR was represented at the Sixth SCAR Biology Symposium (30 May to 3 June 1994, Venice, Italy) by the Science Officer. His report (SC-CAMLR-XIII/BG/7) noted that there was considerable interest in CCAMLR at the symposium, but that the level of knowledge about CCAMLR was still relatively low within the SCAR scientific community. The Scientific Committee commended the Science Officer for the quality of the poster prepared by the Secretariat for this meeting. The proceedings of the symposium are currently being edited and will be published by Cambridge University Press. The next Biology Symposium will be held in New Zealand in 1998.

14.8 Paper CCAMLR-XIII/BG/18 reported on the meeting of the Group of Specialists on Southern Ocean Ecology (GOSSOE), Padua, Italy, May 1994. A major activity being undertaken by this group is the development of the Coastal Zone part of the SCAR Program on the Ecology of the Antarctic Sea-Ice Zone (CS-EASIZ), and a workshop during the meeting established final plans for the program. CS-EASIZ is established for a period of 10 years (1994 to 2004), and it has been suggested that a first methodology workshop be held in 1995 and a mid-term review symposium in

1998/99. A steering committee was set up to coordinate the work of CS-EAZIS. The Scientific Committee agreed that it should maintain close liaison with the CS-EASIZ program and nominated Dr M. Fukuchi (Japan), who also serves on the steering committee to provide liaison with CCAMLR.

14.9 The programs coordinated by GOSSOE are the main marine ecological inputs to the SCAR-IGBP Program, and the SCAR group of specialists responsible for Antarctic input to IGBP is GLOCHANT. It was noted that the Secretariat for GLOCHANT is being established in Hobart, which should act to facilitate further liaison between CCAMLR and SCAR.

14.10 The Bird Biology Sub-Committee met in Padua, Italy, in May 1994, and formally recommended that SCAR develop a register of all Members' activities relating to the use of implantable electronic tags for the identification of individual birds. The Scientific Committee recalled its previous discussions of this item (SC-CAMLR-XII, paragraph 8.9) and encouraged Members to contribute to this register once SCAR circulates appropriate details.

14.11 The SCAR Working Group on Biology met in Rome, Italy, in August and September 1994. The group was particularly interested in the initiatives being pursued by CCAMLR to coordinate scientific research (paragraphs 14.2 to 14.4). The Scientific Committee recommended that the Commission agree to a forthcoming request from SCAR that information on planned research cruises, being compiled annually by CCAMLR, be placed on an electronic bulletin board being developed by SCAR.

14.12 The SCAR *Ad Hoc* Group on Evolutionary Genetics of Antarctic Marine Organisms is proposing to meet in Brazil in 1995. Amongst the topics which will be considered is stock separation, which is of interest to CCAMLR. Dr Fanta was nominated to liaise between CCAMLR and this group.

14.13 The Data Manager acted as CCAMLR Observer to the SCAR/COMNAP *Ad Hoc* Working Group on Antarctic Data Management (29 August to 2 September 1994, Rome, Italy) (SC-CAMLR-XII/BG/10). The Scientific Committee encouraged the development of this liaison between the *ad hoc* group and the Secretariat, and nominated the Data Manager as CCAMLR Observer to the next meeting of this group.

14.14 SCAR has approved the development of an Antarctic Master Directory (AMD) and has called for expressions of interest to host it. A decision on the host is expected in March 1995, and the AMD is expected to be operational after that. The Scientific Committee agreed that it would be appropriate to lodge a directory entry with the AMD, describing some of CCAMLR's data holdings and data access rules.

14.15 The Scientific Committee reaffirmed its belief that close liaison between SCAR and CCAMLR was of great benefit to both organisations. Its nomination of observers and liaison officers to SCAR and various of its committees underlined this commitment.

IWC

14.16 The report of the observer to the 1994 meeting of the Scientific Committee of the IWC (SC-IWC) (May, Puerto Vallarta, Mexico), Dr de la Mare, was distributed as SC-CAMLR-XIII/BG/6. The main topic for the meeting was the refinement of the Revised Management Scheme for Baleen Whales and the assessment of whale stocks subject to aboriginal subsistence whaling.

14.17 The Observer from IWC (Dr Reilly) noted that the SC-IWC was now at a turning point in its history. A common theme running through much of its new or planned initiatives involves the study and monitoring of cetacean populations in relation to their environment. A number of initiatives are of specific interest to CCAMLR (paragraphs 14.19 to 14.25).

14.18 An intersessional meeting of a steering group on research related to the conservation of large baleen whales in the Antarctic was held in Japan, with the following objectives:

- to refine the estimates of abundance in feeding areas;
- to determine the distribution of breeding areas; and
- to evaluate the potential for competition for krill between blue whales, other baleen whales and other high level predators.

14.19 The IWC Observer informed the Scientific Committee that the steering group had noted the need to include a krill specialist in the group, which is likely to meet in January 1995. The Scientific Committee agreed that the Committee work coordination group, planning to meet during the 1994 meeting of the Commission, should consider the appropriate mechanism for inclusion of a krill expert nominated by the Scientific Committee into this steering group.

14.20 In 1992 the IWC decided that its Scientific Committee should keep under review the impact of environmental change on whale stocks. CCAMLR has already responded to a call for exchange of information on this topic (SC-CAMLR-XII, paragraph 12.7). The IWC will pursue this initiative with a workshop in 1995 on the effects of climate change and ozone depletion on whales, as mediated through changes in habitat structure and prey availability. At the invitation of the observer from the

IWC, it was agreed that Dr V. Marín (Chile) would represent CCAMLR at this workshop and would join its steering committee.

14.21 The observer from the SC-IWC reported that whilst the IWC was indirectly interested in the question of baleen whale feeding (previously the subject of correspondence between the IWC and CCAMLR), currently the terms of interest of the SC-IWC were being re-drawn and it would be established next year whether there was any further interest in this subject.

14.22 Dr Reilly noted that the IWC was interested in possible mechanisms for closer exchange of information between the SC-IWC and CCAMLR. A closer exchange had been established with the participation of Dr de la Mare and the Chairman of the Scientific Committee in SC-IWC meetings, the Chairman of the SC-IWC in this meeting, and the nomination of two scientists involved with CCAMLR to participate in forthcoming IWC workshops.

14.23 The Scientific Committee agreed that a suitable further activity would be the exchange of data between the two organisations. It therefore requested the Data Manager to contact the IWC to establish what IWC data were available which might be of use to the Scientific Committee. Dr de la Mare noted that at least two data sets held by the IWC would be of interest to CCAMLR: catch records for southern hemisphere whales and sightings data. It was emphasised that acquisition of data at the highest possible resolution would be most useful.

14.24 Dr Reilly suggested that it might be worthwhile to consider the possibility of adding a well-designed whales sightings survey component to the studies in the CCAMLR ISRs. The Scientific Committee agreed that this suggestion should be investigated further at the next meeting of WG-EMM.

14.25 The Scientific Committee noted that the IWC's comprehensive assessment of southern hemisphere baleen whales was continuing but had been temporarily disrupted by the recent reporting of historical catch data by Russian scientists. The current best estimate for the abundance of 'true' (i.e., not pygmy) blue whales in the Antarctic from sightings surveys is 460 (95% confidence interval 210-1000).

FAO

14.26 There were two interactions between the Secretariat and FAO in the 1994 intersessional period. Firstly, the Science Officer represented CCAMLR at the FAO *Ad Hoc* Consultation on the Role of Regional Fisheries Agencies in Relation to High Seas Statistics (La Jolla, USA, 13 to 16 December 1993). CCAMLR's participation in this consultation was appreciated by FAO as it is the

only Regional Fishery Organisation with responsibilities in all three major oceans. The consultation established requirements for data collection and data reporting for fisheries in high seas areas as advice to the UN Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks.

14.27 Secondly, the Data Manager visited the FAO Fisheries Information Data and Statistics Service in Rome, Italy in September 1994. Cooperation between FIDI and CCAMLR continues to be of great benefit to both organisations. This visit resulted in the acquisition of STATLANT reports from Latvia (see paragraph 5.3). Prof. Beddington suggested that in addition to requesting Latvia to provide more information about these catches, the Data Manager should write to Lithuanian authorities concerning activity in the Convention Area, since Lithuania has also been active in the southwest Atlantic recently.

#### CWP

14.28 Paper SC-CAMLR-XIII/BG/10 reported that the Secretariat was represented at an *ad hoc* meeting of the CWP in Madrid this year. The Scientific Committee recommended that the Secretariat representation at CWP meetings should continue.

#### IOC

14.29 The observer from IOC (Dr P. Quilty, Australia) reported that the IOC maintained an interest in the work of CCAMLR, and that he would be making a full report to IOC of the proceedings of the Scientific Committee.

#### ICAIR

14.30 In May 1994 the Secretariat received a letter from the Director of ICAIR (International Centre for Antarctic Information and Research, Christchurch, New Zealand) with a suggestion that CCAMLR lodge copies of some of its published material on ICAIR's newly developed World Wide Web (WWW) server 'Gateway to Antarctica' (SC-CAMLR-XII-BG/10). The Scientific Committee agreed that it would be appropriate to publicise the work of CCAMLR in this way. Accordingly, the Data Manager was requested to lodge CCAMLR newsletters and other promotional material (e.g., the text of the Convention and certain of the Basic Documents) with the 'Gateway to Antarctica'.

## WWW

14.31 The Data Manager raised the possibility that CCAMLR should consider setting up its own WWW server. Such a system would allow the Secretariat to maintain its own server, lodging whatever documents and data it saw fit, and maintaining direct control over them. This would be technically feasible but costly with the Secretariat's present internet system. The Scientific Committee requested that the Secretariat conduct a feasibility study on establishing a CCAMLR WWW server.

## NOMINATION OF OBSERVERS

14.32 The following observers were nominated to represent CCAMLR at intersessional meetings:

- SC-IWC - Dr de la Mare;
- ICES - Ms I. Lutchman (UK);
- NAFO/ICES workshop on marine mammals-fisheries interactions - Dr T. Øritsland (Norway);
- FAO Secretariat;
- APIS - Dr Boyd;
- EASIZ - Dr Fukuchi
- SCAR/COMNAP - Data Manager
- ICES Acoustic Workshop (Aberdeen, Scotland) - Dr Everson; and
- CWP - Secretariat.

## PUBLICATION

15.1 The first issue of *CCAMLR Science* was distributed at the Scientific Committee meeting. The Scientific Committee congratulated the Editor (Dr E. Sabourenkov) and his Secretariat team on producing a first volume of high technical and scientific quality.

15.2 The Scientific Committee was informed that the Editorial Board had met on 24 October 1994 and considered the report of the Editor on the publication of *CCAMLR Science* (SC-CAMLR-XIII/BG/10). Copies of the journal were provided to the Editorial Board for evaluation. The report addressed the experience gained by the Secretariat in publishing the first issue.

15.3 The Scientific Committee agreed that to avoid overtaxing the Secretariat's resources, the overall limit on any one issue of the journal should be set at approximately 200 pages. This size corresponds with volumes of other similar publications and would be sufficient to allow the annual publication of a diversity of articles on science related to CCAMLR. Should the papers selected exceed this limit, some will be deferred to a later issue. If a sufficient backlog of papers were to build up, publication of a second volume in one year might be necessary. However, the Scientific Committee recognised that this would involve an increased cost since contract personnel would have to be obtained to augment the Secretariat, and agreed that this be brought to the attention of the Commission.

15.4 The Scientific Committee agreed that if any deadline for authors is passed by more than 10 days, the decision on whether publication of the paper concerned should be postponed until the next edition would reside with the Editor. It was also proposed that the Secretariat should provide each author and reviewer with a return postcard containing standard replies for advising the Secretariat in a timely fashion of any delays or other problems with deadlines imposed.

15.5 The Scientific Committee endorsed several changes that the Editorial Board had made to the journal editorial policy. It was decided that, as a general rule, articles describing preliminary results or results of one year's survey would not be encouraged for submission. Papers on fishing gear construction and other subjects of fishing technology would be considered for publication only if they directly relate to fisheries in Antarctic waters. A new section 'Short Notes' was introduced for publishing short scientific articles of particular importance to CCAMLR.

15.6 The Secretariat was asked to maintain an up-to-date list of reviewers. Members were asked to submit more names to the list of reviewers, and to facilitate this the Secretariat was requested to circulate the current list.

15.7 The Secretariat should maintain the practice of reviewing selected papers from the point of view of language (in addition to other technical aspects) and should draw the attention of authors to any deficiencies when requesting the final manuscript. In all instances the authors should have the ultimate responsibility for the quality of the English expression within their papers.

15.8 More stringent requirements will be set concerning the quality of figures presented. Authors must provide 'camera-ready' originals of a standard acceptable to the Editor in order for their work to be considered for publication.

15.9 In response to the Commission direction to investigate the feasibility of obtaining an independent review of the quality of the *CCAMLR Science* publication, the Secretariat wrote to the

editors of a number of international journals and asked whether they would be able to carry out such a review. Editors of *Marine Biology*, *Biological Conservation*, *Antarctic Science* and *Marine Mammal Science* have indicated that they will be happy to comment on the first issue of *CCAMLR Science*, or to provide names of people with special knowledge of marine resources who could review it if this was desirable.

15.10 The Scientific Committee agreed that these journals should be requested to provide reviews of both the layout and scientific content of *CCAMLR Science*.

15.11 A flier leaflet explaining the objectives of the new journal, its layout and contents of the first issue, was widely distributed by the Secretariat to relevant scientists and institutions. So far, from the responses received and the previous circulation list for the *Selected Scientific Papers*, 380 of the 450 copies of the first volume which have been printed will be distributed.

15.12 Members were urged to support *CCAMLR Science*.

## INTERSESSIONAL ACTIVITIES

### MEETINGS OF WORKING GROUPS AND WORKSHOPS

16.1 At this meeting, the Scientific Committee agreed that its Working Groups on Krill and CEMP be merged into a new Working Group on Ecosystem Monitoring and Management (WG-EMM) (see paragraph 7.40).

16.2 The Scientific Committee thanked Dr Bengtson and Mr Miller for their work and commitment as the current Conveners of WG-CEMP and WG-Krill. It noted that much of the work of WG-EMM could only be taken forward because of the substantial work done already by WG-Krill and WG-CEMP.

16.3 Dr Everson expressed the sincere thanks of the Scientific Committee especially to Dr Bengtson, who had indicated that it was unlikely that he would participate in CCAMLR in future, and recognised that he had been a particularly active contributor to all aspects of CCAMLR's work over a number of years.

16.4 Dr Everson was elected to convene WG-EMM, and accordingly resigned the convenership of WG-FSA. The Scientific Committee thanked Dr Everson for his work as Convener of WG-FSA in taking that Working Group a long way forward in its tasks.



16.5 Dr de la Mare was elected to convene WG-FSA.

16.6 An offer was made by Italy to host the meeting of WG-EMM in 1995. This was gratefully received by the Scientific Committee.

16.7 The meeting of WG-EMM will take place in Siena, Italy, from 24 July to 3 August 1995. Should a meeting of the *Ad Hoc* Subgroup on Statistics be required (see paragraph 6.27) this should also take place in Siena, on 20 and 21 July 1995.

16.8 The meeting of WG-FSA will take place from 10 to 19 October 1995 at CCAMLR Headquarters in Hobart. A workshop on methods for the assessment of *D. eleginoides* will take place from 4 to 6 October 1995 at CCAMLR Headquarters provided that the conditions laid out in paragraph 2.17 (see Annex 4, paragraph 4.37) have been met.

#### OTHER WORK OF CCAMLR SCIENTISTS

16.9 Data collected during the cooperative research activities in the Peninsula region in 1994/95 will be analysed at a workshop in Hamburg from 17 to 20 July 1995.

#### BUDGET FOR 1995 AND FORECAST BUDGET FOR 1996

17.1 The budget for 1995 is attached as Annex 9.

17.2 Provision is made for two permanent Working Groups to meet and for a workshop on *D. eleginoides* which includes provision for the invitation of two experts.

17.3 Provision is also made for CCAMLR to be represented by the Secretariat at the 1995 meeting of CWP and SCAR-COMNAP *Ad Hoc* Working Group on Antarctic Data Management.

17.4 Items are included to cover publication and translation of the *CEMP Standard Methods* and a brochure on incidental mortality in longline fisheries.

## ELECTION OF CHAIRMAN OF THE SCIENTIFIC COMMITTEE

18.1 On the nomination of Dr Naganobu, Dr Kock was unanimously re-elected to the office of Chairman of the Scientific Committee for a second term.

## NEXT MEETING

19.1 The next meeting of the Scientific Committee will take place in Hobart from 23 to 27 October 1995.

## OTHER BUSINESS

### CCAMLR DATA AND DATA HANDLING

20.1 A number of items concerning CCAMLR data and data handling was addressed by the Scientific Committee under various sections of its agenda. It was agreed that a specific item on CCAMLR Data Management should be placed on the agenda next year to facilitate structured discussion of such items.

20.2 A paper providing explanatory notes on CCAMLR's rules for data access was circulated as WG-Krill-94/19 at all Working Group meetings. The Scientific Committee endorsed the clarifications provided in this paper and attached it as Annex 10.

### TERMS OF OFFICE FOR CONVENERS OF WORKING GROUPS

20.3 The Scientific Committee considered the question of limits on a Working Group Convener's term of office. It noted that there were many considerations to this question and that it was essential that any limit on the term of office should take into account the requirements for continuity and commitment to the office.

20.4 The Scientific Committee did not agree upon a formal term of office for Conveners but generally agreed that about four years would be an appropriate period. It noted that the ends of terms of office of Conveners of Working Groups and the Chairman of the Scientific Committee should not be coincident. The Scientific Committee will consider this question at its next meeting.

## ADOPTION OF REPORT

21.1 The report of the Thirteenth Meeting of the Scientific Committee was adopted.

## CLOSE OF THE MEETING

22.1 In closing the meeting, Dr Kock thanked Members and observers for their excellent cooperation, hard work and good spirit throughout the meeting. He especially extended his gratitude to rapporteurs, the Secretariat, interpreters and public address system operators for their hard work and dedication.

22.2 The Scientific Committee expressed its gratitude and congratulations to Dr Kock for chairing a successful meeting. It noted that the next two years were likely to be highly productive under Dr Kock's continued chairmanship.

22.3 Mr Miller noted that projections based on the rate of paragraph adoption, and made throughout the adoption of the report, had almost consistently estimated the time of completion of adoption to within 20 minutes (18:20). The Scientific Committee encouraged this approach to monitoring the process of adopting the report.

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	Ludmilla Stern
	Natalie Testorelli



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- CCAMLR-XIII/BG/25 INFORME SOBRE ACCIDENTE DEL NAVIO B/F *FRIOSUR V*  
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- CCAMLR-XIII/BG/26 OBSERVANCIA DE LAS MEDIDAS DE CONSERVACION VIGENTES - SISTEMA  
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TASMANIA

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CCAMLR-XIII/MA/1	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 Germany
CCAMLR-XIII/MA/2	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 Poland
CCAMLR-XIII/MA/3	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 South Africa
CCAMLR-XIII/MA/4	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 France
CCAMLR-XIII/MA/5	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 Sweden
CCAMLR-XIII/MA/6	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 Australia
CCAMLR-XIII/MA/7	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 Chile
CCAMLR-XIII/MA/8 Rev. 1	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 Russia
CCAMLR-XIII/MA/9	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 New Zealand
CCAMLR-XIII/MA/10	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 Norway
CCAMLR-XIII/MA/11	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 Korea
CCAMLR-XIII/MA/12	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 USA
CCAMLR-XIII/MA/13	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 United Kingdom
CCAMLR-XIII/MA/14	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 Japan
CCAMLR-XIII/MA/15	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 Brazil
CCAMLR-XIII/MA/16	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94 Italy



CCAMLR-XIII/MA/17 REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94  
Argentina

CCAMLR-XIII/MA/18 REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1993/94  
Spain

**AGENDA FOR THE THIRTEENTH MEETING  
OF THE SCIENTIFIC COMMITTEE**

**AGENDA FOR THE THIRTEENTH MEETING  
OF THE SCIENTIFIC COMMITTEE**

1. Opening of the Meeting
  - (i) Adoption of the Agenda
  - (ii) Report of the Chairman
  
2. Fish Resources
  - (i) Fishery Status and Trends
  - (ii) Report of the Working Group on Fish Stock Assessment (WG-FSA)
  - (iii) Data Requirements
  - (iv) Advice to the Commission
  
3. Crab Resources
  - (i) Fishery Status and Trends
  - (ii) Report of the Working Group on Fish Stock Assessment (WG-FSA)
  - (iii) Data Requirements
  - (iv) Advice to the Commission
  
4. Squid Resources
  - (i) Review of Activities Related to Squid Resources
  - (ii) Advice to the Commission
  
5. Krill Resources
  - (i) Fishery Status and Trends
  - (ii) Report of the Working Group on Krill (WG-Krill)
  - (iii) Data Requirements
  - (iv) Advice to the Commission

6. Ecosystem Monitoring and Management
  - (i) Report of the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP)
  - (ii) Management Plans for CEMP Sites
  - (iii) Advice to the Commission
7. Report of the Joint Meeting of the Working Groups on Krill and CEMP
8. Marine Mammal and Bird Populations
9. Assessment of Incidental Mortality
  - (i) Incidental Mortality in Longline Fisheries
  - (ii) Incidental Mortality in Trawl Fisheries
  - (iii) Marine Debris
  - (iv) Advice to the Commission
10. Management under Conditions of Uncertainty about Stock Size and Sustainable Yield
11. Scientific Research Exemption
12. New and Exploratory Fisheries
13. CCAMLR Scheme of International Scientific Observation
14. Cooperation with Other Organisations
  - (i) Reports of Observers from International Organisations
  - (ii) Reports of SC-CAMLR Representatives at Meetings of Other International Organisations
  - (iii) Future Cooperation
15. Publication

16. Activities of the Scientific Committee during the 1994/95 Intersessional Period
  - (i) 1994/95 Intersessional Period
  - (ii) Organisation of Future Work
17. Budget for 1995 and Forecast Budget for 1996
18. Election of Chairman of the Scientific Committee
19. Next Meeting
20. Other Business
21. Adoption of the Report of the Thirteenth Meeting of the Scientific Committee
22. Close of the Meeting.

**REPORT OF THE WORKING GROUP  
ON FISH STOCK ASSESSMENT**

(Hobart, Australia, 11 to 19 October 1994)

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## **REPORT OF THE WORKING GROUP ON FISH STOCK ASSESSMENT**

(Hobart, Australia, 11 to 19 October 1994)

### **INTRODUCTION**

1.1 The meeting of the Working Group on Fish Stock Assessment (WG-FSA) was held at CCAMLR Headquarters, Hobart, Australia from 11 to 19 October 1994. The Convener, Dr I. Everson (UK), chaired the meeting.

### **ORGANISATION OF THE MEETING AND ADOPTION OF THE AGENDA**

2.1 The Convener welcomed participants to the meeting and introduced the Provisional Agenda which had been circulated prior to the meeting. He noted that Item 3.3 had been introduced this year to enable a thorough consideration of papers of general biological and ecological interest having implications for management. The Agenda was adopted with the inclusion of two sub-items, 4.10 and 4.11, concerning assessments in Division 58.5.2 and Subarea 48.4.

2.2 The Agenda is included in this report as Appendix A, the List of Participants as Appendix B and the List of Documents presented to the meeting as Appendix C.

2.3 The report was prepared by Drs D. Agnew (Secretariat) and A. Constable (Australia), Prof. G. Duhamel (France), Drs G. Kirkwood (UK) and K.-H. Kock (Chairman, Scientific Committee), Mr D. Miller (South Africa), Drs G. Parkes (UK), G. Watters (USA) and Mr R. Williams (Australia).

### **REVIEW OF AVAILABLE INFORMATION**

#### **DATA REQUIREMENTS ENDORSED BY THE COMMISSION IN 1993**

3.1 Various data were requested by the Working Group in 1993 (SC-CAMLR-XII, Annex 5, Appendix D). Data submitted to the Secretariat in response to this are listed in Appendix D.

## FISHERIES INFORMATION

### Catch, Effort, Length and Age Data

3.2 This year the date for reporting STATLANT data to the Secretariat was brought forward to 31 August (CCAMLR-XII, paragraph 4.18). The Data Manager reported that this change had significantly improved the ability of the Secretariat to acquire all STATLANT data prior to the Working Group meeting, with the result that all catches could be reported to the group in SC-CAMLR-XIII/BG/1.

3.3 The only commercial fisheries which had been in operation in the 1993/94 season were the fisheries for *Dissostichus eleginoides* in Subarea 48.3 and Division 58.5.1. Other species were taken as by-catch in these fisheries, or as research or exploratory catches by Argentina, Australia, France, South Africa and the UK.

3.4 A TAC of 1 300 tonnes had been set in Conservation Measure 69/XII for the *D. eleginoides* fishery in Subarea 48.3. Only 603 tonnes were caught in the fishery. No catches were reported from the fisheries for *Chamsocephalus gunnari*, crabs (*Paralomis* spp.) or *Electrona carlsbergi* in Subarea 48.3, *D. eleginoides* in Subarea 48.4, or the fishery for *Notothenia squamifrons* in Division 58.4.4, all of which had been subject to conservation measures with TACs (Conservation Measures 66/XII, 67/XII, 71/XII, 73/XII and 59/XI).

3.5 Haul-by-haul and length frequency data from the fishery for *D. eleginoides* in Subarea 48.3 were reported in accordance with Conservation Measure 69/XII. France reported fine-scale and length frequency data from the fishery for *D. eleginoides* in Division 58.5.1 and Subarea 58.6. Various other biological data were reported from research cruises in the 1993/94 season.

3.6 It was noted that a number of inspections were carried out this year under the CCAMLR System of Inspection. Reports of these inspections indicated that some *D. eleginoides* may have been caught in Subarea 48.3, and that this had not been officially reported as catch data to the Secretariat. The Working Group requested clarification of these reports in order to record the catches of this species correctly.

## Scientific Observer Information

3.7 Participation in the 1993/94 *D. eleginoides* fishery in Subarea 48.3 was conditional on having a scientific observer under the CCAMLR Scheme of International Scientific Observation (Conservation Measure 69/XII). The UK, USA and Russia had provided observers for Korean and Chilean (UK), Russian (USA) and Bulgarian (Russia) vessels. The Working Group expressed its regret that there was no participant from Russia at the meeting to provide a report from the observer on the Bulgarian vessel.

3.8 Drs R. Holt (USA) and Parkes reported on difficulties experienced by observers. Dr Parkes reported that observers from the UK had found that the fishing vessel captains had not always been fully aware of their obligations under Conservation Measure 69/XII, particularly with respect to fishing within the experimental depletion site, and that this had led to some difficulties on board ship. The Working Group recommended that fishing nations be requested to ensure that the operators of their vessels are made fully aware of the implications of their obligations under conservation measures, especially when they are expecting to host international observers.

3.9 Dr Holt reported that the US observer had collected a great deal of detailed data additional to that reported to CCAMLR under Conservation Measure 69/XII. Dr Parkes reported that the UK and Chilean observers had also collected such data, but that it had yet to be fully analysed. He also reported that the observer data collected on the *Friosur V* had regrettably been lost in the tragic fire on that vessel.

3.10 The Working Group recognised that providing an observer under the scheme was a major exercise, requiring careful planning, a qualified observer, and provision at the planning stage of sufficient resources for subsequent data analysis and reporting work.

3.11 The Working Group emphasised that the data collection forms provided in the CCAMLR *Scientific Observers Manual* should be used as a guide for the collection of relevant data. However, to make best use of the information collected by observers, the Working Group recommended that all data that could be reported in CCAMLR format (for instance in research data format C4, length frequency format B2 and age composition format B3) should be submitted to the Secretariat for entering into the CCAMLR Database. The Data Manager confirmed that other data, whether on the *Scientific Observers Manual* forms or not, could be sent to the Secretariat for safe keeping, but that only data in the recognised CCAMLR formats would be accepted for entry into the CCAMLR Database.

3.12 The scientific observers on board vessels taking part in the 1994 fishery for *D. eleginoides* in Subarea 48.3 (the FVs *Ihn Sung 66*, *Maksheevo* and *Friosur V*) reported some interaction between the longline fishery and killer whales and sperm whales. Whales were observed foraging for fish caught on longlines, taking fish, hooks and sometimes destroying the line itself. On some occasions when killer whales were present in large numbers, hauling was stopped and the vessel moved to another area, returning after some time to resume hauling. The Working Group considered that the influence of this interaction on the CPUE in the longline fishery should be investigated.

### Research Surveys

3.13 Three research surveys of finfish took place in the 1993/94 season; by the UK (January 1994, Subarea 48.3), Argentina (February to March 1994, Subareas 48.3 and 48.2) and Australia (September, Division 58.5.2).

3.14 The Argentinian survey of South Georgia, Shag Rocks and the South Orkneys was reported in WG-FSA-94/29. A novel survey design, based on the random selection of a number of 'chains' of stations within each of three depth strata, was used to optimise ship time.

3.15 The UK survey was described in WG-FSA-94/18. It used the same design as previous surveys, and produced biomass estimates which were generally lower than those found in 1992.

3.16 The Working Group decided that since it generally uses survey results as indices of abundance, it would be most appropriate to use the UK survey results, in conjunction with previous results from the UK, as its primary index of abundance in Subarea 48.3 (see paragraph 4.96 and Tables 7 and 8).

3.17 It was noted that the UK survey had found a rather even distribution of *C. gunnari* over the shelf area of South Georgia and Shag Rocks, whereas the later Argentinian survey had found a persistent high-density region close to Shag Rocks. Differences in other characteristics, such as representative length frequencies and diet of various species, were also identified and are further discussed in paragraphs 3.28, 3.33 and 4.73 to 4.75.

3.18 Discussing the two approaches to survey design, the Working Group noted that one of the main difficulties in surveys around South Georgia lies in locating survey stations on grounds suitable for trawling. The stations used for the UK surveys were chosen according to a stratified random design during the first survey year, and then the same set of stations was used in subsequent surveys.

Randomly selecting a new set of stations each year was considered infeasible. Using a fixed set of stations may introduce some bias, but this is not important when the results are used as indices of abundance.

3.19 On the Argentine survey, a smaller number of stations was chosen in a stratified random way and these were then used as starting points for selecting further ‘chains’ of stations by searching for further suitable trawling grounds in a random direction from the starting points. This procedure is described in WG-FSA-94/29. In part, this approach was followed in order to reduce the searching time for survey sites on suitable trawling grounds. The other reason for adopting this approach to site selection was a desire to take account of the expected heterogeneity in the distribution of the fish when determining the design and analysis of the survey. It was anticipated that it would be possible to reduce the CV of the abundance estimate and thereby optimise ship time. Because not all sites are randomly chosen in this method of site selection, methods of analysis need to be used which differ from those used by the Working Group to analyse the UK survey results. The analysis reported in WG-FSA-94/29 did suggest that some reductions in CV might be achieved by treating the ‘chains’ as a nested factor in the analysis. The comparison used, however, was difficult to interpret because of the non-random site selection procedure.

3.20 Maximising the information obtained from surveys is a common goal and the approach taken on the Argentine survey was felt to be interesting and innovative. However, several members of the Working Group felt that further development and investigation was needed. They wondered whether the difficult grounds around South Georgia provided the best testing area. The Working Group agreed that if proper account could be taken of the spatial heterogeneity, it should be possible to reduce the CV of the abundance estimate below that calculated in the normal way from random stratified surveys. In this context it would be useful if an analysis of the UK survey results incorporating spatial variability could be attempted.

3.21 The Australian survey was reported in WG-FSA-94/10 which included the results of two previous surveys of Heard Island conducted using similar survey designs. The results of the surveys are described in paragraph 4.148.

#### Experiments Affecting Catchability

3.22 Paper WG-FSA-94/23 reported experiments on the FP-120 trawl used during the UK survey in Subarea 48.3. ‘Scanmar’ trawl monitoring equipment was used to make *in situ* measurements of trawl dimensions and derive a multiple regression equation relating opening width to depth of trawling and tow speed (this had a high correlation coefficient).

3.23 Mr Williams commented that the good correlations among various trawl parameters, depth and tow speed in this study contrasted with Australian experiences around Heard Island. It was suggested that the relatively greater current speeds in the Heard Island area may have acted to distort the net dimension relationships to a greater extent than in the study around South Georgia.

3.24 The times of the start and end of each tow during the UK trawl surveys are recorded as the times at which the captain estimates that the trawl arrives at and leaves the seabed. The 'Scanmar' equipment provided the opportunity to compare these times with observations from the trawl itself. The comparison was undertaken for six tows, all of which showed that the trawl actually reached the seabed after the captain considered that it had. The average difference was two minutes, representing a 6.7% error on a standard 30-minute tow. The largest difference was 3 minutes 20 seconds. Differences between the estimated and observed times when the trawl left the bottom were much less. It was noted that whilst these differences were small, the effect might be significant if the trawl duration was much less than 30 minutes.

#### FISH AND CRAB BIOLOGY/DEMOGRAPHY/ECOLOGY

3.25 The Working Group considered a number of background papers dealing with various aspects of the biology and demography of selected species.

#### Age and Growth

3.26 The first of three Ukrainian papers (WG-FSA-94/4) dealt with the dynamics of *Notothenia rossii rossii* on the Kerguelen Island shelf.

3.27 The two other Ukrainian papers (WG-FSA-94/6 and 8) reported on the determination of age of *C. gunnari* at Heard and McDonald Islands using otolith weights. The Working Group looked forward to further submissions on the topic.

3.28 An age/length key for *C. gunnari* from Subarea 48.3 was presented in WG-FSA-94/11. Mostly small and medium sized specimens were found in the whole subarea, while age groups 1-4 and 2-3 were well represented at South Georgia and Shag Rocks respectively. The mean length-at-age values for fish collected around South Georgia were in line with results from previous surveys (see also paragraph 4.54).

3.29 Paper WG-FSA-94/12 reported results of a validation method for age determination of *Notothenia coriiceps* based on a tag-recapture experiment at Potter Cove, South Shetland Islands. Scale samples were taken from fish on tagging and when recaptured. The annulus count on scales corresponded well with the elapsed time between tagging and recapture. Good agreement was found on age readings from the scales and otoliths of recovered specimens. The method was recognised as having promise and the Working Group encouraged further work of this kind.

### Reproduction and Early Life

3.30 The first of three papers on this topic (WG-FSA-94/14) described the early life of *D. eleginoides* in the western Atlantic sector. This species spawns over the shelf slope between July and September, with eggs being observed primarily in the upper reaches of the water column in water depths between 2 200 and 4 400 m. The paper described Stages III and IV of embryonic development and concluded that hatching is likely to occur in October/November. Scales do not form until animals are about 64 to 74 mm in length.

3.31 In considering these results, Prof. Duhamel noted that at Kerguelen growth rates during the first two years of life for *D. eleginoides* and *C. gunnari* are remarkably similar, as are their distribution and feeding preferences.

3.32 Paper WG-FSA-94/16 described the results of sampling *C. gunnari* at South Georgia and Shag Rocks. The mean and median sizes of fish at the two locations were significantly different, with two size modes being evident at Shag Rocks compared to one at South Georgia. The Working Group agreed that such conditions may arise from a number of different circumstances which may include different spawning times in the two localities, different spawning patterns, different growth rates and/or be the result of sampling a patchily distributed resource. The Working Group thought it unlikely that the results were indicative of two separate stocks.

3.33 A histological description of the ovaries of *C. gunnari* was presented in WG-FSA-94/28. Six stages of oocyte development were identified, and these are similar to those described for other species. A stage of generalised atresia of oocytes was described and was found to be similar to the regression stage reported for the 1991 year of krill shortage. A revision of the gonad maturation scale was presented. The Working Group agreed that the revised scale set out in Appendix E should be used for future studies.



## Trophic Relationships

3.34 Papers WG-FSA-94/15 and 27 reported on the diet of *C. gunnari* at South Georgia during the period January to March 1994. Both concluded that in the absence of large concentrations of krill, the hyperiid amphipod *Themisto gaudichaudii* was the major component in the diet of *C. gunnari*. Further discussion of these papers is given in paragraphs 4.73 and 4.74.

3.35 Paper WG-FSA-94/17 suggested that predation by fur seals could potentially exert a more profound effect on stocks of *C. gunnari* at South Georgia than hitherto appreciated, particularly in the absence of krill concentrations such as occurred during the 1993/94 austral summer (see also paragraphs 4.77 and 5.5).

## Management Units

3.36 Paper WG-FSA-94/10 highlighted possible stock differences for *C. gunnari* in Division 58.5.2. The Working Group agreed that these results may have some application in the allocation of management units in the respective areas and further work was encouraged.

## Seabed Areas

3.37 The Working Group welcomed WG-FSA-94/13, which presented a revised bathymetric map of the Elephant Island area and estimates of seabed areas around the island, as an addition to the CCAMLR data on seabed areas.

3.38 The Data Manager reported that following the request of the Working Group in 1993 (SC-CAMLR-XII, Annex 5, paragraph 5.24), the Secretariat has written a program to calculate areas of seabed within selected depth ranges for all subareas within the Convention Area. This program is available on request from the Secretariat.

## ASSESSMENT WORK AND MANAGEMENT ADVICE

4.1 Both the Scientific Committee and the Commission have requested more work on the question of management under conditions of uncertainty (SC-CAMLR-XII, paragraph 3.95 and CCAMLR-XII, paragraph 4.26). The Working Group looked at this question on a stock-by-stock

basis and its advice is contained in the management advice for individual stocks where appropriate. General conclusions are given in paragraphs 4.161 to 4.164.

#### NEW FISHERIES

4.2 CCAMLR has had no notifications under Conservation Measure 31/X that Members intend to initiate a new fishery. The Working Group therefore had nothing to consider under this item.

#### SOUTH GEORGIA (SUBAREA 48.3) - FINFISH

4.3 Summaries of assessments presented in the following section are given in Appendix F.

#### Reported Catches

4.4 The catch history for Subarea 48.3 is shown in Table 1. The only finfish to be targeted in this subarea was *D. eleginoides*; catches of other species were taken as by-catch in these fisheries or as research catches.

Table 1: Catches of various finfish species from Subarea 48.3 (South Georgia subarea) by year. Species are designated by abbreviations as follows: KCV (*Paralomis spinosissima*), SSI (*Chaenocephalus aceratus*), ANI (*Champscephalus gunnari*), SGI (*Pseudochaenichthys georgianus*) and ELC (*Electrona carlsbergi*), TOP (*Dissostichus eleginoides*), NOG (*Notothenia gibberifrons*), NOR (*Notothenia rossii*), NOS (*Notothenia squamifrons*), NOT (*Patagonotothen guntheri*). 'Others' includes Rajiformes, unidentified Channichthyidae, unidentified Nototheniidae and other Osteichthyes.

Split year	KCV	SSI	ANI	SGI	ELC <sup>e</sup>	TOP	NOG	NOR	NOS	NOT	Others	Total
1970	0	0	0	0	0	0	0	399704	0	0	0	399704
1971	0	0	10701	0	0	0	0	101558	0	0	1424	113713
1972	0	0	551	0	0	0	0	2738	35	0	27	3351
1973	0	0	1830	0	0	0	0	0	765	0	0	2595
1974	0	0	254	0	0	0	0	0	0	0	493	747
1975	0	0	746	0	0	0	0	0	1900	0	1407	4053
1976	0	0	12290	0	0	0	4999	10753	500	0	190	28732
1977	0	293	93400	1608	0	441	3357	7945	2937	0	14630 <sup>a</sup>	124611
1978	0	2066	7557	13015	0	635	11758	2192	0	0	403	37626
1979	0	464	641	1104	0	70	2540	2137	0	15011	2738 <sup>b</sup>	24705
1980	0	1084	7592	665	505	255	8143	24897	272	7381	5870	56664
1981	0	1272	29384	1661	0	239	7971	1651	544	36758	12197 <sup>c</sup>	91677
1982	0	676	46311	956	0	324	2605	1100	812	31351	4901	89036
1983	0	0	128194	0	524	116	0	866	0	5029	11753 <sup>d</sup>	146482
1984	0	161	79997	888	2401	109	3304	3022	0	10586	4274	104742
1985	0	1042	14148	1097	523	285	2081	1891	1289	11923	4238	38517
1986	0	504	11107	156	1187	564	1678	70	41	16002	1414	32723
1987	0	339	71151	120	1102	1199	2844	216	190	8810	1911	87882
1988	0	313	34620	401	14868	1809	5222	197	1553	13424	1387	73794
1989	0	1	21359	1	29673	4138	838	152	927	13016	55	70160
1990	0	2	8027	1	23623	8311	11	2	24	145	2	40148
1991	0	2	92	2	78488	3641 <sup>f</sup>	3	1	0	0	1	82423
1992	0	2	5	2	46960	3703 <sup>g</sup>	4	1	0	0	1	50678
1993	299	0	0	0	0	3049 <sup>h</sup>	0	0	0	0	0	3348
1994	0	2	13	1	0	604 <sup>i</sup>	4	2	0	1	13	640

<sup>a</sup> Includes 13 724 tonnes of unspecified fish caught by the Soviet Union

<sup>b</sup> Includes 2 387 tonnes of unspecified Nototheniidae caught by Bulgaria

<sup>c</sup> Includes 4 554 tonnes of unspecified Channichthyidae caught by the GDR

<sup>d</sup> Includes 11 753 tonnes of unspecified fish caught by the Soviet Union

<sup>e</sup> Before 1988, it is not confirmed that these were *E. carlsbergi*

<sup>f</sup> Includes 1 440 tonnes taken before 2 November 1990

<sup>g</sup> Includes 1 tonne taken as research catch by the UK, 132 tonnes taken as research catch by Russia before 30 June

<sup>h</sup> 59 tonnes taken by Russian research cruise July 1992, 2 990 tonnes by the longline fishery December 1992 to February 1993

<sup>i</sup> Includes 179 tonnes taken in the 1994 fishing season but after 1 July 1994, 1 tonne taken by research cruises

*Dissostichus eleginoides* (Subarea 48.3)

4.5 In the 1993/94 season, Subarea 48.3 was designated as a Special Area for Protection and Scientific Study. Fishing during the season was undertaken by one vessel from each of the Republic of Korea, Russia, Chile and Bulgaria, with one vessel operating in each of five 55-day periods. Detailed operational statistics are given in WG-FSA-94/20. Catches by vessel and month during the season are shown in Table 2. A site for local depletion experiments was specified for each fishing period. Figure 1 shows the positions of catches and the local depletion sites. The site originally allocated to the Korean vessel was found to be unsuitable for fishing and was changed to that shown in Figure 1.

Table 2: Catches by vessel and month during the 1993/94 season.

Period	Allocated Periods	Actual Fishing	Catch (tonnes)	Month	Catch (tonnes)
1	15 December 93 - 7 February 94	22 December 93 - 7 February 94	99	December	32
2	8 February - 3 April 94	27 February - 29 March 94	103	January	32
3	4 April - 28 May 94	7 April - 6 May 94	151	February	39
4	29 May - 22 July 94	1 June - 22 July 94	115	March	80
5	23 July - 15 September 94	23 July - 10 September 94	135	April	147
				May	23
				June	70
				July	73
				August	72
				September	35
Total			603		603

4.6 The Working Group felt that the catches reported to the Secretariat may not represent all of the catches taken in Subarea 48.3. Lack of this information will hamper assessments. In addition, it was recalled that detailed information on catches to the north and west of Subarea 48.3 had been available last year and had proved very useful in assessment. The Working Group noted that it had no information on catches outside the Convention Area for other years and agreed that acquisition of these data would greatly assist its work.

4.7 Dr C. Moreno (Chile) explained that the discrepancy between the 5-day reported catch and the final reported catch for the Chilean vessel (WG-FSA-94/20, Table 1) was due to use in the final reported catch of an updated conversion factor from processed to whole weight. The updated conversion factor (0.50) had been estimated from data collected during the fishing period. The previous value was 0.48. The Working Group agreed that information on the conversion factors used should be requested along with each catch report.

## Review of 1992/93 Estimates of Local Densities

4.8 Assessments of the toothfish fishery in Subarea 48.3 undertaken by the Working Group at its meetings in 1992 and 1993 were based on estimates of local densities calculated using CPUE data for single commercial longline vessels fishing in small areas over a limited period of time. The stock depletion estimation method involved fitting a linear regression of CPUE against cumulative catch. Valid estimates can only be obtained if this regression has a negative slope. Paper WG-FSA-94/24 reported the results of a review of the stock depletion analyses undertaken at the 1993 Working Group meeting and of a re-analysis of the 1992/93 longline data for Chilean vessels.

4.9 Paper WG-FSA-94/24 found that the method used at the 1993 Working Group meeting to select CPUE data for analysis was not in full accordance with the assumptions of the stock depletion method of analysis. It also found that in some cases the cumulative catch had not been calculated appropriately. The resulting estimates of local densities were therefore not correct. An attempt was then made to re-analyse the 1992/93 Chilean data both from Subarea 48.3 and from the North and Rhine banks.

4.10 Series of data were selected for analysis on the basis of single vessels operating in localised areas for periods of three consecutive days or more. The size of the localised areas was restricted to an area of similar size to the circle of 10 n miles diameter specified for the 1993/94 Experimental Protocol. A total of 23 series was selected for Subarea 48.3 and a further 12 and 13 for North and Rhine Banks respectively. All catches during the selected time periods in the selected localised areas were included in the calculation of the accumulated catch, regardless of which vessel had taken them. Linear regressions of CPUE against accumulated catch were then performed and a one-tailed t-test was used to test whether the slope was significantly less than zero.

4.11 For the 23 series identified in Subarea 48.3, at the 5% level only three regressions had slopes significantly less than zero, and 11 had positive slopes. Of the 12 series from North Bank, none of the slopes were significantly less than zero and seven were positive. Of the 13 series from Rhine Bank, two had slopes significantly less than zero and five were positive. Since most of the series in the 1992/93 data set with potential for showing significant local stock depletion did not show depletion, it was concluded that on the scale of single longline vessels operating in localised areas the stock depletion method cannot be applied.

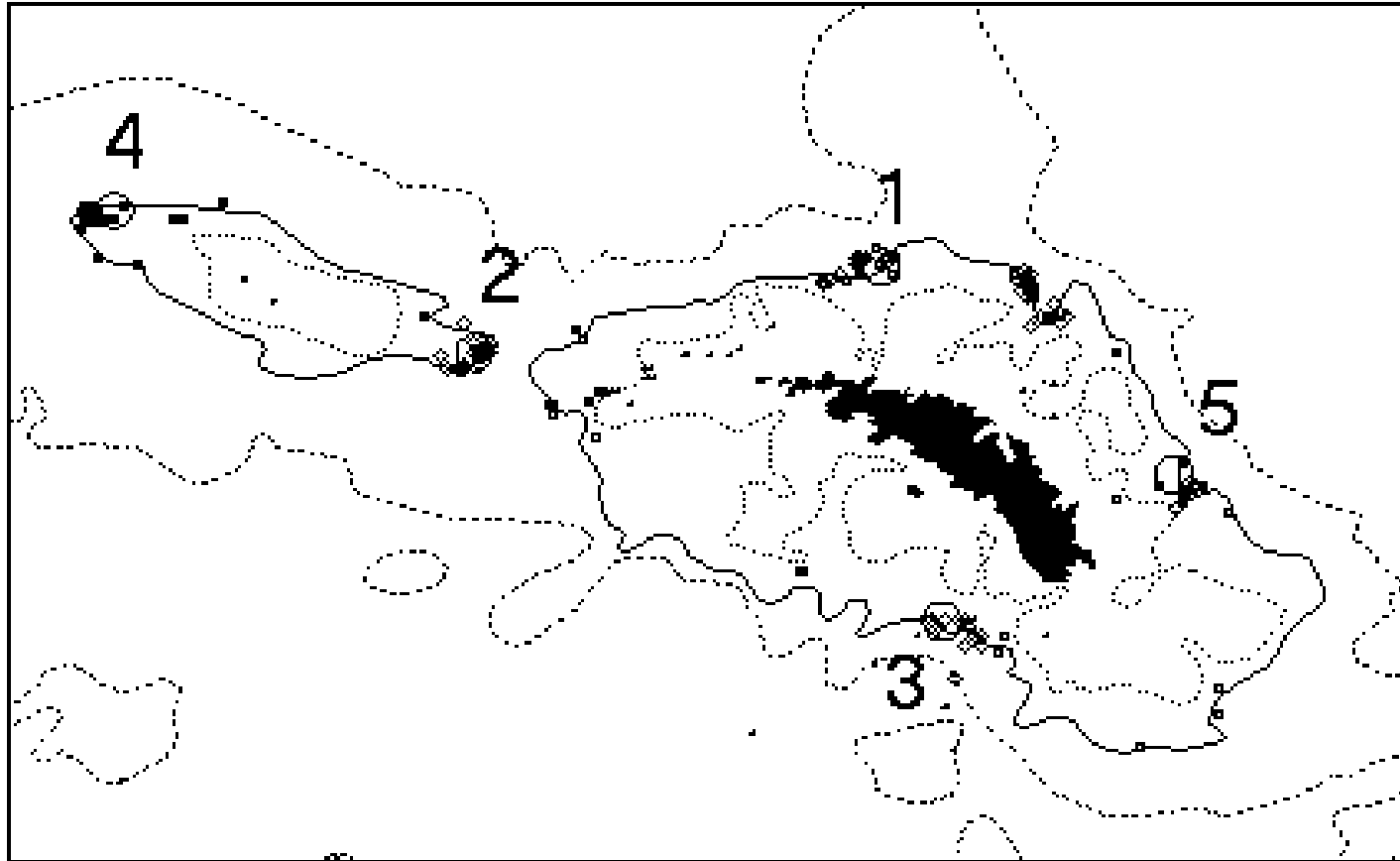


Figure 1: Location of catches in the *D. eleginoides* fishery, Subarea 48.3: squares = Republic of Korea, diamonds = Russia, crosses = Chile, dots = Bulgaria. Positions of experimental sites are numbered

4.12 The Working Group accepted the conclusions of WG-FSA-94/24 and agreed that it was not possible to calculate estimates of stock densities from the 1992/93 data using the stock depletion method, at least on the temporal and spatial scales it had originally envisaged would be appropriate.

#### Analysis of the 1993/94 Local Depletion Experiments

4.13 Local depletion experiments were conducted on five vessels in Subarea 48.3 during 1993/94 in accordance with Conservation Measure 69/XII and the experimental protocol in COMM CIRC 93/50.

4.14 Paper WG-FSA-94/22 reported an analysis of the local depletion experiment conducted on the Korean vessel *Ihn Sung 66*. Ten longline sets were undertaken on successive days at site 1 (see Figure 1). Of these, the set on the first day had a much longer soak time than the others, the line set on the fourth day was broken and tangled, and the set on the sixth day was made in water shallower (725 m) than on the other days (1 000 to 1 500 m). CPUE data for these three days were omitted from the analysis. A linear regression of CPUE data against accumulated catch was then undertaken. Significant stock depletion was found, and an estimate of local density was calculated. In discussion of this paper, it was agreed that it would be more appropriate not to omit the CPUE with the long soak time, given that the measure of effort was the number of hooks. Similarly, the depth of the shallower set was still within the depth range of the commercial fishery, and it was believed that this datum should also have been included. It was therefore agreed that the data should be re-analysed.

4.15 Paper WG-FSA-94/31 reported an analysis of the local depletion experiment conducted on the Chilean vessel *Friosur V*. Longline sets were made on 10 consecutive days at site 3. When all the data were included, the regression slope was neither significant nor negative. However, when the data for the last longline set were omitted, a regression of CPUE (tonnes) against accumulated catch (tonnes) indicated that depletion had occurred. The Working Group agreed that there was no *a priori* reason to omit the last datum, and therefore it should be included, despite the fact that no density estimate could then be calculated. An interesting feature of the data was that there was a considerable decline in mean weight over the 10 days. No reason was identified as to why this should have occurred.

4.16 Data from the local depletion experiment conducted on the Russian vessel *Maksheevo* at site 2 were reported in SC-CAMLR-XII/BG/9 Rev. 1. No analysis of these data had been attempted prior to the Working Group meeting. In all, 11 longline sets were made within the site on five consecutive days. Three sets were hauled on the third day and five on the fourth day. The Working

Group noted that, while multiple sets on a single day were entirely in accordance with the experimental protocol, the possibility existed that there may have been interactions between these longlines. This would have to be allowed for when analysing the data.

4.17 The final local depletion experiments were undertaken on the Bulgarian vessel *RK-1* over two periods. The experimental protocol had envisaged that two experiments would be undertaken, one at site 4 and one at site 5. In actuality, all fishing was undertaken at site 4, and data satisfying the experimental protocol were available for three time periods of 10, 23 and 13 days duration. Data from these experiments were reported to the CCAMLR Secretariat. No analyses had been undertaken prior to the Working Group meeting.

4.18 Noting some minor differences in the methods of analysis used in WG-FSA-94/22 and 31, as well as the need to include some data that had been omitted in the analyses tabled, the Working Group agreed that the data from all of the experiments should be re-analysed using a consistent methodology.

4.19 Plots of CPUE in numbers per hook against accumulated catch in numbers (calculated using the Ricker 1975 correction) are shown in Figure 2, along with the fitted regression lines. These plots show clear positive slopes for both the Russian and Chilean data, clear negative slopes for the Korean data and the Bulgarian data in period 4, and close to zero slopes for the Bulgarian data for the next two periods. Two of the slopes were significantly less than zero at the 5% level.



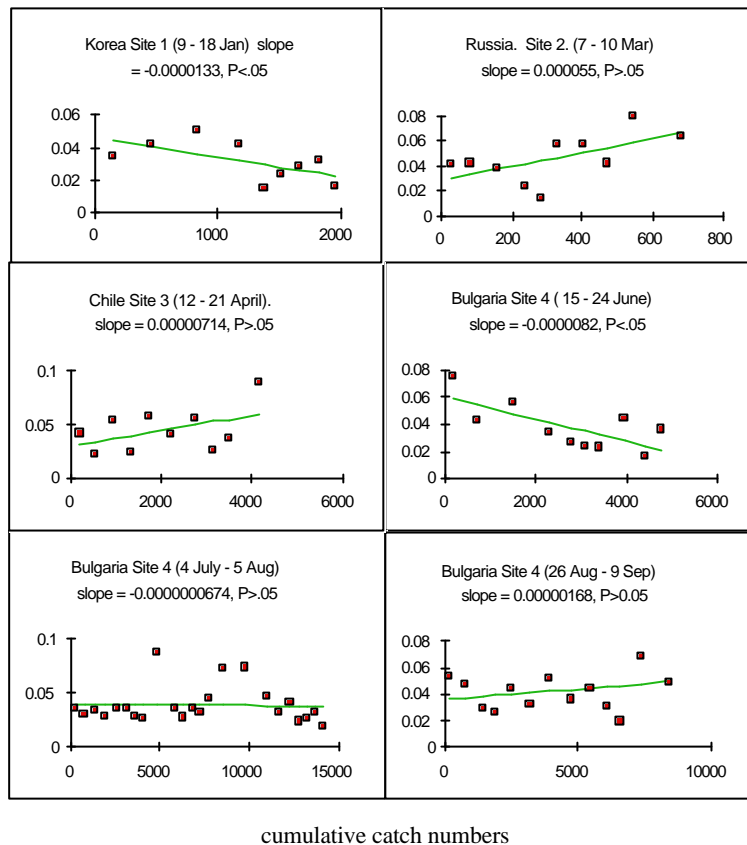


Figure 2: Plots of CPUE in numbers/hook against accumulated catch in numbers for the six depletion experiments.

4.20 Despite the fact that all of these local depletion experiments had been conducted in full accordance with the experimental protocol, the analyses indicate that the assumptions underlying the experiments and the analyses have not been satisfied. Significant local depletion at this temporal and spatial scale has not been consistently detected. Consequently, no estimates of local densities and, therefore, estimates of abundance in Subarea 48.3 can be calculated from these data. This matches the conclusion reached after re-analysing the 1992/93 commercial longline data.

4.21 Dr Moreno reported that a similarly designed local depletion experiment for toothfish undertaken in the 1992 season in southern Chile, involving seven vessels and a total catch of close to 7 000 tonnes, had also failed to detect stock depletion.

### Review of Other Data

4.22 The Working Group reviewed the annual mean CPUE data by fleet for 1991/92, 1992/93 and 1993/94 given in WG-FSA-94/20. For the Russian and Bulgarian fleets, the annual CPUE either remained level or rose slightly. Only for the Chilean fleet did the CPUE decline over the three

seasons, however, it is known that there have been significant changes in the Chilean fleet over that time period, and the mean CPUE data are therefore not comparable across seasons. It was believed that CPUE data for some vessels in the Chilean fleet would be comparable across seasons, however the data held by the CCAMLR Secretariat do not allow identification of individual vessels. The Working Group agreed that attempts should be made to obtain information sufficient to identify individual Chilean vessels across seasons, while still retaining the anonymity required for commercial confidentiality.

4.23 Plots of length frequencies for catches taken by Russian vessels for the four seasons 1990/91 to 1993/94 were also examined. There were no obvious changes in the length frequencies for the first three seasons, although there was an increased frequency of smaller fish and slightly lower frequencies of fish around 130 cm in 1994.

4.24 An attempt was made to estimate the abundance of pre-recruit *D. eleginoides* from recent UK surveys. These, in conjunction with size frequency distributions, were used to estimate the abundance of 2-, 3- and 4-year-old fish for 1990, 1991, 1992 and 1994 to provide indications of levels of recruitment in recent years using the approach in WG-FSA-91/20.

4.25 Because the surveys were designed primarily to assess *C. gunnari*, the number of *D. eleginoides* which were caught was low for each survey. Consequently the results of this analysis gave no indication of any trend in recruitment in recent years.

#### Stock Status and Research Needs

4.26 None of the data (CPUE, length frequency) examined by the Working Group, either on the short temporal and spatial scale of the local depletion experiments or on an annual time scale for the whole subarea, have provided any clear indications of trends in stock abundance. Accordingly, the Working Group was unable to conduct a formal stock assessment. Possible reasons for this were discussed.

4.27 On the short temporal and spatial scale, movement into and out of the local areas of the experiments was identified as a possible reason for no depletion having been observed; the toothfish, a large mobile predator, can move at a sufficient speed and over sufficient distances to violate the assumption that there was no migration into or out of the localised area for the duration of the period analysed. At the subarea level, it is also possible that the waters around South Georgia form only part of the range of a single stock of toothfish that may extend over a much wider area. Existing information about the life history and biology of the toothfish suggests that it is capable of large-scale migrations.

4.28 Little is known about the stock structure of toothfish, which have a circumpolar distribution in sub-Antarctic waters. It is believed that separate stocks probably exist in Atlantic and Indian Ocean waters, and there is evidence that the fish around Crozet Island and Kerguelen come from different stocks. However, the stock structure in the Atlantic is unknown. It was noted that the presence of jellymeat, especially in larger fish, has been observed both at South Georgia and in southern Chile, but not in northern Chile.

4.29 The Working Group was advised by Mr Williams that a mitochondrial DNA study of toothfish from a number of different areas was soon to commence. Progress on this and similar studies was strongly encouraged by the Working Group.

4.30 No data on migrations of toothfish are available, and this is clearly of major importance. The Working Group agreed that this could be addressed through tagging studies, probably using snap-off hooks, and it encouraged such experiments.

4.31 Another possible reason for the failure to detect fishery-induced changes in stock indicators in the depletion experiments is simply that the current catches are small in relation to the available local stock of fish. While this could by no means be ruled out, the Working Group was very reluctant to adopt it as a working hypothesis. The Working Group has previously expressed concerns about the probable high vulnerability to over-exploitation of a long-lived and slow-growing fish like the toothfish. It is also quite possible that the relationship between CPUE and abundance may be such that changes in abundance only become apparent when the stock has been reduced to low levels. The Working Group reiterated its view that a conservative approach should be taken to the management of toothfish in this subarea.

4.32 The Working Group reviewed the requirements for data reporting in this fishery. In addition to the required information listed in the *Inspectors Manual*, the following information should be requested from commercial fishing operations:

- (i) conversion factors from processed to whole weight;
- (ii) bottom depths at both start and end of a longline set;
- (iii) direction of haul;
- (iv) percentage of hooks baited;
- (v) by-catch of birds and marine mammals;
- (vi) amounts of discarded fish;
- (vii) design of longline gear (e.g., Spanish, traditional);
- (viii) an unequivocal measure of the depth at which hooks were set off the bottom; and

- (ix) information allowing unique identification of individual vessels across years within the CCAMLR Database.

4.33 There is a clear need for the collection of length frequency data and of otoliths and scales for age reading. These data should be collected in such a way as to ensure full coverage of fishing throughout the season and throughout the subarea. It was recognised that these data could only be collected by qualified observers, and therefore the Working Group recommended that all vessels fishing in the subarea should have a scientific observer on board. The observer should also collect biological data on, for example, sex and maturity stage of fish caught.

4.34 With regard to future research, the need for studies of stock identity and of migrations has already been identified. The Working Group noted that there had been insufficient time during the meeting to undertake as thorough an analysis of the CPUE and length frequency data as would be desirable. It recommended that such an analysis be undertaken in the intersessional period. This analysis should take full account, *inter alia*, of both the area fished within the zone and the depths fished.

4.35 Another possible new source of data for stock assessment is properly designed longline surveys. These would need careful consideration and planning, as would any future possible depletion experiments, given the disappointing results of the ones conducted during the 1993/94 season.

4.36 Since a certain amount of time is needed to consider fully the results of analyses to be conducted in the coming year, to plan the collection of new data and to review possible new assessment methods for this stock, the Working Group recommended that a three-day meeting be scheduled prior to next year's Working Group meeting to address these issues with the following terms of reference:

- (i) to review catch information, including the location and size of catches both in and outside the Convention Area;
- (ii) to review and evaluate available information on stock identity over the entire range of the species and in particular the relationships between stocks in Subarea 48.3 and neighbouring areas;
- (iii) to review and evaluate methods for conducting surveys of stocks targeted using longlines;

- (iv) to review and evaluate methods for assessing the status of stocks and for determining appropriate yields, including the utility of CPUE data from the longline fishery in these assessments;
- (v) to identify the data requirements from the longline fishery; and
- (vi) to provide advice to the Working Group on stock identity and on stock survey and assessment procedures.

4.37 In order to help decide whether to hold the workshop and when it should be held in relation to the meeting of the Working Group, haul-by-haul longline fishery data, results of stock identification analyses, and papers relevant to the terms of reference (i) to (iv) should be submitted to the Secretariat by 1 August 1995. At that time, the work of the Working Group regarding stock assessments can be reviewed to see whether the workshop can be held during the meeting of the Working Group or whether it should be held three days prior to that meeting.

4.38 The Working Group agreed that the workshop would require the assistance of experts who have been involved with the assessment of longline fisheries elsewhere in the world, in particular, the fisheries for *D. eleginoides* in South America. Therefore, the Working Group recommended that the Scientific Committee request funds be provided for two experts to participate in the workshop.

#### Management Advice

4.39 The Working Group has been unable this year to carry out a stock assessment of the toothfish in Subarea 48.3 and is therefore unable to advise appropriate TACs. It therefore is faced by a position similar to that of two years ago.

4.40 In none of the data examined were there indications that the current and recent levels of catches had had any detectable effect on the fishery. However, given the concerns expressed previously about the interpretation of longline CPUE and the probable high vulnerability of toothfish to overfishing, the Working Group agreed that a precautionary approach should be taken to the setting of any TACs until a reliable stock assessment has been completed.

4.41 In view of this, the Working Group is not in a position to advise on particular levels of TAC for the 1994/95 season. It noted the following TACs and catches from past years:

	TAC	Catch
1991	2 500	3 641 <sup>a</sup>
1992	3 500	3 703 <sup>b</sup>
1993	3 350	3 049 <sup>c</sup>
1994	1 300	604 <sup>d</sup>

<sup>a</sup> Includes 1 440 tonnes taken before 2 November 1990

<sup>b</sup> Includes 1 tonne taken as research catch by the UK, 132 tonnes taken as research catch by Russia before 30 June

<sup>c</sup> 59 tonnes taken by Russian research cruise July 1992, 2 990 tonnes by the longline fishery December 1992 to February 1993

<sup>d</sup> Includes 179 tonnes taken in the 1994 fishing season but after 1 July 1994, 1 tonne taken by research cruises

4.42 To better assess *D. eleginoides* stocks in the future, the Working Group recommends, pending the submission of data and appropriate papers, that a three-day workshop be scheduled to run immediately prior to, or during, the 1995 WG-FSA meeting to discuss stock identity, survey designs, assessment methodologies and data requirements.

4.43 The Working Group requests that prior to the workshop the Secretariat compile comprehensive haul-by-haul data from all longline catches in Subarea 48.3.

4.44 It also requested that data on catches of *D. eleginoides* taken in areas of the southwest Atlantic which are outside the Convention Area be sought and compiled by the Secretariat.

#### *Champscephalus gunnari* (Subarea 48.3)

##### Commercial Catch

4.45 There was no reported commercial catch of *C. gunnari* in Subarea 48.3 during the 1993/94 season, despite a TAC of 9 200 tonnes (Conservation Measure 66/XII). The season lasted from 1 January 1994 to 1 April 1994, when it was closed in accordance with Conservation Measure 66/XII until the end of the Commission meeting on 4 November 1994. There has now been no reported commercial catch of *C. gunnari* in Subarea 48.3 since March 1990. A total of 8 027 tonnes was reported in that season.

## Research Surveys

4.46 Two research surveys aimed at estimating the abundance of *C. gunnari* in Subarea 48.3 were conducted during the 1993/94 season. The results of these surveys were reported in documents WG-FSA-94/18 (UK survey on MV *Cordella*) and WG-FSA-94/29 (Argentine survey on *Dr Eduardo L. Holmberg*). The methods used during these surveys are discussed in paragraphs 3.18 to 3.20.

4.47 The start of the 1993/94 season for *C. gunnari* in Subarea 48.3 was delayed to coincide with the trawl survey undertaken by the UK in January 1994. The TAC was agreed on the condition that any significant trend which would affect current estimates of the stock size would be immediately brought to the attention of the Commission. The preliminary results of the survey indicated that there was a substantially smaller biomass of *C. gunnari* in Subarea 48.3 than had been predicted by the projections conducted by the Working Group in 1993. This information was communicated to the Commission and circulated to Members in COMM CIRC 94/11 on 17 February 1994.

4.48 Estimates of the standing stock of *C. gunnari* from the two surveys are presented in Tables 3 and 4. Estimates from the UK survey were calculated using two estimators: the Minimum Variance Unbiased Estimate (MVUE) (de la Mare, 1994<sup>1</sup>) and the sample mean (WG-FSA-94/18). WG-FSA-94/29 presented results based on a log transform within a nested model. Due to the non-random survey design the standing stock estimates from WG-FSA-94/29 were not recalculated using the MVUE model. The results presented in the paper are therefore recorded in Table 4.

Table 3: Comparison of biomass estimates (tonnes) for *C. gunnari* for the UK survey in Subarea 48.3.

Area and Estimation Method	Depth Strata (m)			Entire Depth Range	CV	95% Confidence Limits	
	50-150	150-250	250-500			Lower	Upper
South Georgia							
MVUE <sup>1</sup>	6 050	9 073	965	16 088	0.24	10 365	39 207
Sample Mean	6 254	7 699	970	14 923	0.22	-	-
Shag Rocks							
MVUE <sup>1</sup>	506	4 364	-	4 870	0.25	2 930	29 046
Sample Mean	453	4 358	20	4 831	0.24	-	-

<sup>1</sup> de la Mare, 1994

<sup>1</sup> de la Mare, W.K. 1994. Estimating confidence intervals for fish stock abundance estimates from trawl surveys. *CCAMLR Science*, Vol. 1: 203-207.

Table 4: Biomass estimates (tonnes) for *C. gunnari* for the Argentine survey in Subarea 48.3.

Area and Estimation Method	Depth Strata (m)			Entire Depth Range	95% Confidence Limits	
	50-150	150-250	250-500		Lower	Upper
South Georgia Log transform, nested model	375	1 608	29	2 012	252	8 246
Shag Rocks Log transform, nested model	-	-	-	67 259	23	14 x 10 <sup>6</sup>

4.49 The standing stock estimates from the two surveys could not be compared directly due to differences in the survey design, sampling equipment and estimation methods.

4.50 The UK survey was a continuation of the series of surveys undertaken by the UK in Subarea 48.3 during recent years, using the same methodology as before. The results of this survey were therefore used as the basis for an assessment of the current status of the stock.

4.51 No concentrations of *C. gunnari* were detected during the UK survey. The population was comparatively evenly distributed over the shelf at low densities. The use of both methods of estimation (MVUE and sample mean) resulted in low standing stock estimates. The CVs were also low, although the confidence limits provided by the MVUE program were considered to present a more realistic indication of the uncertainty in the estimates.

4.52 The Argentine survey also did not detect any concentrations on the South Georgia shelf. However, one very large catch on the Shag Rocks shelf at the start of the survey resulted in a high abundance estimate for that area, with very large confidence limits.

### Stock Status

4.53 The standing stock estimates from the UK survey were considerably lower than expected from cohort projections made at last year's meeting.

4.54 Age data from the UK survey had not been fully analysed prior to the meeting and preliminary examination of these data during the meeting indicated that they could not be used in their present form. The age structure of the samples taken on the UK survey was estimated from the catch weighted length frequency from that survey and the age/length key from the Argentine survey, reported in WG-FSA-94/11. This age/length key was considered to be applicable to the samples taken on the UK survey due to the short time difference between the two surveys.



4.55 Figures 3 and 4 provide comparisons between the biomass-at-age projected at last year's meeting and that observed during the UK survey. Two projections were performed at last year's meeting: projection 1 starting from the median estimate of biomass from the UK survey in 1991/92 and projection 2 starting from the lower 95% confidence bound (MVUE). Projection 2 was re-run at this year's meeting using the  $q$ s from the VPA to adjust the biomass estimate used as the starting point in accordance with the comments in last year's Working Group report (SC-CAMLR-XII, Annex 5, paragraph 6.52).

4.56 Both projections conducted at last year's meeting assumed no fishing took place up to 1993/94 and a constant coefficient of natural mortality ( $M$ ) of 0.48.

4.57 In order to compare the current estimate from the survey directly with the projections, the former was back-calculated to 1 July 1993. To provide estimates of absolute abundance a value of  $M$  of 0.48 was used, taking into account catchability ( $q$ ) at age from run 5 of the VPA performed at last year's meeting (SC-CAMLR-XII, Annex 5, Table 10). The error bars shown on the figures for ages 2 and 3 represent the uncertainty in the projections derived purely from the simulation of recruitment variability (SC-CAMLR-XII, Annex 5, paragraph 6.53).

4.58 The total discrepancy between observed and median expected biomass over all age classes was 113 500 tonnes and 83 100 tonnes for projections 1 and 2 respectively.

4.59 The Working Group recalled the similar drop in biomass between 1989/90 and 1990/91 described in the 1991 Working Group report (SC-CAMLR-X, Annex 6, paragraphs 7.28 to 7.36). The decline in standing stock between 1989/90 and 1990/91 was indicated by the bottom trawl surveys undertaken in those seasons by the UK and the former USSR. The current decline, however, was indicated by the discrepancy between the cohort projections from the survey in January 1992 and the survey in January 1994. There was no survey in the 1992/93 season.

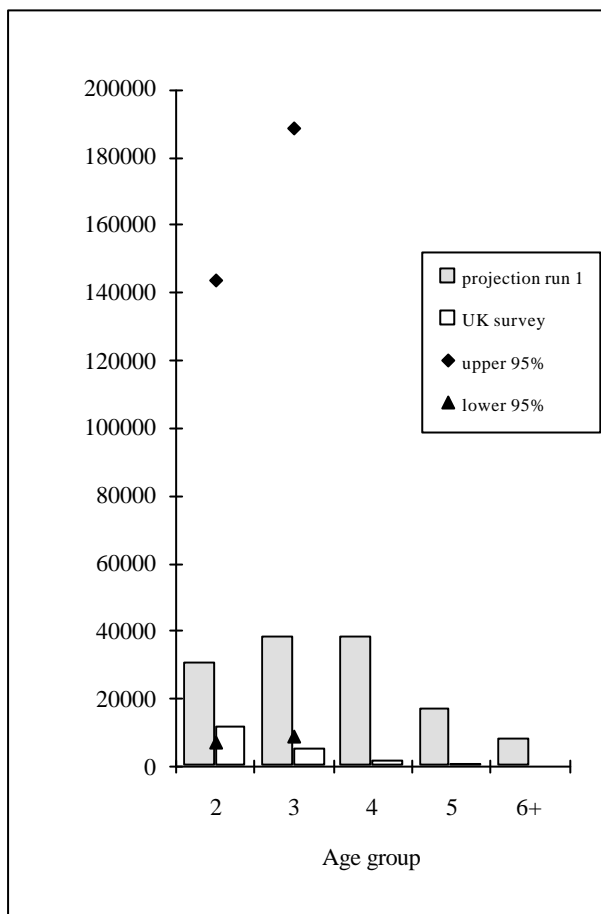


Figure 3: Projections of biomass of *C. gunnari* by age group (projection 1), with confidence intervals for the first two ages, compared with results from the UK survey in 1994.

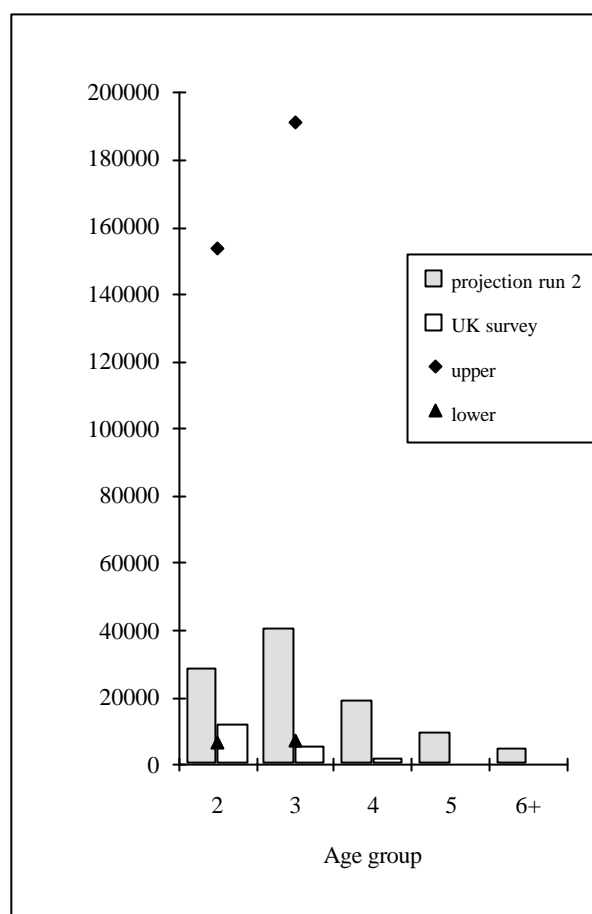


Figure 4: Projections of biomass of *C. gunnari* by age group (projection 2), with confidence intervals for the first two ages, compared with results from the UK survey in 1994.

4.60 In 1991 the Working Group considered a number of possible explanations for the apparent decline. These were reconsidered at the present meeting under the following headings:

- (i) unreported fishing mortality;
- (ii) recruitment failure;
- (iii) uncertainty in the estimates from the surveys including uncertainty caused by possible dispersal; and
- (iv) natural mortality in the recruited population above the level assumed in the projection.

## Unreported Fishing Mortality

4.61 The Working Group had received no information which suggested that unreported fishing on a scale necessary to account for the observed discrepancy had taken place.

## Recruitment Failure

4.62 The observed biomass of 2-year-olds in 1993/94 was within the 95% confidence bounds of the projections (Figures 3 and 4). The number of 2-year-olds in 1993/94 was projected back to the recruitment of 1-year-olds in 1992/93, assuming an  $M$  of 0.48. The absolute level of recruitment was in the region of 300 million individuals, which was at the lower end of the range of recruitment indicated by the VPA results at last year's meeting (SC-CAMLR-XII, Annex 5, Figure 7). These recruits would have resulted from the spawning event in March/April 1991, just after the UK survey in that year which indicated some abnormality in the ovarian maturation cycle of some fish, possibly linked to the low availability of krill in Subarea 48.3 at that time (SC-CAMLR-X, Annex 6, paragraph 7.31).

4.63 The observed biomass of 3-year-olds in 1993/94 was lower than the lower 95% confidence bounds of the projections (Figures 3 and 4). The number of 3-year-olds in 1993/94 was projected back to the recruitment of 1-year-olds in 1991/92. This implied an absolute level of recruitment of 1-year-olds in 1991/92 of only 80 million individuals. This would be considerably lower than the lowest recruitment estimated over the history of the fishery by the VPA performed at last year's meeting.

4.64 The Working Group concluded that the abundance of 2-year-olds observed in 1994 could be explained by a poor recruitment in 1992. However, the level of recruitment required to explain the observed number of 3-year-olds in 1994 was lower than would reasonably be expected. The current low abundance could not therefore be explained solely by poor recruitment.

## Uncertainty in the Estimates from the Surveys

4.65 Uncertainty in the stock estimates from the surveys arises from the patchy distribution of fish within strata and the consequent variation in density estimates between sampling stations. The confidence limits for the 1992 and 1994 UK surveys, shown in Table 3 and in Table 7 of last year's report (SC-CAMLR-XII, Annex 5), are comparatively narrow for trawl surveys of this type, reflecting the relatively even distribution of fish encountered.

4.66 The Working Group pointed out that these confidence limits do not take into account the possibility that there were patches of high density *C. gunnari* in Subarea 48.3 which were not detected by the UK surveys. For example, the Argentine survey in 1994 detected a high concentration of fish at Shag Rocks which apparently persisted for the few weeks during which the vessel was in Subarea 48.3. This patch was not detected during the UK survey which sampled in the Shag Rocks area only a few weeks before. The data could be re-analysed - to include the probability of encountering a patch - based on the results of the whole survey series. This would provide more realistic upper confidence limits regardless of whether a patch was encountered or not.

4.67 There were substantial uncertainties in the estimates of abundance from the surveys and recruitment, which may account for the observed discrepancy. However, the Working Group considered that this was unlikely given that the observations are based on best estimates. It was further considered that there could be serious implications for stock status if the observed decline was a genuine occurrence, but had been dismissed as an artefact of the analysis. Therefore other possible explanations were investigated.

4.68 Dr Everson recalled that the possibility of changes in distribution of *C. gunnari*, resulting in changes in availability to the trawl survey in Subarea 48.3, was considered at the Working Group meeting in 1991 as an explanation of the observed decline in abundance in that year. Such changes may also be responsible for the apparent decline in 1993/94.

4.69 There is no evidence that *C. gunnari* undertakes migrations away from Subarea 48.3 to other shelf areas on the scale necessary to account for the apparent decline.

4.70 Temporary dispersal of the population across the shelf and throughout the water column in Subarea 48.3 could reduce the availability of the fish to the bottom trawl survey, thus resulting in an artificially low estimate of standing stock. This could reasonably be expected to be followed by a corresponding increase in abundance associated with the fish returning to their normal distribution close to the seabed when conditions became favourable again. The increase in abundance indicated by the survey in the 1991/92 season was broadly in line with cohort projections from the 1990/91 survey. There was no indication that a substantial number of fish, absent in 1990/91, had returned to the shelf in 1991/92. The Working Group considered that the observations in 1991 and 1994 were sufficiently similar to infer that changes in distribution were probably not responsible for the apparent decline in 1993/94.

## Natural Mortality in the Recruited Population Above the Level Assumed in the Projection

4.71 There are two components to variation in M: an interannual component and an inter-age component. The historical low abundance of older fish (>5 years old) in the population shown by the VPA suggests that M may be increasing with age. The recent stock dynamics indicated by the surveys and cohort projections suggest that there may also be considerable variation in M between years.

4.72 The projections undertaken at last year's meeting were re-run at this year's meeting, incorporating variable M-at-age to investigate the level of M which would be required to match the projection with the observation in 1993/94. The variation in M around the normally assumed level of 0.48 was assumed to apply between 1992/93 and 1993/94. The implied change in M was substantial, ranging from 2.5 on 2- to 3-year-old fish to 4.5 on 4- to 5-year-old fish.

4.73 In considering the possible causes of such a change in M, the Working Group recalled the tentative link in 1991 made between the decline in *C. gunnari* abundance and the low availability of krill in Subarea 48.3 in that year. 1993/94 has also been characterised as a season of low krill availability at South Georgia. Discussions on the reliance of *C. gunnari* on krill as a food supply have been presented in previous Working Group reports. Information on the feeding status of *C. gunnari* during the UK survey was presented in WG-FSA-94/15. Overall feeding intensity was low, and the occurrence of krill in the diet was the lowest recorded since 1967. The main prey item in the absence of krill was *T. gaudichaudii*.

4.74 According to the diet analysis from the Argentine survey presented in WG-FSA-94/27, krill was the main food item in terms of frequency of occurrence, however a large proportion of empty stomachs were found and those stomachs containing food had a high proportion of *T. gaudichaudii*. The difference between both surveys may be due to methodological differences and their timing, as well as changes in plankton composition associated with water movements indicated in WG-FSA-94/29.

4.75 The occurrence of patches of high concentrations of *C. gunnari* has been linked to the fish feeding on krill concentrations in the past. The overall lack of krill concentrations in Subarea 48.3 during this period may explain the absence of high concentrations of *C. gunnari* in the UK survey. Lic. E. Marschoff (Argentina) suggested that the presence of a high concentration of *C. gunnari* around Shag Rocks in the Argentine survey may be explained by a localised aggregation of krill, perhaps resulting from oceanographic changes, given the higher frequency of occurrence of krill in the diets of fish in this area during its survey (see paragraphs 4.73 and 4.74).

4.76 The Working Group agreed that the repeat occurrence of an apparent drop in biomass at the same time as a low availability of krill was interesting, however in the absence of information on the stock in 1992/93, it was not possible to assess over what period the increase in M might have been occurring and whether the short-term shortage of krill could be responsible.

4.77 Information was presented to the Working Group in WG-FSA-94/17, suggesting that Antarctic fur seals (*Arctocephalus gazella*) might be responsible for periodic increases in mortality of *C. gunnari* in poor krill years. *A. gazella* feed substantially on krill and, to a smaller extent, on fish. When krill are scarce they change diet and feed predominantly on fish (North *et al.*, 1983<sup>2</sup>). The population of *A. gazella* has been increasing rapidly over the past three decades to the point where the current estimate of population size is 4.2 million animals (Boyd, 1993<sup>3</sup>). A change in the proportion of fish in the diet of fur seals, as might be expected when krill are scarce, would be sufficient to account for the observed decline in *C. gunnari* (see paragraph 5.5). Further work is required to refine the understanding of the spatial and temporal scales of the interaction between icefish, krill and fur seals before any firm conclusions can be drawn. The Working Group noted that the prey requirements of fur seals, particularly during periods of low krill availability, may need to be considered in future management advice for the *C. gunnari* fishery in Subarea 48.3.

#### Development of a Longterm Management Approach

4.78 On the basis of the uncertainties in the current stock status, the Working Group agreed that calculations of yield based on the approach developed for krill would be appropriate for this fishery. It was further agreed that work should begin on a longterm management plan for the fishery which accounts for uncertainty in biomass estimates, variability in recruitment, variability in M with age and between years, and variability in growth. In particular, the Working Group noted that the calculations of yield will need to incorporate the possibility of major mortality events occurring every few years. This estimate of a longterm annual yield should have a low probability of causing depletion in the stock.

4.79 The Working Group agreed that decision rules need to be developed for this fishery for deciding (i) what levels of longterm yield are appropriate, and (ii) under what circumstances the longterm yield may be varied (e.g., the use of pre-season surveys for setting annual TACs). An

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<sup>2</sup> North, A.W., J.P. Croxall and D.W. Doidge. 1983. *British Antarctic Survey Bulletin*, 61: 27-37.

<sup>3</sup> Boyd, I.L. 1993. *Antarctic Science*, 5: 17-24.

important component of this work is to determine the features of the stock that needs to be protected according to the objectives of the Convention.

#### Management Advice

4.80 The Working Group considered that developing a longterm management plan should be accorded a high priority. Uncertainty over many of the parameter values means that such an approach will take some time to develop. In the meantime, the Working Group provided advice solely on short-term management options.

4.81 The Working Group agreed that the calculation of yield on the basis of  $F_{0.1}$ , as done in the past, is no longer appropriate for this fishery given the uncertainty in stock biomass estimates, recruitment variability and possible large interannual variation in  $M$  and the potential for  $M$  to increase with age. Also, the recent apparent decline in stock abundance and the potential influence of predation by seals in some years suggest that the level of escapement of the spawning stock should be much greater than that which would occur under an  $F_{0.1}$  strategy. This is necessary in order to prevent a significant depletion of the stock and possible recruitment failure in poor krill years. The Working Group agreed that escapement of the spawning stock should be high for the 1994/95 season.

4.82 Given the uncertainties in  $M$  and other characteristics of the stock, the Working Group is unable to determine with any confidence the level of yield that would avoid significant depletion. Consequently, the Working Group recommends the fishery be closed for the 1994/95 season.

4.83 The Working Group strongly recommended that a survey be carried out during the coming season to monitor the status of the stock and provide more information for the development of the longterm management approach.

#### *Electrona carlsbergi* (Subarea 48.3)

4.84 The TAC for *E. carlsbergi* for the 1993/94 season was set at 200 000 tonnes in this subarea, and a local TAC for the Shag Rocks region was set at 43 000 tonnes (Conservation Measure 67/XII). No commercial catches were reported for the 1993/94 season.

4.85 No new survey or fishery information on the stock had been submitted to CCAMLR since last meeting.

4.86 A new assessment of yield for *E. carlsbergi* was presented to the Working Group in WG-FSA-94/21. This assessment was undertaken because:

- (i) previous assessments of WG-FSA showed that determining yield at  $F_{0.1}$  was not appropriate for this species (SC-CAMLR-X, Annex 6, paragraph 7.139);
- (ii) the biological and survey data available for the stock are now much older than the life expectancy of fish in the stock (SC-CAMLR-X, Annex 6, paragraph 7.133; SC-CAMLR-XII, Annex 5, paragraph 6.69); and
- (iii) WG-FSA has identified that a greater escapement of *E. carlsbergi* may be required to meet the needs of predators (SC-CAMLR-XII, Annex 5, paragraph 6.68).

4.87 An approach based on stock projections was used to estimate yields for *E. carlsbergi* given the uncertainties in the characteristics of the stock and in line with the objectives in Article II of the Convention. This approach has been endorsed by the Scientific Committee (SC-CAMLR-IX, paragraph 8.11) and developed further by WG-Krill with a krill yield model (SC-CAMLR-XII, paragraphs 2.66 to 2.75; Annex 5, paragraph 5.1). WG-Krill has developed three decision rules for adopting a yield estimate (where  $Y = \gamma \cdot B_0$ ):

- (i) choose  $\gamma_1$ , so that the probability of the spawning biomass dropping below 20% of its pre-exploitation median level over a 20-year harvesting period is 10%;
- (ii) choose  $\gamma_2$ , so that the median escapement over a 20-year period is 75%;
- (iii) select the lower of  $\gamma_1$  and  $\gamma_2$  as the level of  $\gamma$  for calculation of yield.

4.88 These decision rules and the use of the krill yield model as the basis for the analysis were used for estimating an appropriate  $\gamma$  for *E. carlsbergi* because this species and krill share a number of attributes, including population dynamics, behaviour and their importance as prey in the Antarctic ecosystem.

4.89 Paper WG-FSA-94/21 discusses the modifications made to the krill yield model to use it for estimating  $\gamma$  for fish stocks generally. The basic attributes of the krill model were retained in the generalised model, i.e. the timing of growth, options for fishing and the general projection structure (see Annex 5, paragraphs 4.51 to 4.110 for discussion of this work). The model was updated to allow input of biological and survey parameters and to allow variation of the simulation characteristics. The input parameters used to estimate  $\gamma$  with this generalised model are shown in



Table 5. Table 6 shows the values for  $\gamma$  for each decision rule. On the basis of the decision rules, the estimate of  $\gamma$  for calculating a TAC for *E. carlsbergi* was 0.091.

Table 5: Input parameters used to estimate  $\gamma$  for *E. carlsbergi*.

Parameter	Estimates	Source
Natural mortality (M)	0.65 to 0.98	SC-CAMLR-X, Annex 6, paragraph 7.138
Maximum age	5 years	SC-CAMLR-X, Annex 6, paragraph 7.136
$L_8$	95 mm	SC-CAMLR-X, Annex 6, paragraph 7.136
von Bertalanffy K	0.771	Derived using non-linear regression - SYSTAT, 1992 - of standard von Bertalanffy model with age and mean length from SC-CAMLR-X, Annex 6, Table 10
Age-at-maturity	3	SC-CAMLR-X, Annex 6, paragraph 7.131
Length-at-maturity	81.8 mm	Knife-edge maturity - taken as mean length-at-age of maturity minus one standard deviation (data from SC-CAMLR-X, Annex 6, Table 10)
Age-at-recruitment	2	SC-CAMLR-X, Annex 6, paragraph 7.131
Length-at-recruitment	60 mm	Knife-edge recruitment (SC-CAMLR-X, Annex 6, paragraph 7.131)
Range in recruitment variability	0.4 to 0.6	No data are available to determine variation in recruitment (SC-CAMLR-X, Annex 6, paragraph 7.133). This range has been adopted from Butterworth <i>et al.</i> (1994)* for krill.
CV of biomass estimate	0.3	SC-CAMLR-X, Annex 6, paragraph 7.134
Fishing season	All year	Consistent with Conservation Measure 67/XII
Selectivity	Ages 1,4,5 = 0 Age 2 = 1 Age 3 = 0.2	SC-CAMLR-X, Annex 6, paragraph 7.138

\* Butterworth, D.S., G.R. Gluckman, R.B. Thomson, S. Chalis, K. Hiramatsu and D.J. Agnew. 1994. Further computations of the consequences of setting the annual krill catch limit to a fixed fraction of the estimate of krill biomass from a survey. *CCAMLR Science*, Vol. 1: 81-106.

Table 6:  $\gamma$  values derived for *E. carlsbergi*.

Decision Rule 1	Decision Rule 2	Decision Rule 3
$\gamma_1$ 0.091	$\gamma_2$ 0.102	$\gamma$ to calculate yield 0.091

4.90 The Working Group agreed that the approach and decision rules adopted for estimating krill yields by WG-Krill are appropriate for estimating yield for *E. carlsbergi*. On this basis, the Working Group agreed that the estimate of  $\gamma$  of 0.091 was the best available. However, the

Working Group also noted that the estimate will be influenced by the variability in the pre-exploitation biomass estimate, range of recruitment variability, estimates of  $M$  and von Bertalanffy  $K$ , the timing of the period of fish growth (punctuated versus continuous growth) and the relationship between the fishing season and the growth and reproductive periods. For these reasons, the Working Group noted that the estimate of  $\gamma$  will need to be refined following (i) investigations of the sensitivity of the model to uncertainty in these parameters, and (ii) acquisition of refined estimates of those model parameters, such as and in particular, recruitment variability.

#### Management Advice

4.91 The Working Group agreed that, pending refined estimates of the stock parameters and biomass, the decision rules adopted for estimating krill yield are appropriate for *E. carlsbergi* and that the estimate of  $\gamma$  of 0.091 is the best available.

4.92 The most recent estimate of *E. carlsbergi* biomass was from a survey in 1987/88. This was used as the basis for calculating a TAC of 200 000 tonnes (Conservation Measure 67/XII) in 1993/94. Using this estimate of biomass and the new estimate of  $\gamma$  from the generalised krill yield model, the corresponding catch levels would be 109 100 tonnes for Subarea 48.3 and 14 500 tonnes for the region around Shag Rocks.

4.93 The Working Group reiterated its concern that the biomass estimate is out of date and that, as a consequence, the recalculated catch levels should be viewed with caution. The Working Group requests that in the event that a fishery should recommence on this stock, a new biomass survey and revision of the biological parameters should be undertaken in accordance with Conservation Measure 67/XII, paragraph 4, in order to be able to refine the estimates of yield for this stock.

#### Other Species (Subarea 48.3)

4.94 Biomass estimates and length compositions were available from the UK (WG-FSA-94/18) and Argentine (WG-FSA-94/29) bottom trawl surveys around South Georgia. Due to methodological differences in survey design and analysis between the two surveys, the Working Group based its assessments primarily on results from the UK surveys for which comparable data are available for a number of recent years (Tables 7 and 8).

Table 7: Comparison of biomass estimates (tonnes) with the results from previous UK surveys around South Georgia.

Species	Season									
	1988/89		1989/90		1990/91		1991/92		1993/94	
	A	CV%	B	CV%	C	CV%	D	CV%	E	CV%
<i>C. gunnari</i>	31700	45	95435	63	22089	16	37311	21	14923	21
<i>C. aceratus</i>	5770	14	14226	37	13474	15	12459	15	9685	19
<i>P. georgianus</i>	8278	53	5761	28	13948	19	13469	15	5707	18
<i>N. gibberifrons</i>	8510	17	12417	28	28224	18	29408	15	23459	20
<i>N. rossii</i>	2439	54	1481	76	4295	49	7309	61	6600	45
<i>D. eleginoides</i>	326	66	335	39	885	37	2460	21	2219	24
<i>N. squamifrons</i>	131	98	1690	-	1374	43	1153	60	1148	79

A = Parkes *et al.* (1989) WG-FSA-89/6

B = Parkes *et al.* (1990) WG-FSA-90/11

C = UK Falklands Protector survey (1991) WG-FSA-91/14

D = UK Falklands Protector survey (1992) WG-FSA-92/17

E = UK FPV Cordella survey (1994) WG-FSA-94/18

Table 8: Comparison of biomass estimates (tonnes) with the results from previous UK surveys around Shag Rocks. Surveys as for Table 7.

Species	Season							
	1989/90		1990/91		1991/92		1993/94	
	B	CV%	C	CV%	D	CV%	E	CV%
<i>C. gunnari</i>	279000	83*	3919	75	2935	35	4601	24
<i>C. aceratus</i>							10	100
<i>P. georgianus</i>	37	73	15	62				
<i>N. gibberifrons</i>	267	39	117	34	166	26	107	35
<i>D. eleginoides</i>	9631	55	19315	94	3353	35	1767	25
<i>N. squamifrons</i>	120	44	631	33	83	74	618	56
<i>P. guntheri</i>	13608	90	584	45	12764	61	4589	36

\* with large-scale adjustment added (SC-CAMLR-X, Annex 6)

4.95 Biomass estimates provided in WG-FSA-94/18 were based on the 'traditional' method of calculating biomass by using sample means (Saville, 1977<sup>4</sup>). Re-analysis of these results using the MVUE model (WG-FSA-93/20) resulted in higher biomass estimates for all species; the trend in biomass over time was similar to results presented in Table 7.

4.96 The difference in biomass estimates obtained using the 'traditional' method and the MVUE approach varied among species, sometimes to a larger extent than was expected from the assumed comparatively even spatial distribution of the species. The Working Group therefore recommended that the causes of these differences be explored in the intersessional period. For the time being the

<sup>4</sup> Saville, A. (Ed.) 1977. Survey methods of appraising fisheries resources. *FAO Fish. Tech. Paper.*, 71: 76 pp.

Working Group decided that since it generally uses survey results as indices of abundance, it would be appropriate to use the results derived by the 'traditional' method from the UK surveys since 1989 as its primary index of abundance (Table 7).

#### *Notothenia rossii* (Subarea 48.3)

4.97 The biomass estimate of 6 600 tonnes was within the confidence limits of estimates from previous surveys since 1991 (Table 7). Length compositions, albeit based on sample sizes of a few hundred specimens only, were similar to those from previous surveys. Both observations suggest little change in stock composition in recent years.

#### Management Advice

4.98 The Working Group reiterated its advice from previous years that all conservation measures for this species should remain in force (Conservation Measures 2/III, 3/IV and 68/XII).

#### *Notothenia gibberifrons*, *Chaenocephalus aceratus* and *Pseudochaenichthys georgianus* (Subarea 48.3)

4.99 Biomass estimates for these three species were lower than from previous surveys (Tables 7 and 8). The decrease in biomass of *N. gibberifrons* and *C. aceratus* fell within the confidence limits of estimates from previous surveys. However, the biomass estimate for *P. georgianus* was significantly below previous estimates (Table 7).

4.100 Length composition data for *N. gibberifrons* showed a steady increase in the proportion of adult fish (>34 cm) in the stock (Figure 5). The proportion of adult *C. aceratus* (>42 to 45 cm) has decreased from 1990 to 1992, but increased again in 1994 (Figure 6).

4.101 Length composition data for *P. georgianus* demonstrated that a strong year-class (1988 cohort) had recruited to the stock in 1990. Recruitment in subsequent years was much lower (Figure 7). The 1988 cohort was still dominant in the stock in 1991 and 1992. If this species is as short-lived as has been assumed in a previous assessment (Agnew and Kock, 1990<sup>5</sup>), part of the decline in biomass may be explained by the disappearance of this year-class from the stock.

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<sup>5</sup> Agnew, D.J. and K.-H. Kock. 1990. An assessment of *Chaenocephalus aceratus* and *Pseudochaenichthys georgianus* in Subarea 48.3. Document WG-FSA-90/6 (mimeo). CCAMLR, Hobart, Australia.

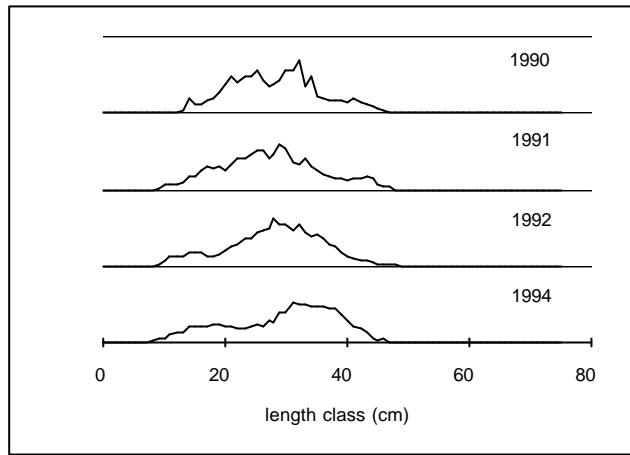


Figure 5: Length frequency distributions of *N. gibberifrons* from UK surveys in Subarea 48.3. There was no survey in 1993.

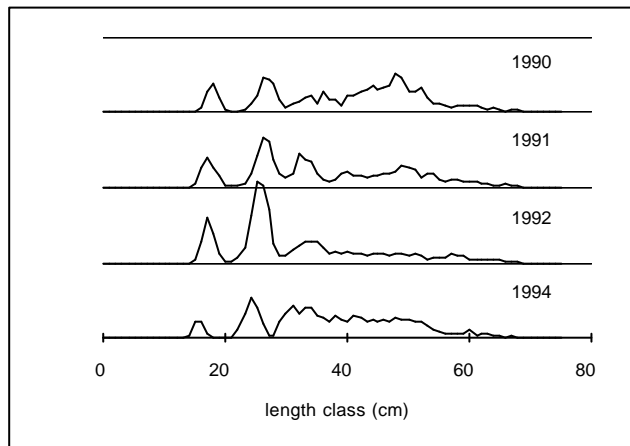


Figure 6: Length frequency distributions of *C. aceratus* from UK surveys.

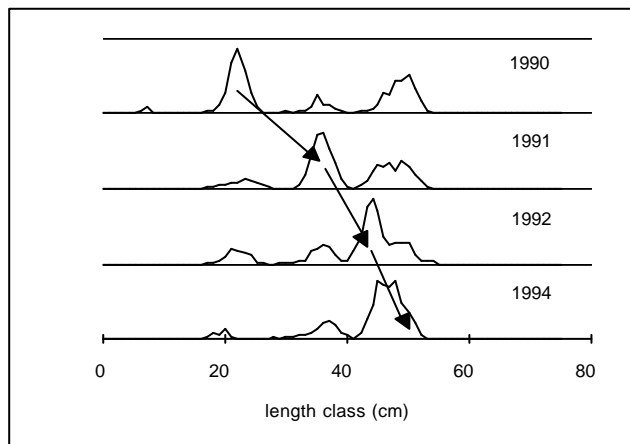


Figure 7: Length frequency distributions of *P. georgianus* from UK surveys.

## Management Advice

4.102 The Working Group reiterates its advice from previous years (e.g., SC-CAMLR XII, Annex 5, paragraph 6.64). All these species have been taken in quantity only by the commercial bottom trawl fishery. None of them can be taken without a significant by-catch of other species. Given the current low potential yield of these species and the likely high by-catch of *C. gunnari* in a fishery of these species, the Working Group recommended that a directed fishery of these species should remain prohibited (Conservation Measures 48/XI and 68/XII).

### *Notothenia squamifrons*, *Patagonotothen guntheri* (Subarea 48.3) - Management Advice

4.103 The distributional range of both species was not adequately covered during the survey. The bathymetric range of *N. squamifrons* extends considerably beyond 500 m. *P. guntheri* has a semi-pelagic mode of life. Consequently, both biomass estimates provided in WG-FSA-94/18 underestimate stock size to an unknown extent. In the absence of any new information which would allow an assessment of the two stocks, the Conservation Measures presently in force should be retained (Conservation Measures 48/XI and 68/XII).

### SOUTH GEORGIA (SUBAREA 48.3) - CRABS (*Paralomis spinosissima* and *P. formosa*)

4.104 During the 1993/94 season no vessels fished for crabs in Subarea 48.3.

4.105 No new data were available for assessing the crab stock in Subarea 48.3. Consequently, there are still large uncertainties associated with the most recent estimates of the standing stocks of these species (SC-CAMLR-XI, paragraph 4.15).

4.106 Since it was not possible to reassess the crab stock, the Working Group recognised that a conservative management scheme is still appropriate for this fishery. In particular, the Working Group noted that the fishery should be controlled by direct limitations on catch and effort, as well as by limitations on the size and sex of individual crabs which may be retained in the catch. The Working Group agreed that Conservation Measure 74/XII contains such limitations, and that it should continue to be applied in the management of the crab fishery.

4.107 The Working Group recalled the Commission's view that 'an exploratory fishery should not be allowed to expand faster than the acquisition of information necessary to ensure that the

fishery can and will be conducted in accordance with the principles in Article II of the Convention' (CCAMLR-XI, paragraph 4.28; SC-CAMLR-XI, paragraph 3.49). Given this view, the Working Group agreed that Conservation Measure 75/XII could provide valuable information about the crab stock (SC-CAMLR-XII, Annex 5, paragraph 6.97) and should continue to be applied in the management of the fishery.

4.108 The Working Group also noted that the Commission has requested the Scientific Committee to develop a longterm management strategy for the crab fishery (CCAMLR-XI, paragraphs 9.48 to 9.50). The Working Group reviewed WG-FSA-94/26 in addressing this topic.

4.109 Paper WG-FSA-94/26 outlines the construction of a simulation model that might be useful for evaluating certain aspects of Conservation Measure 75/XII and facilitating the development of a longterm management plan for the crab fishery. The simulation model is spatially explicit and describes crab distribution and movement, recruitment and fishing strategy.

4.110 The Working Group welcomed the development of the crab fishery simulation model and encouraged further work. The Working Group recommended that data from other crab fisheries (e.g., the Alaskan King crab fishery) be used to refine parameter estimates and test various assumptions in the model. Since results from the simulation are likely to be sensitive to fishing strategy, the Working Group also agreed that alternative fishing models should be explored.

4.111 Given the lack of data available for assessing the crab stock, the Working Group reiterated its prior recommendation that fishery-independent surveys of the crab stock be given a high priority (SC-CAMLR-XII, Annex 5, paragraph 6.101).

#### Management Advice

4.112 High-priority topics for future research are identified in SC-CAMLR-XII, Annex 5, paragraph 6.89. These include:

- (i) consideration should be given to the use of time-release or biodegradable devices to reduce the effects of ghost fishing should pots be lost from a line;
- (ii) a minimum mesh size should be adopted and/or an escape port included in pots (usually a metal ring set into the side of the pot) following research on mesh or port selectivity. This will serve to select only crabs of harvestable size more effectively as

well as reducing the number of potential discards but will reduce the ability to monitor parasitic infection; and

- (iii) experiments should be conducted using pots with finer mesh or escape ports added to commercial pot lines in order to obtain more representative length frequency information from harvested stocks.

No data relating to these topics are currently available.

4.113 The current TAC of 1 600 tonnes and other regulations contained in Conservation Measure 74/XII should remain in force for the 1994/95 fishing season.

4.114 The Working Group recommended that Conservation Measure 75/XII should remain in force for the 1994/95 fishing season.

4.115 The data required for collection from the fishery are detailed in SC-CAMLR-XII, Annex 5, paragraph 6.102; these data should be submitted to CCAMLR in haul-by-haul form.

ANTARCTIC PENINSULA (SUBAREA 48.1)  
AND SOUTH ORKNEY ISLANDS (SUBAREA 48.2)

*Champocephalus gunnari*, *Notothenia gibberifrons*, *Chaenocephalus aceratus*,  
*Pseudochaenichthys georgianus*, *Chionodraco rastrispinosus*  
and *Notothenia kempfi* - Management Advice

4.116 No new information was available to enable the Working Group to assess stocks in these subareas. Previous biomass assessments from research surveys have become completely out of date and although the Argentinian survey reported in paragraph 3.14 above (February 1994) did extend to Subarea 48.2, only two hauls were taken in this area, insufficient to provide a biomass estimate. Accordingly, the Working Group reiterated the advice offered in 1993 that the fisheries in Subareas 48.1 and 48.2 should remain closed until a survey is conducted to provide more accurate estimates of the status of these stocks (Conservation Measures 72/XII and 73/XII).



SOUTH SANDWICH ISLANDS (SUBAREA 48.4)

4.117 Although a small fishery of *D. eleginoides* was open in this area (TAC of 28 tonnes), no catches were reported. In the absence of further information the Working Group could not update its advice from last year and recommended that Conservation Measure 71/XII be retained.

STATISTICAL AREA 58

4.118 Catches from the 1994 season are shown in Table 9. Catches of *D. eleginoides* in Division 58.5.1 were taken in the directed French and Ukrainian trawl and longline fisheries.

4.119 Catches in Subarea 58.6 were taken in a French exploratory trawl fishery around the Crozet Islands. This exploratory fishery was part of a series of such expeditions conducted by France in 1983, 1987, 1988 and now 1994. Results will be presented at the next meeting of the Working Group.

Kerguelen Islands (Division 58.5.1)

*Notothenia rossii* (Division 58.5.1)

4.120 Dr P. Tankevich (Ukraine) suggested in WG-FSA-94/4 that data from small by-catches of *N. rossii* in fisheries directed at other species and from research cruises after the closure of the directed fishery for *N. rossii* in 1985 show that the age and size structure of the population are approaching those that existed in the early stages of the fishery. On this basis WG-FSA-94/4 suggested that a small fishery for this species would be appropriate.

4.121 Although Prof. Duhamel agreed that there was an increase in juvenile fish in their inshore nursery grounds according to the results of a scientific monitoring program between 1982 and 1992, these fish would not yet have been fully recruited to a fishery. Therefore, he considered it would be premature to re-open the fishery.

Table 9: Total catches by species and subarea in Statistical Area 58. Species are designated by abbreviations as follows: ANI (*Champscephalus gunnari*), LIC (*Channichthys rhinoceratus*), TOP (*Dissostichus eleginoides*), NOR (*Notothenia rossii*), NOS (*Notothenia squamifrons*), ANS (*Pleuragramma antarcticum*), MZZ (Unknown), SRX (*Rajiformes spp.*), WIC (*Chaenodraco wilsoni*).

Split-Year	ANI		LIC	WIC	TOP				NOR			NOS			ANS		MZZ			SRX		
	58	58.5			58.5	58.4	58	58.4	58.5	58.6	58	58.4	58.5	58	58.4	58.4	58	58.4	58		58.4	58.5
1971	10231				XX				63636			24545								679		
1972	53857				XX				104588			52912								8195		
1973	6512				XX				20361			2368								3444		
1974	7392				XX				20906			19977								1759		
1975	47784				XX				10248			10198								575		
1976	10424				XX				6061			12200								548		
1977	10450				XX				97			308								11		
1978	72643	250	82		196	-	2	-	46155			31582		98	234					261		
1979				101	3	-	-	-				1307								1218		
1980		1631	8	14		56	138	-					4370	11308						239		
1981		1122	2			16	40	-		217	7924		2926	6239						375	21	
1982		16083				83	121	-		237	9812		785	4038	50					364	7	
1983		25852				4	128	17			1829		95	1832	229					4	17	1
1984		7127				1	145	-		50	744		203	3794							611 <sup>1</sup>	17
1985		8253		279		8	6677	-		34	1707		27	7394	966					11	7	4
1986		17137		757		8	459	-		-	801		61	2464	692							3
1987		2625		1099		34	3144	-		2	482		930	1641	28					22		
1988		159		1816		4	554	488		-	21		5302	41	66							

Split-Year	ANI		WIC	TOP		NOR	NOS		ANS			
	58.5.1	58.5.2		58.4.2	58.4.4		58.5.1	58.6	58.4.4	58.5.1	58.4.2	58.4.4
1989	23628	-	306	35	1630	21		245	3660	-	30	17
1990	226	-	339	5	1062	-		155	1450	-	-	-
1991	13283 <sup>2</sup>	-	-	-	1944	-		287	575	-	-	-
1992	44	3	-	-	7492 <sup>3</sup>	-		-	-	1	-	-
1993	-	-	-	-	2722	-		-	-	-	-	-
1994	12	3	-	-	5083	56		-	-	-	-	-

<sup>1</sup> Mainly *Rajiformes spp.*

<sup>2</sup> There are some discrepancies between the French statistics for the Soviet fishery under licence (12 644 tonnes) in Division 58.5.1 and the STATLANT A data provided by the USSR (13 268 tonnes). It may be explained by the inclusion of 826 tonnes of by-catch (mainly *Rajiformes*) in this total.

<sup>3</sup> 1 589 tonnes - France; 5 903 tonnes - Ukraine, of which 705 tonnes were caught by longline.

NB: Before 1979/80 catches reported in Statistical Area 58 mainly concern Division 58.5.1 (Kerguelen subarea). Catch reporting was not divided into Divisions 58.5.1 and 58.5.2 until the 1989 season.

4.122 The most recent biomass survey for this species, in the 1987/88 season, indicated less than 10 000 tonnes total biomass. The current biomass is therefore very much less than the biomass before the fishery commenced, when 168 000 tonnes were taken in the first two years of the fishery. The Working Group also noted that the data were taken from a different part of the shelf to that on which the fishery was conducted, and therefore are not representative of the entire fished stock. To recommence the fishery now would be in contravention of Article II 3(a) which stipulates that the size of a population be prevented from falling below a level close to that which ensures greatest net annual increment.

#### Management Advice

4.123 The Working Group recommended 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.

#### *Notothenia squamifrons* (Division 58.5.1)

4.124 As no data have been received on this species no new assessment can be made.

#### Management Advice

4.125 In the absence of new data and assessments, the Working Group recommended that the Kerguelen shelf fishery should remain closed.

#### *Champscephalus gunnari* (Division 58.5.1)

4.126 Following management advice from the 1993 meeting, no commercial fishing for this species was conducted. Some research trawls were made to investigate length frequency distribution.

4.127 Prof. Duhamel presented data from a monitoring program on *C. gunnari* stocks on the northern part of the Kerguelen inner shelf between 1989 and 1992 (WG-FSA-94/9). This confirmed previous ideas on the structure of the population:

- only one strong cohort exists in the fishery at any time;
- other cohorts exist, but their abundance is very low;
- each cohort lasts three years and then disappears from the fishery;
- recruitment seems to be very variable - there are great interannual differences in the number of spawners on the winter inshore spawning grounds, and abundance of juvenile fish is in proportion to the strength of the spawning cohort, which maintains a three-year cycle of abundance; and
- growth rate and size at maturity are not significantly different between cohorts.

4.128 In the 1994/95 season there should be a strong age 3+ cohort (born in 1991), which spawned for the first time during winter (July 1994). The 1991 cohort has been identified both in the inshore part of the shelf (1991/92) and subsequently on the usual fishing grounds during 1993/94.

#### Management Advice

4.129 The 1993 report recommended that fishing of the strong cohort being recruited should be delayed until the 1994/95 season, by which time it would have had the opportunity to spawn. Also, only restricted fishing in the 1994/95 season should be allowed, to enable sufficient escapement of fish to spawn a second time and because a declining trend in strength of previous strong cohorts has been detected. The first requirement of last year's recommendation, i.e. that no fishing take place in the 1993/94 season, has been met. The Working Group cannot, however, recommend a catch limit for the 1994/95 season because no data on the biomass of this cohort are available. The Working Group reiterates the advice that a proportion of the cohort be allowed to survive another year to spawn a second time, in the hope that this will contribute to establishing a population with more than one strong cohort and consequently reduce variability in biomass.

4.130 The Working Group recommended that the fishery in the 1994/95 season be kept to a low level to allow the present strong cohort to spawn a second time.

*Dissostichus eleginoides* (Division 58.5.1)

4.131 Fishing for this species continued in the 1993/94 season in the two traditional areas, a longline fishery on the western slope and a trawl fishery on the northern shelf. In the area on the western slope of the plateau, 942 tonnes were caught by three Ukrainian longliners. This catch was less than the 1 400 tonnes recommended in the 1993 report. French authorities have already set a 1994/95 limit of 1 000 tonnes in the western area for the longline fishery.

4.132 In the northern area, 4 141 tonnes were caught by two French trawlers. The 1993 report recommended limitation of catches for this area, but as this fishery is only three years old the trend in the abundance index (CPUE) is not yet defined enough to give any clear indication of what a catch limit might be. A precautionary catch limit of 3 000 tonnes in the northern area for the trawl fishery has been set by French authorities for the 1994/95 season.

4.133 No other new data were provided.

Management Advice

4.134 In the absence of any new data, the Working Group endorses the French conservation measures (paragraphs 4.131 and 4.132). These are consistent with the Working Group's previous advice that a longterm sustainable yield for the western area is estimated at 1 400 tonnes, and that a precautionary approach should be taken with the northern area to prevent the spawning stock size falling to low levels before the stock has been adequately assessed.

4.135 The Working Group reiterates its previous advice that for proper assessment of these stocks, trawl surveys of the entire stocks would provide indices of abundance to model the stock dynamics and sustainable yield.

Ob and Lena Banks (Division 58.4.4)

4.136 In 1992 the Working Group stated that the stocks of *N. squamifrons* on the Ob and Lena Banks are likely to sustain a fishery of only a few hundred tonnes. It recommended that a survey to determine age structure and stock size on both banks should be undertaken before the fishery is reopened. This view was endorsed by the Scientific Committee (SC-CAMLR-XI, paragraph 3.94).

4.137 During the same meeting of the Scientific Committee, Ukraine stated that it intended to conduct a survey to estimate the biomass of fish species on both banks in 1993 (SC-CAMLR-XI, paragraph 3.95). As a consequence, the Commission implemented Conservation Measure 59/XI limiting the catch of *N. squamifrons* on both banks for the 1992/93 and 1993/94 seasons. No survey was undertaken in either of these two seasons although a proposal for a survey had been submitted for review to WG-FSA in 1993 (WG-FSA-93/10). The conservation measure expired on 30 June 1994.

4.138 Paper WG-FSA-94/7 has provided amended catch statistics and given age and length composition data for *N. squamifrons* from Lena Bank in the 1990/91 season. The paper also states that interannual fluctuations in mean length and age in the catch were more a result of sampling variations than of real change in the population structure. The Working Group requests the author to provide more evidence for his assertion because, if true, it would invalidate previous assessments.

4.139 Paper WG-FSA-94/7 also reports a catch of 29 tonnes of *D. eleginoides* in the 1990/91 season.

4.140 During the meeting Ukraine submitted revised catch figures for both banks for 1978 to 1991 as part of SC-CAMLR XIII/BG/13. However, this new information did not arrive in time for the Working Group to attempt to revise previous assessments.

#### Management Advice

4.141 The Working Group reaffirms its position of 1992 and 1993 that a biomass survey is likely to improve considerably assessments of the fish stocks on the two banks.

4.142 The Working Group recommended that Ukraine should conduct the proposed survey on the Ob and Lena Banks as outlined in paragraphs 6.9 to 6.15. However, it was noted that the survey vessel will have to use a net monitor cable (see paragraph 6.13).

4.143 Given the uncertainties associated with stock size and stock structure of the fish stocks on both banks, the Working Group recommended that a TAC of 1 150 tonnes for *N. squamifrons* (715 tonnes for Lena Bank and 435 tonnes for Ob Bank) - as previously set in Conservation Measure 59/XII - be re-instituted for the seasons 1994/95 and 1995/96 combined.

4.144 Data reporting should follow the CCAMLR Database format and data recording should be in accordance with the requirements set out in Conservation Measure 64/XII. This information should include all species caught.

4.145 In the event that the proposed survey is postponed by one year, the TAC recommended may need to be revised in the light of new assessments by the Working Group based on the revised catch figures provided in SC-CAMLR-XIII/BG/13.

4.146 The presence of seabirds close to the ship should be monitored and any incidental mortality caused by the net monitor cable must be reported.

#### Heard and McDonald Islands (Division 58.5.2)

4.147 No commercial catches have ever been reported for this area. However, some exploratory Polish fishing occurred in 1975 and some of the Soviet catch from the early 1970s in Subarea 58.5 may have come from this division before separate statistics were kept for each division.

4.148 The results of three trawl surveys conducted in the area since 1990 were reported in WG-FSA-94/10. Estimates of abundance were derived from a swept-area trawl survey according to a random stratified survey design. Strata were by depth around Heard Island with the addition of a number of banks in the region - Shell, Discovery, Pike, Coral and Aurora Banks and Gunnari Ridge (see WG-FSA-94/10 for variation of the design between surveys). These surveys were undertaken in (austral) winter 1990, summer 1992 and spring 1993. The composition of fish fauna obtained during these surveys was very similar to that found around Kerguelen Island. The main species found were *C. gunnari*, *D. eleginoides*, *Channichthys rhinoceratus*, *N. squamifrons* and rays (*Bathyraja* spp.). These fish varied in their distribution around Heard Island from an even distribution across strata for *D. eleginoides* to a very patchy distribution of *C. gunnari* concentrating in the shelf areas and banks between 200 and 300 m depth. A summary of biomass estimates for each survey (with 95% confidence intervals (CI) and CV) is shown in Table 10. These estimates and confidence intervals were derived using de la Mare's (1994)<sup>6</sup> method for obtaining MVUES.

4.149 For *C. rhinoceratus* and rays, there are no reliable biological parameters that can be used in a yield analysis.

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<sup>6</sup> de la Mare, W.K. 1994. Estimating confidence intervals for fish stock abundance estimates from trawl surveys. *CCAMLR Science*, Vol. 1: 203-207.

Table 10: Summary of estimates and 95% confidence intervals of total abundance by species and survey in tonnes. Survey 1 = winter 1990; survey 2 = summer 1992; survey 3 = spring 1993.

	Lower CI	Estimate	Upper CI	CV (%)
<i>C. gunnari</i>				
Survey 1	2606	4585	113019	25.7
Survey 2	944	3111	427728	53.5
Survey 3	4112	31701	14712200	80.1
<i>C. rhinocerotus</i>				
Survey 1	1249	2019	4924	25.6
Survey 2	1485	2765	24649	30.8
Survey 3	1397	2210	6629	24.8
<i>D. eleginoides</i>				
Survey 1	11210	17714	45004	25.2
Survey 2	2220	3179	8488	19.2
Survey 3	8375	11880	19284	18.6
<i>L. squamifrons</i>				
Survey 1	1310	2844	58658	41.8
Survey 2	4249	41378	9586070	87.0
Survey 3	14	31	94	39.2
Rays				
Survey 1	735	5370	26771	35.6
Survey 2	7060	10506	46280	21.2
Survey 3	850	2369	25453	52.9

4.150 Paper WG-FSA-94/30 presents yield estimates for two stocks, *C. gunnari* and *D. eleginoides*, based on the generalised version of the krill yield model used for estimating yield for *E. carlsbergi* (WG-FSA-94/21; paragraphs 4.87 to 4.90). The same decision rules adopted for krill and for *E. carlsbergi* have been used to estimate  $\gamma$  in the equation  $Y = \gamma \cdot B_0$ . The input parameters are shown in Table 11 and the estimates of  $\gamma$  for each survey estimate of these two species are shown in Table 12.

4.151 The Working Group agreed that this approach for estimating yield was a useful way of deriving precautionary TACs for these stocks. It was noted that the estimates of  $\gamma$  may be subject to the following sources of error:

- (i) the length and timing of fishing season (estimates in WG-FSA-94/30 were based on a summer fishing season);
- (ii) estimates of M and K (estimates in Table 11 are from stocks other than Heard Island);
- (iii) the potential correlation between M and K; and



- (iv) the number of years in the pre-exploitation period, because fishing in the simulation should begin in a year where the stock composition is independent of the initial stock structure in the simulation.

Table 11: Parameters used to determine gamma ( $\gamma$ ) in the generalised krill yield model for *C. gunnari* and *D. eleginoides* around Heard Island.

Parameter	Value	Source
<i>C. gunnari</i>		
M	0.3 to 0.5	(1)
$L_{inf}$	39cm	(2)
K	0.3702	(3)
Maximum age	6 years	(4)
Length-at-maturity	25cm	(2)
Age-at-maturity	3 years	(2)
Length-at-recruitment (Nov)	28cm	(2)
Age-at-recruitment (Nov)	3 years	(2)
Recruitment variability	10 to 90%	(4)
CV of biomass estimate	(Survey 1) 0.257	(5)
	(Survey 2) 0.535	(5)
	(Survey 3) 0.801	(5)
<i>D. eleginoides</i>		
M	0.1 to 0.2	(1)
$L_{inf}$	204cm	(1)
K	0.0563	(1)
max. age	20 years	(2)
Length-at-maturity	94cm	(2)
Age-at-maturity	10 years	(2)
Length-at-recruitment (Nov)	35cm	(4)
Age-at-recruitment (Nov)	3 years	(4)
Recruitment variability	40 to 60%	(4)
CV of biomass estimate	(Survey 1) 0.252	(5)
	(Survey 2) invalid - survey omitted major area of distribution	
	(Survey 3) 0.186	(5)

Sources: (1) estimates based on Kock *et al.* (1985); (2) from Kerguelen data of Duhamel (various publications); (3) Kerguelen data from Kock *et al.* (1985); (4) authors' estimate, based on behaviour of Kerguelen population and data from Heard Island region; (5) this paper.

Table 12: Values of  $\gamma$  from WG-FSA-94/30, determined to satisfy the two decision rules discussed in the text for *C. gunnari* and *D. eleginoides* in three surveys around Heard Island. These estimates are based on a fishing season over summer only. The length of pre-exploitation period is 10 years in all calculations. Column 1 is that  $\gamma$  for which the probability of depletion to 0.2 of the pre-exploitation spawning biomass over 20 years harvesting = 0.1. Column 2 is that  $\gamma$  for which the median spawning stock biomass after 20 years fishing will be 0.75 of the median pre-exploitation spawning stock biomass.

Species	Survey	1	2
<i>C. gunnari</i>	Survey 1	0.112	0.120
<i>C. gunnari</i>	Survey 2	0.093	0.129
<i>C. gunnari</i>	Survey 3	0.080	0.149
<i>D. eleginoides</i>	Survey 1	0.043	0.027
<i>D. eleginoides</i>	Survey 3	0.046	0.027

4.152 The program for estimating yield was modified to embrace the last point. New estimates of  $\gamma$  were derived for both stocks for a fishing season lasting the whole year, which is likely to be more realistic. Also, the effect of different levels of M and K on  $\gamma$  was explored. These results are shown in Table 13.

Table 13: Estimates of  $\gamma$  for different input parameters in the yield model for *C. gunnari* and *D. eleginoides* at Heard Island. The fishing season is all year. 'Source parameters' refers to estimates of  $\gamma$  using the parameters in Table 11, but with a fishing season covering the whole year. Model parameters indicated in the table are those which differ from those in Table 11. Numbers in parentheses refer to the % difference of that  $\gamma$  from the baseline. The number of years in the simulations before fishing begins is 10 for *C. gunnari* and 20 for *D. eleginoides*.

Model	Survey 1 Winter 1990		Survey 2 Summer 1992		Survey 3 Spring 1993	
<i>C. gunnari</i>						
Source parameters	0.119		0.100		0.094	
M: 0.2-0.6	0.120	(1)	0.099	(1)	0.090	(4)
M: 0.2-0.4	0.117	(-2)	0.096	(-4)	0.083	(-12)
M: 0.4-0.6	0.125	(5)	0.108	(8)	0.101	(7)
K = 0.32	0.103	(-13)	0.090	(-10)	0.077	(-18)
K = 0.42	0.143	(20)	0.136	(36)	0.135	(44)
<i>D. eleginoides</i>						
Source parameters	0.026		-		0.025	
M: 0.05-0.25	0.026	(0)	-		0.026	(4)
M: 0.2-0.3	0.028	(8)	-		0.028	(12)
K = 0.045	0.025	(-4)	-		0.024	(-4)
K = 0.065	0.026	(0)	-		0.026	(4)
Re-run of summer fishing with 20-year pre-fishing period	0.026	(0)	-		0.025	(0)

4.153 For *C. gunnari*, the lowest estimate of  $\gamma$  resulting from application of the decision rules was always that associated with Decision Rule 1, i.e. that the probability of the spawning stock becoming depleted to less than 20% of the median pre-exploitation spawning biomass during a 20-year fishing period was not to exceed 0.1. These estimates showed little sensitivity to variation in M (<10% variation) according to alternatives available in the literature (e.g., Kock *et al.*, 1985<sup>7</sup>), except for the third survey in which the CV was greatest. Sensitivity to von Bertalanffy K was greater (up to 44% greater than sensitivity derived using parameters from the literature). These variations in estimates of  $\gamma$  were considered to be unimportant compared to the variation in biomass estimates.

4.154 For *D. eleginoides*, the lowest estimate of  $\gamma$  resulting from application of the decision rules was always that associated with Decision Rule 2, i.e. that the median spawning biomass after 20 years of fishing would not be less than 0.75 of the median pre-exploitation biomass. Variation in M

<sup>7</sup> Kock, K.-H., G. Duhamel and J.-C. Hureau. 1985. Biology and status of exploited Antarctic fish stocks: a review. *BIOMASS Scientific Series*, 6: 143 pp.

and K had only small effects on the values of  $\gamma$  (up to 12% for increasing the potential values of M from 0.1-0.2 to 0.2-0.3).

4.155 The Working Group agreed that consideration of precautionary TACs on the basis of the current estimates of  $\gamma$  was still valid following these analyses. It was noted that estimates of M and K for Heard Island would be available by the next meeting of the Working Group. In the absence of these estimates, the Working Group accepted that the levels of  $\gamma$  estimated using the source parameters (Table 11) were appropriate as interim estimates until refined values for the input parameters are obtained.

4.156 The Working Group considered the biomass estimates in WG-FSA-94/10 for use as  $B_0$  in the calculations of yield. The Working Group noted there was sufficient evidence to consider the stock of *C. gunnari* around Heard Island to be separate from those around Kerguelen Island. It was recognised that the survey results for *C. gunnari* are likely to be due to interannual variation in stock size (as observed for this species in other areas), but could to some degree represent variation in catchability between different seasons because the surveys were done at different times of the year.

4.157 For *D. eleginoides*, there were no data to determine whether stocks around Heard Island are different from those around Kerguelen Island. In the absence of such information, the Working Group treated these stocks as being separate. They noted that the survey results for *D. eleginoides* are appropriate for a trawl fishery but not for a longline fishery. Trawling was not undertaken in deeper waters where longline activities usually take place.

4.158 The pre-exploitation biomass will vary naturally through time in the absence of fishing. Consequently, the determination of  $B_0$  will involve accounting for variation of biomass through time as well as the errors associated with biomass surveys at different points in time. In the absence of methods to deal with this calculation, the Working Group recommends that a conservative approach be taken to the estimates of yield. Therefore, the Working Group adopted the lowest biomass estimates for the two species and the respective estimates of  $\gamma$  to calculate precautionary TACs. The Working Group recognised that these would be refined when better estimates of the input parameters are obtained and variability in estimates of  $B_0$  is incorporated into the calculations.

#### Management Advice

4.159 The Working Group recommends that precautionary TACs be set for *C. gunnari* and *D. eleginoides* around Heard Island according to the principles outlined above. For *C. gunnari*, the lowest biomass was in survey 2 (3 112 tonnes), with a corresponding  $\gamma$  of 0.1, which gives a

precautionary TAC of 311 tonnes. For *D. eleginoides*, the lowest biomass was in survey 3 (11 880 tonnes), with a corresponding  $\gamma$  of 0.025, giving a precautionary TAC of 297 tonnes.

#### Coastal Areas of the Antarctic Continent (Divisions 58.4.1 and 58.4.2)

4.160 No new data on the fish stocks in these areas were available. Therefore, no management advice could be provided for these areas.

#### MANAGEMENT UNDER CONDITIONS OF UNCERTAINTY CONCERNING STOCK SIZE AND SUSTAINABLE YIELD

4.161 At their 1993 meetings, the Scientific Committee and Commission requested that more work be undertaken on this topic (CCAMLR-XII, paragraph 4.26; SC-CAMLR-XII, paragraph 3.96).

4.162 This year the Working Group has considered this topic for a number of species (for instance, in the assessments of *E. carlsbergi*, *C. gunnari* and other species in Subarea 48.3) and has provided management advice which reflects various levels of uncertainty. For instance, the state of the stocks in Subareas 48.1 and 48.2 is practically unknown, and a continued closure is recommended, and the assessment of *C. gunnari* in Subarea 48.3 incorporates much uncertainty about current stock size, population structure, and mortality.

4.163 The Working Group has this year applied the approach developed by WG-Krill (the krill yield model) to estimating potential yield for a number of fish stocks. This approach allows for the incorporation of uncertainty in many demographic parameters, stock size and recruitment, into a calculation of potential yield. This development reflects the Working Group's increasing use of techniques that take account of uncertainty, and could be applied to other species in the future.

4.164 It is worth pointing out that these techniques and models operate in such a way that calculated yields and catch limits usually decrease as uncertainty in any of the parameters increases.

## CONSIDERATIONS OF ECOSYSTEM MANAGEMENT

### MONITORING OF COASTAL FISH POPULATIONS

5.1 Three papers presented at this year's meeting of WG-CEMP (WG-CEMP-94/29, 31 and 32) extended studies on the diet composition and feeding of blue-eyed shags (*Phalacrocorax atriceps*) in the South Shetland Islands from the previous year (SC-CAMLR-XII, Annex 6, paragraphs 4.29 to 4.34; Annex 5, paragraphs 7.7 to 7.10). The objective of these studies was to investigate the regular occurrence of fish otoliths in shag pellets as a means of monitoring the dynamics of coastal fish species over time. Comments provided by WG-CEMP are given in Annex 6, paragraphs 4.31 to 4.33.

5.2 The results of the stomach content analysis and the feeding trials on a captive shag (WG-CEMP-94/29 and 31) confirmed the experience obtained in other areas that fish species are differentially represented by otoliths in the pellets. Species with small and brittle otoliths, such as *N. coriiceps* and *N. rossii*, were either largely under-represented or not represented at all. For species represented in sufficient numbers in the feeding trials, preliminary correction factors both for the under-representation in the pellets and for the reduction in otolith size due to erosion could be established. The authors of the studies concluded that their investigations still bear a considerable potential for improvement by increasing sample size and more realistically simulating natural feeding conditions.

5.3 The Working Group welcomed this effort to monitor coastal fish species which are not accessible by trawl surveys. The Working Group encouraged the authors to undertake further investigations on the applicability of this method.

### INCIDENTAL MORTALITY OF BIRDS IN LONGLINE FISHERIES

5.4 The Working Group did not discuss subjects related to the incidental mortality of seabirds in longline fisheries in the Southern Ocean. Extensive discussions on this matter can be found in the Report of the *Ad Hoc* Working Group on Incidental Mortality Arising from Longline Fishing (WG-IMALF) (Annex 8).

## INTERACTIONS WITH FUR SEALS

5.5 Paper WG-FSA-94/17 investigated the potentially substantial influence of fur seals on the abundance of *C. gunnari* in Subarea 48.3, particularly in seasons of low krill availability. Further discussion is given in paragraph 4.77.

## BY-CATCH OF YOUNG FISH IN THE KRILL FISHERY

5.6 Two papers reported on the by-catch of young fish in the krill fishery. One (WG-Krill-94/25) assessed the by-catch in the Japanese commercial krill fishery off the South Shetland Islands in January/February 1994, the other (WG-FSA-94/25) the occurrence of fish in commercial krill catches taken by a Polish trawler in the vicinity of the South Orkney Islands and South Georgia from March to May 1993. They have been the first two studies after the introduction of CCAMLR's *Scientific Observers Manual*. However, only WG-FSA-94/25 used the subsample size and extrapolated total catch figures standardised to numbers per one tonne of krill caught and numbers per tonne/hour, as recommended in the *Scientific Observers Manual*. Comments on WG-Krill-94/25 are also given in Annex 5, paragraphs 3.12 to 3.15.

5.7 The results of these studies show that the proportion of analysed hauls containing fish and the species composition of the by-catch of fish during krill fishing operations differed considerably between areas. In addition to early life stages, juvenile and adult specimens were also caught, although in lower numbers. The proportion of krill catches containing fish varied between 25% off the South Shetland Islands and 43% in the vicinity of South Georgia. The predominant species were *Lepidonotothen larseni*, *C. aceratus* and *Chaenodraco wilsoni* off the South Shetland Islands, unidentified Myctophidae in the South Orkney Islands and unidentified Myctophidae, *L. larseni* and *C. gunnari* in the vicinity of South Georgia.

5.8 Although estimations of the abundance of fish in krill catches were not directly comparable in the two studies, results suggest that the amount of by-catch per hour of trawling was of the same order of magnitude in all three fishing grounds. This finding is in contrast to observations made by WG-Krill (Annex 5, paragraph 3.12) that the level of by-catch in the South Shetland Islands was an order of magnitude less than the by-catch reported by the Ukrainian fishery in the vicinity of South Georgia last year (WG-FSA-93/8).

5.9 Both recent studies tend to confirm earlier conclusions by the Working Group that the largest by-catch occurred when the krill catch was comparatively low.

5.10 The Working Group welcomed these studies and recommended that they be continued in the future, following closely the instructions set out in the *Scientific Observers Manual*. The Working Group reiterated its recommendations from last year's meeting (SC-CAMLR-XII, Annex 5, paragraphs 7.1 to 7.5) that future studies should preferably provide information on spatial, seasonal and diurnal differences in the by-catch of fish to assess when fish are most vulnerable to the krill fishery. The Working Group stressed that appropriate statistical procedures should be applied to the analysis of the data (see SC-CAMLR-XII, Annex 4, paragraph 3.32).

#### INTERACTIONS WITH WHALES

5.11 Interactions between the longline fishery and marine mammals, including killer and sperm whales, were reported by observers in the 1993/94 season and are discussed in paragraph 3.12.

#### RESEARCH SURVEYS

##### TRAWL SURVEY SIMULATIONS

6.1 At both its 1991 and 1992 meetings, WG-FSA attached high priority to addressing the difficulties associated with the application of the swept-area method in trawl surveys to species with patchy distributions, such as *C. gunnari*. The need to undertake simulation studies of a range of fish behaviours to determine the possible forms of underlying statistical distributions was reiterated by the Working Group at its 1993 meeting (SC-CAMLR-XII, Annex 5, paragraphs 8.1 to 8.3).

6.2 As no new submissions have been received on the above, the Working Group again called for work on trawl survey simulations as a matter of high priority. It was agreed that current efforts to validate the models already submitted to WG-FSA (WG-FSA-93/20) should continue.

##### RECENT AND OTHER SURVEYS

6.3 The Working Group noted that the United Kingdom has notified CCAMLR of its intention to undertake a fish survey in Subarea 48.3 in January/February 1995 along the lines of previous years.

6.4 Lic. Marschoff indicated that Argentina hopes to undertake, at some time between January and March 1995, a demersal fish survey in Subarea 48.3. If favourable ice conditions prevail, the cruise will also investigate krill in Subarea 48.2.

6.5 The Working Group was informed that the USA intends to conduct a survey of the crab stock in Subarea 48.3. During the survey, to be conducted during March 1995, a remotely operated vehicle (ROV) will be used to take video pictures of the crabs. Line transect theory will be used to estimate the abundance of crabs around South Georgia. The survey design includes a bathymetric mapping component to correlate crab densities with different types of habitat.

6.6 The Working Group welcomed the proposed crab survey, and suggested that the data resulting from the survey be analysed to estimate the abundance of fishes as well as crabs. In particular, the Working Group suggested that the ROV could be used to look for the presence of spawning aggregations of fish in some of the fjords surrounding South Georgia.

6.7 Certain members of WG-FSA indicated that they had found the six-month lead-in-time required for the notification of intended survey activity (CCAMLR-V, paragraph 60) to be restrictive. The Working Group agreed to review this requirement at its next meeting.

6.8 In response to the Commission's request (CCAMLR-XII, paragraph 6.10) to review the applicability of a 50-tonne catch limit for research prescribed by Conservation Measure 64/XII, the Working Group agreed that this limit appears appropriate for crabs, given the relatively tight provisions under Conservation Measures 74/XII and 75/XII.

#### Ob and Lena Banks

6.9 A bottom trawl survey design for the Ob and Lena Banks was proposed by Ukraine in WG-FSA-94/32. This proposal was identical to a proposal submitted to the Working Group in 1993. Discussion of the paper clarified a number of points already addressed during last year's deliberations (SC-CAMLR-XII, Annex 5, paragraph 8.5).

6.10 The timing of the survey is still unknown and will depend on the availability of the survey vessel. The participation of observers from Members is welcomed and arrangements may be made on a bilateral basis.

6.11 The survey will be conducted using a commercially-sized bottom trawl with a mesh size (diamond mesh) of 40 mm in the codend. To be consistent with previous surveys, the duration of hauls will be 60 minutes. The survey will be conducted in two phases as outlined in CCAMLR-XI/BG/21, paragraph 5. Phase 1 will comprise of a bottom trawl survey with a stratified random



survey design. During phase 2 it is intended to map areas of high fish density by carrying out hauls randomly in areas of high concentrations.

6.12 Data will be collected and reported according to the standard methods set out in the CCAMLR *Scientific Observers Manual*. Data reporting will follow the CCAMLR research database format and recording will be done in accordance with the requirements set out in Conservation Measure 64/XII.

6.13 Despite the prohibition of net monitor cables from the 1994/95 season onwards (Conservation Measure 30/X), the survey vessel will have to use a net monitor cable. The vessel has no hull-mounted transducer. She is only equipped with a towed transducer which, if used, would constantly be at risk of being lost due to the severe weather conditions. No incidental mortality of birds has been reported during previous surveys. The presence of seabirds close to the ship will be monitored with each haul and any incidental mortality caused by the net monitor cable will be reported.

6.14 The total catch anticipated is 1 150 tonnes in accordance with the TAC set in Conservation Measure 59/XI for a period of two seasons.

6.15 It is intended to conduct such surveys regularly, although not on an annual basis.

## FUTURE WORK

### DATA REQUIREMENTS

7.1 Data requirements carried over from those requested last year are listed in Appendix D.

7.2 In addition to these requirements, the Working Group recalled that it had requested that:

- (i) data collected by observers be submitted to the Secretariat in approved reporting formats whenever possible (paragraph 3.11); and
- (ii) the format for reporting longline data to CCAMLR (Format C2) be updated to include the items identified in paragraph 4.32.

## SOFTWARE AND ANALYSES REQUIRED

7.3 The Working Group requested that the trawl survey analysis program developed last year (WG-FSA-93/30) continue to be validated. In addition to test simulation runs, the method and its assumptions should be examined in the light of actual survey results from various parts of the CCAMLR Convention Area (paragraph 4.96).

7.4 The Working Group noted that several assessments had made use of a modified version of the krill yield program developed by WG-Krill and agreed that a more general version of this program, applicable to fish stocks, would be of use. Dr Constable agreed to coordinate an intersessional group which would prepare a modified version by correspondence.

## WORKING GROUP ORGANISATION

7.5 The Chairman informed the Working Group that the Joint Meeting of WG-CEMP and WG-Krill (South Africa, July 1994) had recommended that the two groups meet as a joint group from now on. It had commented, however, that it saw no immediate requirement to consider joint meetings between itself and WG-FSA (Annex 7, paragraph 6.4).

7.6 The Working Group agreed that whilst its work included consideration of biological information of use in providing advice on management in addition to assessments, it was important that these two aspects of its work remained under the umbrella of a single group. It was agreed, therefore, that no change to its terms of reference was necessary at this time.

7.7 The Working Group considered that the work of WG-IMALF was closely linked to its own. Should WG-IMALF continue its work in future years, it would be important to maintain a close liaison between the groups, although a joint meeting would not be necessary in the foreseeable future. However, there was some concern that if WG-IMALF took place between the WG-FSA meeting and the meeting of the Scientific Committee, there would be no opportunity for WG-FSA to act on the results of the deliberations of WG-IMALF in formulating its advice to the Scientific Committee.

7.8 The Working Group noted that many assessments within WG-FSA and other groups are moving in similar directions, both in methodology and operational considerations such as decision rules and consideration of escapement. This trend was helpful for the development of sound advice by all of the Scientific Committee's working groups, and has been considerably assisted by the continuing good communication between the groups.

## FUTURE MEETINGS

7.9 A workshop to consider assessment of the *D. eleginoides* fishery in Subarea 48.3 was proposed in paragraph 4.36. The terms of reference for this group are also given in paragraph 4.36.

## OTHER BUSINESS

8.1 The Convener of WG-Krill, Mr Miller, introduced WG-Krill-94/19 which aimed to clarify the issue of access to data in CCAMLR. The Working Group endorsed the approach outlined in the paper, which conforms with current Working Group and CCAMLR practice. In principle, this reiterates that:

- (i) analyses presented as Working Group documents are not considered to be public documents; and
- (ii) if the final aim of the analysis is formal publication, then the onus is on the person(s) undertaking the analysis to obtain the necessary permission from the originators of the data at the outset of any collaborative undertaking.

## ADOPTION OF THE REPORT

9.1 The report of the meeting was adopted.

## CLOSE OF THE MEETING

10.1 In closing the meeting the Convener thanked the rapporteurs, Secretariat and all participants for cooperating well to complete the Working Group's business smoothly and effectively. He also thanked all participants who had worked hard intersessionally to produce analyses and reports which had contributed to the Working Group's business.

10.2 Mr Miller congratulated the Convener for conducting the meeting efficiently in his inimitable fashion.

**AGENDA**

Working Group on Fish Stock Assessment  
(Hobart, Australia, 11 to 19 October 1994)

1. Opening of the Meeting
2. Organisation of the Meeting and Adoption of the Agenda
3. Review of Available Information
  - 3.1 Data Requirements Endorsed by the Commission in 1993
  - 3.2 Fisheries Information
    - (a) Catch, Effort, Length and Age Data
    - (b) Scientific Observer Information
    - (c) Research Surveys
    - (d) Mesh/Hook Selectivity and Related Experiments Affecting Catchability
  - 3.3 Fish and Crab Biology/Demography/Ecology
  - 3.4 Seabed Areas
4. Assessment Work and Management Advice
  - 4.1 New Fisheries
  - 4.2 South Georgia (Subarea 48.3) - Finfish
  - 4.3 South Georgia (Subarea 48.3) - Crabs
  - 4.4 South Orkney Islands (Subarea 48.2)
  - 4.5 Antarctic Peninsula (Subarea 48.1)
  - 4.6 Kerguelen Islands (Division 58.5.1)
  - 4.7 Ob and Lena Banks (Division 58.4.4)
  - 4.8 Coastal Areas of Antarctic Continent (Divisions 58.4.1 and 58.4.2)
  - 4.9 Pacific Ocean Sector (Area 88)
  - 4.10 Heard Island (Division 58.5.2)
  - 4.11 South Sandwich Islands (Subarea 48.4)
5. Considerations of Ecosystem Management
  - 5.1 Interactions with other CCAMLR Working Groups
  - 5.2 Other Interactions (e.g. Multispecies, Benthos, etc.)

6. Research Surveys
  - 6.1 Trawl Survey Simulation Studies
  - 6.2 Recent and Proposed Surveys
  
7. Future Work
  - 7.1 Data Requirements
  - 7.2 Software to be Prepared or Developed Prior to the Next Meeting and Data Analyses Required
  - 7.3 Future Organisation and Work of WG-FSA
  
8. Other Business
  
9. Adoption of the Report
  
10. Close of the Meeting.

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(Hobart, Australia, 11 to 19 October 1994)

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## LIST OF DOCUMENTS

Working Group on Fish Stock Assessment  
(Hobart, Australia, 11 to 19 October 1994)

WG-FSA-94/1	PROVISIONAL AGENDA AND ANNOTATION TO THE PROVISIONAL AGENDA FOR THE 1994 MEETING OF THE WORKING GROUP ON FISH STOCK ASSESSMENT (WG-FSA)
WG-FSA-94/2	LIST OF PARTICIPANTS
WG-FSA-94/3	LIST OF DOCUMENTS
WG-FSA-94/4	DYNAMICS OF <i>NOTOTHENIA ROSSII ROSSII</i> SIZE-AGE STRUCTURE ON THE KERGUELEN ISLANDS SHELF P.B. Tankevich (Ukraine)
WG-FSA-94/5	ANALYSES PERFORMED AT THE 1993 MEETING OF THE WORKING GROUP ON FISH STOCK ASSESSMENT Secretariat
WG-FSA-94/6	PRELIMINARY RESULTS OF MACKEREL ICEFISH, <i>CHAMPSOCEPHALUS GUNNARI</i> AGE DETERMINATION BY WEIGHT METHOD I.B. Russelo (Ukraine)
WG-FSA-94/7	COURSE OF FISHERIES IN THE LENA BANK AREA (DIVISION 58.4.4) IN THE SEASON OF 1990-91 A.K. Zaitsev (Ukraine)
WG-FSA-94/8	PRELIMINARY RESULTS OF AGE DETERMINATION BY OTOLITH MASS IN MACKEREL ICEFISH <i>CHAMPSOCEPHALUS GUNNARI</i> LONNBERG 1905 IN THE HEARD ISLAND AREA (AUSTRALIA) I.B. Russelo (Ukraine)
WG-FSA-94/9 Rev. 1	NEW DATA ON SPAWNING, HATCHING AND GROWTH OF THE KERGUELEN ISLANDS <i>CHAMPSOCEPHALUS GUNNARI</i> SHELF STOCK G. Duhamel (France)
WG-FSA-94/10	FISH DISTRIBUTION AND BIOMASS IN THE HEARD ISLAND ZONE (DIVISION 58.5.2) R. Williams and W.K. de la Mare (Australia)

- WG-FSA-94/11 AGE-LENGTH KEY FOR *CHAMPSOCEPHALUS GUNNARI* FROM SUBAREA 48.3, DR EDUARDO HOLMBERG SURVEY, FEBRUARY/MARCH 1994  
E. Barrera-Oro, E. Marschoff and R. Casaux (Argentina)
- WG-FSA-94/12 VALIDATION OF AGE DETERMINATION IN *NOTOTHENIA CORIICEPS*, BY MEANS OF A TAG-RECAPTURE EXPERIMENT AT POTTER COVER, SOUTH SHETLAND ISLANDS  
Esteban R. Barrera-Oro and Ricardo J. Casaux (Argentina)
- WG-FSA-94/13 AREAS OF SEABED WITHIN THE 500 M ISOBATH AROUND ELEPHANT ISLAND (CCAMLR STATISTICAL SUBAREA 48.1)  
Karl-Hermann Kock and Urte Harm (Germany)
- WG-FSA-94/14 THE EARLY LIFE HISTORY OF THE PATAGONIAN TOOTHFISH *DISSOSTICHUS ELEGINOIDES* SMITT, 1898  
S.A. Evseenko (Russia), K.-H. Kock (Germany) and M.M. Nevinsky (Russia)
- WG-FSA-94/15 THE DIET COMPOSITION AND FEEDING INTENSITY OF MACKEREL ICEFISH (*CHAMPSOCEPHALUS GUNNARI*) AT SOUTH GEORGIA IN JANUARY/FEBRUARY 1994  
K.-H. Kock (Germany), I. Everson, L. Allcock, G. Parkes (UK), U. Harm (Germany), C. Goss, H. Daly (UK), Z. Cielniaszek and J. Szlakowski (Poland)
- WG-FSA-94/16 EVIDENCE OF TWO STOCKS OF *CHAMPSOCEPHALUS GUNNARI* IN THE SOUTH GEORGIA REGION, CCAMLR FISHING AREA 48.3  
A.W. North (UK)
- WG-FSA-94/17 LARGE VARIATIONS IN MACKEREL ICEFISH (*CHAMPSOCEPHALUS GUNNARI*) STANDING STOCK AT SOUTH GEORGIA; ARE ANTARCTIC FUR SEALS (*ARCTOCEPHALUS GAZELLA*) THE CAUSE?  
Inigo Everson, Graeme Parkes, Ian Boyd (UK) and Karl-Hermann Kock (Germany)
- WG-FSA-94/18 FISH STOCK ASSESSMENT SURVEY IN SUBAREA 48.3  
I. Everson, G. Parkes (UK), K.-H. Kock (Germany), C. Goss (UK), D. Cielniaszek, J. Szlakowski (Poland), H. Daly, L. Allcock and G. Pilling (UK)
- WG-FSA-94/19 SOFTWARE FOR FSA-94  
Secretariat
- WG-FSA-94/20 SUMMARY OF THE *DISSOSTICHUS ELEGINOIDES* FISHERY IN SUBAREA 48.3 IN THE 1993/94 SEASON  
D.J. Agnew (Secretariat)

- WG-FSA-94/21 REVISSED ESTIMATES OF YIELD FOR *ELECTRONA CARLSBERGI* BASED ON A GENERALISED VERSION OF THE CCAMLR KRILL YIELD MODEL  
A.J. Constable and W.K. de la Mare (Australia)
- WG-FSA-94/22 DETERMINATION OF LOCAL DENSITY OF *DISSOSTICHUS ELEGINOIDES* IN SUBAREA 48.3 - CCAMLR PROTOCOL LOCAL DEPLETION EXPERIMENT *IHN SUNG 66* - JANUARY 1994  
Caradoc Jones and Graeme Parkes (UK)
- WG-FSA-94/23 PERFORMANCE AND GEOMETRY OF THE FP-120 TRAWL USED DURING THE UK 1993/94 FISH STOCK ASSESSMENT SURVEY AROUND SOUTH GEORGIA, SUBAREA 48.3  
Graham Pilling and Graeme Parkes (UK)
- WG-FSA-94/24 COMMENTS ON THE USE OF STOCK DEPLETION MODELS FOR THE ASSESSMENT OF LOCAL ABUNDANCE OF TOOTHFISH IN SUBAREA 48.3 AND ADJACENT WATERS  
Graeme Parkes and Graham Pilling (UK)
- WG-FSA-94/25 PRELIMINARY RESULTS ON BY-CATCH OF FISH DURING KRILL FISHERY IN MARCH TO MAY 1993 ON THE POLISH TRAWLER M/T *LEPUS*  
Zdzislaw Cielniaszek and Roman Pactwa (Poland)
- WG-FSA-94/26 PRELIMINARY ASPECTS OF A SIMULATION MODEL TO BE USED FOR EVALUATING THE EXPERIMENTAL CRAB FISHERY  
George Watters (USA)
- WG-FSA-94/27 DIET COMPOSITION OF *CHAMPSOCEPHALUS GUNNARI* IN SUBAREA 48.3, *DR EDUARDO HOLMBERG* SURVEY, FEBRUARY/ MARCH 1994  
E. Barrera-Oro, R. Casaux and A. Roux (Argentina)
- WG-FSA-94/28 PRELIMINARY STUDY ON REPRODUCTION IN *CHAMPSOCEPHALUS GUNNARI* FROM SUBAREA 48.3, *DR EDUARDO HOLMBERG* SURVEY, FEBRUARY/MARCH 1994  
Gustavo J. Macchi and Esteban R. Barrera-Oro (Argentina)
- WG-FSA-94/29 PRELIMINARY RESULTS OF THE *E.L. HOLMBERG* 1994 CRUISE TO SUBAREAS 48.3 AND 48.2  
E.R. Marschoff, Bruno Prenski, Beatriz Gonzalez, Claudio Remaggi and Carlos Balestrini (Argentina)
- WG-FSA-94/30 ADDENDUM TO DOCUMENT WG-FSA-94/10  
R. Williams and W.K. de la Mare (Australia)
- WG-FSA-94/31 DEPLETION EXPERIMENT OF *DISSOSTICHUS ELEGINOIDES* STOCK IN THE SOUTH OF SOUTH GEORGIA ISLAND (ANTARCTICA)  
P. Rubilar, C.A. Moreno (Chile) and J. Ashford (UK)

WG-FSA-94/32                    BOTTOM TRAWLING SURVEY ON THE OB AND LENA BANKS  
Observer (Ukraine)

OTHER DOCUMENTS

SC-CAMLR-XIII/BG/1            STATUS OF CATCHES IN THE CONVENTION AREA 1993/94 SEASON  
Rev. 1                            Secretariat

SC-CAMLR-XIII/BG/9            CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION -  
Rev. 1                            PRELIMINARY REPORT OF THE SCIENTIFIC OBSERVER *ŔV MAKSHEEVO*, 7  
FEBRUARY TO 18 APRIL 1994  
Delegation of USA

WG-CEMP-94/29                 PRELIMINARY RESULTS OF A FEEDING TRIAL ON THE BLUE-EYED SHAG  
*PHALACROCORAX ATRICEPS*  
R. Casaux, M. Favero, E. Barrera-Oro and P. Silva (Argentina)

WG-CEMP-94/31                 ANALYSIS OF THE STOMACH CONTENT IN THE BLUE-EYED SHAG  
*PHALACROCORAX ATRICEPS BRANSFIELDENSIS* AT NELSON ISLAND,  
SOUTH SHETLAND ISLANDS  
N. Coria, R. Casaux, M. Favero and P. Silva (Argentina)

WG-CEMP-94/32                 FISH AS DIET OF THE BLUE-EYED SHAG, *PHALACROCORAX ATRICEPS*  
*BRANSFIELDENSIS* AT HALF-MOON ISLAND, SOUTH SHETLAND ISLANDS  
Esteban R. Barrera-Oro and Ricardo J. Casaux (Argentina)

WG-Krill-94/19                 ACCESS TO AND USE OF DATA WITHIN CCAMLR  
(Prepared by Convener, WG-Krill)

WG-Krill-94/25                 FISHES CAUGHT ALONG WITH THE ANTARCTIC KRILL IN THE VICINITY OF  
THE SOUTH SHETLAND ISLANDS DURING THE AUSTRAL SUMMER MONTHS  
OF 1994  
Tetsuo Iwami (Japan)

## DATA REQUIREMENTS FOR THE WORKING GROUP

I Data Required by WG-FSA-93	II Data Received by WG-FSA-94	III Data Requested by WG-FSA-94
1. <i>D. eleginoides</i> , Subarea 48.3 <ul style="list-style-type: none"> <li>studies on hook selection factors required</li> <li>studies on loss rates of fish</li> </ul>	None received  Some information	<i>D. eleginoides</i> , Subarea 48.3 <ul style="list-style-type: none"> <li>studies on hook selection factors required</li> <li>studies on loss rates of fish</li> </ul>
2. <i>D. eleginoides</i> , Subarea 48.3 <ul style="list-style-type: none"> <li>age and maturity determination required for an expanded range of lengths from historical and current commercial and research catches</li> </ul>	None received	<i>D. eleginoides</i> , Subarea 48.3 <ul style="list-style-type: none"> <li>age and maturity determination required for an expanded range of lengths from historical and current commercial and research catches</li> </ul>
3. Representative length frequency from the commercial catch of <i>C. gunnari</i> in Subarea 48.3 should be reported for the most recent years of the fishery	None received	Representative length frequency from the commercial catch of <i>C. gunnari</i> in Subarea 48.3 should be reported for the most recent years of the fishery and required from historical fishery
4. Trawl fisheries in Subarea 48.3: <ul style="list-style-type: none"> <li>detailed data on the by-catch in pelagic (midwater) and demersal (bottom) trawl fisheries in Subarea 48.3 are urgently required to establish management advice</li> <li>research data should be submitted to the Secretariat</li> </ul>	None received  Being done by UK and Argentina (WG-FSA-94/18 and 29)	Trawl fisheries in Subarea 48.3 <ul style="list-style-type: none"> <li>detailed data on the by-catch in pelagic (midwater) and demersal (bottom) trawl fisheries in Subarea 48.3 are urgently required to establish management advice. Historical data required</li> </ul>
5. <i>E. carlsbergi</i> <ul style="list-style-type: none"> <li>clarification of position and time of catch of 1 518 tonnes reported for Subarea 48.2 in 1990/91</li> <li>clarification of position and time of catch of 50 tonnes in Subarea 48.1 in 1991/92</li> </ul>	No information	<i>E. carlsbergi</i> <ul style="list-style-type: none"> <li>clarification of position and time of catch of 1 518 tonnes reported for Subarea 48.2 in 1990/91</li> <li>clarification of position and time of catch of 50 tonnes in Subarea 48.1 in 1991/92</li> </ul>
6. Call for historic information from surveys to assist the Workshop on the Design of Bottom Trawl Surveys in investigating the interannual variability in the occurrence of fish aggregations	Heard Island (WG-FSA-94/10)	Call for historic information from surveys to assist the Workshop on the Design of Bottom Trawl Surveys in investigating the interannual variability in the occurrence of fish aggregations. Also required for validation of MVUE methods (paragraph 7.3)
7. <i>D. eleginoides</i> , Subarea 48.3 <ul style="list-style-type: none"> <li>stock identification studies</li> <li>data on the position or bearing of each end of longlines</li> </ul>	WG-FSA-94/14	<i>D. eleginoides</i> , Subarea 48.3 <ul style="list-style-type: none"> <li>stock identification studies</li> <li>data on the position or bearing of each end of longlines especially in preparation for workshop</li> </ul>
8. Crab fishery, Subarea 48.3 Investigations on the use of time-release devices, escape ports and pot selectivity	No information	Crab fishery, Subarea 48.3 Investigations on the use of time-release devices, escape ports and pot selectivity
9.		Additional data from <i>D. eleginoides</i> fishery (paragraph 4.32)
10.		All observer data should be reported if possible (paragraph 3.11)
11.		<i>D. eleginoides</i> : Data requested from outside CCAMLR Convention Area (paragraphs 4.6 and 4.44)

**MATURATION SCALE USED FOR OVARIES  
OF *CHAMPSOCEPHALUS GUNNARI* \***

	Maturity Stage	General Histological Features
1	Immature	Compact ovigerous lamellas with oocytes I and II
2	Early maturation	Oocytes I, II and III elements starting secondary vitellogenesis (IV)
3	Advanced maturation	Oocytes I, II, III and V
4	Total maturation	Oocytes I, II, III and VI
5	Post-spawning	Lax ovigerous lamellas, with oocytes I, II and III. Residual components V in resorption and post-ovulatory follicles.
6	Pre-reproductive regression	Compact ovigerous lamellas, with oocytes I and II. Yolky elements (V) in different resorption phases.

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\* WG-FSA-94/28

**1994 ASSESSMENT SUMMARIES**

Assessment Summary: *Notothenia rossii*, Subarea 48.3

**Source of Information:** This report

Year:	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>
Recommended TAC		0						
Agreed TAC		300	300	0				
Landings	152	2	1	1	0			
Survey Biomass	2439	1481 <sup>a</sup> 3915 <sup>b</sup> 3900 <sup>b</sup>	4295 <sup>c</sup> 10022 <sup>d</sup>	7309		6600		
Surveyed by	UK/POL	UK/POL <sup>a</sup> USSR <sup>b</sup>	UK <sup>c</sup> USSR <sup>d</sup>	UK		UK		
Sp. Stock Biomass <sup>3</sup>		No information						
Recruitment (age...)		available						
Mean F (.....) <sup>1</sup>		since 1985/86						

Weights in tonnes, recruits in .....

- 1 ... weighted mean over ages (...)
- 2 Over period 1982 to 1992
- 3 From VPA using (.....)

**Conservation Measures in Force:** 2/III, 3/IV and 68/XII

**Catches:**

**Data and Assessment:** No new assessment was performed for this species.

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** Little change in stock composition in recent years.

**Forecast for 1994/95:** Recommend continued closure.



Assessment Summary: *Champsocephalus gunnari*, Subarea 48.3

**Source of Information:** This report

Year:	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>
Recommended TAC	10200	12000		8400-61900	9200-15200	0		
Agreed TAC	4	8000	26000	0	9200			
Landings	21359	8027	92	5	0	13		
Survey Biomass	24241	72090 <sup>a</sup> 442168 <sup>b</sup>	27111 <sup>a</sup> 192144 <sup>b</sup>	43763 <sup>a</sup>		16088 <sup>+a</sup> 4870 <sup>*a</sup> 2012 <sup>+b</sup> 67259 <sup>*b</sup>		
Surveyed by	UK/POL	UK/POL <sup>a</sup> USSR <sup>b</sup>	UK <sup>a</sup> USSR <sup>b</sup>	UK <sup>a</sup>		UK <sup>a</sup> Arg <sup>b</sup>		
Stock Biomass <sup>3</sup>	50	50	50.5					
Recruitment (age 1)	500	(millions)						
Mean F (.....) <sup>1</sup>				0				

Weights in '000 tonnes

- 1 ... weighted mean over ages (...)
- 2 Over period 1982 to 1992
- 3 From VPA (2+)
- 4 Prohibition from 4 November 1988
- \* Shag Rocks
- + South Georgia

**Conservation Measures in Force:** 19/IX and 66/XII

**Catches:** Research catches only - 13 tonnes.

**Data and Assessment:** Surveys in 1993/94 indicated significantly lower biomass than predicted by projections made at the 1993 Working Group meeting. Decline in biomass in the absence of fishing may be linked to the low availability of krill in Subarea 48.3 during the 1993/94 season.

**Fishing Mortality:** None.

**Recruitment:** Recruitment of 1-year-olds in 1992/93 projected back from the UK survey was at the lower end of the range in the VPA at last year's meeting. Poor recruitment was not considered to explain the low biomass of age 3+ in the 1993/94 surveys.

**State of Stock:** Overall biomass is low according to the 1993/94 UK survey, but there is a high degree of uncertainty and reliable projections could not be made.

**Forecast for 1994/95:** Closure and survey recommended.

Assessment Summary: *Patagonotothen guntheri*, Subarea 48.3

**Source of Information:** This report

Year:	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>
Recommended TAC	-	-	20-36000	0				
Agreed TAC	13000	12000	0	0				
Landings	13016	145	0	0	0			
Survey Biomass			584 <sup>a</sup>	12764		4589		
Surveyed by			16365 <sup>b</sup>					
			UK <sup>a</sup>	UK		UK		
			USSR <sup>b</sup>					
Sp. Stock Biomass <sup>3</sup>		na						
Recruitment (age 1)		na						
Mean F (3 - 5) <sup>1</sup>		na						

Weights in tonnes

- 1 ... weighted mean over ages (...)
- 2 Over period 1982 to 1992
- 3 From VPA using (.....)
- 4 Maximum catch in 1989

**Conservation Measures in Force:** 48/XI

**Catches:**

**Data and Assessment:** No new assessment was performed for this species.

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** Biomass estimates provided by surveys above may underestimate stock size because they do not sample its complete depth range.

**Forecast for 1994/95:** Recommend conservation measures presently in force be retained.

Assessment Summary: *Dissostichus eleginoides*, Subarea 48.3

**Source of Information:** This report

Year:	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>
Recommended TAC		-						
Agreed TAC		-	2500 <sup>5</sup>	3500	3350	1300		
Landings	4138	8311	3843	3703	2990	604		
Survey Biomass	326	9631 <sup>*a</sup>	335 <sup>+a</sup>	19315 <sup>*</sup>	3353 <sup>*</sup>	14923 <sup>*a</sup>	2012 <sup>*b</sup>	
		1693 <sup>*b</sup>	3020 <sup>+b</sup>	885 <sup>+</sup>	2460 <sup>+</sup>	4831 <sup>+a</sup>	67259 <sup>+b</sup>	
Surveyed by	UK/ POL <sup>4</sup>	POL/UK <sup>a</sup> USSR <sup>b</sup>	UK	UK		UK <sup>a</sup> Arg <sup>b</sup>		
Stock Biomass <sup>3</sup>		20745 - 435817		11000-17000				
Recruitment (age...)		na						
Mean F (.....) <sup>1</sup>		na						

Weights in tonnes

- |                                     |   |
|-------------------------------------|---|
| 1 ... weighted mean over ages (...) | 5 TAC from 1 November 1990 to 2 November 1991 |
| 2 Over period 1982 to 1992          | 6 Estimated from various methods              |
| 3 Estimated from cohort projections | * Shag Rocks                                  |
| 4 Survey excluding Shag Rocks       | + South Georgia                               |

**Conservation Measures in Force:** 69/XII, 70/XII and 71/XII

**Catches:** TAC of 1 300 tonnes, 603 tonnes taken during five depletion experiments, 1 tonne research catch.

**Data and Assessment:** 1992/93 haul-by-haul data were re-analysed and 1993/94 depletion experiment data were analysed with the aim of estimating local density. No consistent depletion observed, so no density estimates calculated. No stock assessment possible.

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** Unknown. A precautionary approach should be taken in setting any TACs.

**Forecast for 1994/95:**

Assessment Summary: *Notothenia gibberifrons*, Subarea 48.3

**Source of Information:** This report

Year:	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>
Recommended TAC				500-1500				
Agreed TAC				0				
Landings	838	11	3	4	0			
Survey Biomass	8500	17000	25000	29600		23566		
Surveyed by	UK	UK USSR	UK USSR	UK		UK		
Sp. Stock Biomass <sup>3</sup>	3300	4300	6200					
Recruitment (age 2)	21000	27000	25000					
Mean F (.....) <sup>1</sup>	0.54	0.014	0.0002					

Weights in tonnes

- <sup>1</sup> Weighted mean over ages 2 to 16
- <sup>2</sup> Over period 1975/76 to 1991/92
- <sup>3</sup> From VPA using survey  $q = 1$  model

**Conservation Measures in Force:** 48/XI and 68/XII

**Catches:**

**Data and Assessment:**

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** Biomass decreased from last survey; potential yield currently low.

**Forecast for 1994/95:** Recommend directed fishery remain prohibited.

Assessment Summary: *Chaenocephalus aceratus*, Subarea 48.3

**Source of Information:** This report

Year	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>
Recommended TAC	1100	0	300	300-500				
Agreed TAC	0	300	300	0				
Landings	1	2	2	2	0		1272	1
Survey Biomass	5770	14226 <sup>a</sup> 14424 <sup>b</sup> 17800 <sup>b</sup>	13474 <sup>c</sup> 18022 <sup>d</sup>	12500		9695		
Surveyed by	UK/POL	UK/POL <sup>a</sup> USSR <sup>b</sup>	UK <sup>c</sup> USSR <sup>d</sup>	UK		UK		
Sp. Stock Biomass <sup>3</sup>	4404	5098 <sup>4</sup>						
Recruitment (age 2)	6717	4047 <sup>4</sup>						
Mean F (.....) <sup>1</sup>	0.002							

Weights in tonnes, recruits in '000s

- 1 ... weighted mean over ages 3 to 11
- 2 Over period 1982 to 1992
- 3 From VPA using revised VPA from WG-FSA-90/6
- 4 Predicted

**Conservation Measures in Force:** 48/XI and 68/XII

**Catches:**

**Data and Assessment:**

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** Biomass decreased from last survey; potential yield currently low.

**Forecast for 1994/95:** Recommend directed fishery remain prohibited.

Assessment Summary: *Pseudochaenichthys georgianus*, Subarea 48.3

**Source of Information:** This report

Year	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>
Recommended TAC	1800	0	300	300-500				
Agreed TAC		300	300	0				
Landings	1	1	2	2	0		1661	1
Survey Biomass	8278	5761 <sup>a</sup> 12200 <sup>b</sup> 10500 <sup>b</sup>	13948 <sup>c</sup> 9959 <sup>d</sup>	13469		5707		
Surveyed by	UK/POL	UK/POL <sup>a</sup> USSR <sup>b</sup>	UK <sup>c</sup> USSR <sup>d</sup>	UK		UK		
Sp. Stock Biomass <sup>3</sup>	8889 <sup>4</sup>							
Recruitment (age 1)								
Mean F (.....) <sup>1</sup>								

Weights in tonnes, recruits in '000s

- 1 ... weighted mean over ages 3 to 6
- 2 Over period 1982 to 1992
- 3 From VPA described in WG-FSA-90/6
- 4 Predicted

**Conservation Measures in Force:** 48/XI and 68/XII

**Catches:**

**Data and Assessment:**

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** Biomass significantly lower than last survey; potential yield currently low.

**Forecast for 1994/95:** Recommend directed fishery remain prohibited.

Assessment Summary: *Notothenia squamifrons*, Subarea 48.3

**Source of Information:**

Year	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>	Mean <sup>2</sup>
Recommended TAC		0	300	300					
Agreed TAC		300	300	0					
Landings	927	0	0	0	0		1553	0	563
Survey Biomass	131	1359 <sup>a</sup>	1374	1232					
		534 <sup>b</sup>							
Surveyed by	UK/PO L	UK/POL <sup>a</sup> USSR <sup>b</sup>	UK	UK					
Sp. Stock Biomass <sup>3</sup>									
Recruitment (age...)									
Mean F (.....) <sup>1</sup>									

Weights in tonnes, recruits in .....

<sup>1</sup> ... weighted mean over ages (...)

<sup>2</sup> Over period 1982 to 1992

<sup>3</sup> From VPA using (.....)

**Conservation Measures in Force:** 48/XI and 69/XII

**Catches:**

**Data and Assessment:** No new assessment was performed for this species.

**Fishing Mortality:**

**Recruitment:**

**State of Stock:**

**Forecast for 1994/95:** Recommend conservation measures presently in force be retained.

Assessment Summary: *Electrona carlsbergi*, Subarea 48.3

**Source of Information:**

Year	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>	Mean <sup>2</sup>
Recommended TAC	-	-	-	-					
Agreed TAC	-	-	-	245000	200 000 <sup>6</sup>				
Landings	29673	23623	78488	46960	0	0			
Survey Biomass	USSR <sup>4</sup>								
Surveyed by	USSR <sup>5</sup>								
Sp. Stock Biomass <sup>3</sup>									
Recruitment (age...)									
Mean F (.....) <sup>1</sup>									

Weights in tonnes, recruits in .....

<sup>1</sup> ... weighted mean over ages (...)

<sup>2</sup> Over period 1982 to 1992

<sup>3</sup> From VPA using (.....)

<sup>4</sup> WG-FSA-90/21 large portion of Subarea 48.3

<sup>5</sup> WG-FSA-90/21 Shag Rocks region

<sup>6</sup> 43 000 tonnes at Shag Rocks (Conservation Measure 67/XIII)

**Conservation Measures in Force:** 54/XI, 67/XII; TAC 200 000 tonnes

**Catches:** Nil

**Data and Assessment:** Use of generalised krill yield model to estimate  $\gamma$  in  $Y = \gamma B_0$  gave  $\gamma = 0.091$ . [Program FYIELD.EXE Input File 94ECYLD.DAT (use as IN.DAT)]

**Fishing Mortality:**

**Recruitment:** No estimate.

**State of Stock:** No new estimates of biomass. Using old estimates of biomass: yield = 109 100 for Subarea 48.3 and 14 500 for Shag Rocks.

**Forecast for 1994/95:**



Assessment Summary: *Notothenia rossii*, Division 58.5.1

**Source of Information:** This report

Year	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>	Mean <sup>2</sup>
Recommended TAC									
Agreed TAC									
Landings	245	155	287	0	0	0			
Survey Biomass									
Surveyed by									
Sp. Stock Biomass <sup>3</sup>									
Recruitment (age...)									
Mean F (.....) <sup>1</sup>									

Weights in tonnes, recruits in .....

1 ... weighted mean over ages (...)

2 Over period 1982 to 1992

3 From VPA using (.....)

**Conservation Measures in Force:** Conservation Measure 2/III. Resolution 3/IV. Limitation of trawlers allowed on fishing grounds each year. Arrêté N<sup>o</sup>: 18, 20, 32 (for details see SC-CAMLR-VIII, Annex 6, Appendix 10, page 290).

**Catches:**

**Data and Assessment:**

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** Still low compared with initial levels. Most recent survey (1987/88) estimated total biomass at 10 000 tonnes. In the first two years of the fishery 168 000 tonnes of this species were taken.

**Forecast for 1994/95:**

Assessment Summary: *Notothenia squamifrons*, Division 58.5.1

**Source of Information:** This report

Year	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>	Mean <sup>2</sup>
Recommended TAC									
Agreed TAC	2000 <sup>4</sup>								
Landings	1553	1262	98	1	0	0			
Survey Biomass									
Surveyed by									
Sp. Stock Biomass <sup>3</sup>									
Recruitment (age...)									
Mean F (.....) <sup>1</sup>									

Weights in tonnes, recruits in .....

- 1 ... weighted mean over ages (...)
- 2 Over period 1982 to 1992
- 3 From VPA using (.....)

**Conservation Measures in Force:**

**Catches:**

**Data and Assessment:** No new assessment was performed for this species.

**Fishing Mortality:**

**Recruitment:**

**State of Stock:**

**Forecast for 1994/95:**

Assessment Summary: *Champscephalus gunnari*, Division 58.5.1

**Source of Information:** This report

Year	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>	Mean <sup>2</sup>
Recommended TAC									
Agreed TAC									
Landings (Kerguelen)	23628	226	12644	44	0	12	25852	0	
Landings (Combined)									
Survey Biomass									
Surveyed by									
Sp. Stock Biomass <sup>3</sup>									
Recruitment (age...)									
Mean F (.....) <sup>1</sup>									

Weights in tonnes, recruits in .....

- <sup>1</sup> ... weighted mean over ages (...)
- <sup>2</sup> Over period 1982 to 1994
- <sup>3</sup> From VPA using (.....)

**Conservation Measures in Force:** None. Recommendation that no fishery be conducted during the 1993/94 season and a limited fishery during the 1994/95 season (CCAMLR-XII, paragraph 4.21).

**Catches:** 12 tonnes to assess the length frequency distributions of the stock. No fishery.

**Data and Assessment:** No new assessment was performed for this species.

**Fishing Mortality:**

**Recruitment:** Pre-recruit abundances highly variable from one year to another (results of 1989 to 1992 inshore monitoring program).

**State of Stock:** Biomass in relation to the strength of a three-year abundant cohort. Presently the 1991 normally strong cohort is coming and has spawned for the first time during 1994.

**Forecast for 1994/95:** Low level of catches to allow the present cohort to spawn a second time.

Assessment Summary: *Dissostichus eleginoides*, Division 58.5.1

**Source of Information:** This report

Year	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>	Mean <sup>2</sup>
Recommended TAC									
Agreed TAC									
Landings	1630	1062	1848	7492	2722	5083	7492	121	
Survey Biomass									
Surveyed by									
Sp. Stock Biomass <sup>3</sup>									
Recruitment (age...)									
Mean F (.....) <sup>1</sup>									

Weights in tonnes, recruits in .....

1 ... weighted mean over ages (...)

2 Over period 1982 to 1994

3 From VPA using (.....)

**Conservation Measures in Force:** None. Recommendation not to exceed 1 400 tonnes in western fishing grounds (CCAMLR-XII, paragraph 4.21).

**Catches:** Western grounds: 942 tonnes, longline only by Ukraine. Northern grounds: 4141 tonnes, trawling only by France.

**Data and Assessment:** 1987/88 biomass survey mainly for the western sector. No new assessment was performed for this species.

**Fishing Mortality:**

**Recruitment:**

**State of Stock:**

**Forecast for 1994/95:**

Western stock:  $F_{50\%SSB}$  gives 1 400 tonnes longterm yield.

Northern stock: Precautionary limitation of catches to prevent spawning stock size falling to low level before the stock has been adequately assessed.

Assessment Summary: *Champtocephalus gunnari*, Division 58.5.2

**Source of Information:** This report

Year	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>	Mean <sup>2</sup>
Recommended TAC						311			
Agreed TAC									
Landings	0	0	0	0	0				
Survey Biomass			4585	3111		31701			
Surveyed by			Australia						
Sp. Stock Biomass <sup>3</sup>									
Recruitment (age...)									
Mean F (....) <sup>1</sup>									

Weights in tonnes, recruits in .....

<sup>1</sup> ... weighted mean over ages (...)

<sup>2</sup> Over period 1982 to 1992

<sup>3</sup> From VPA using (.....)

**Conservation Measures in Force:**

**Catches:**

**Data and Assessment:** Biomass surveys by Australia according to random stratified design and calculated by MVUE. Precautionary TACs calculated by estimating  $\gamma$  from modified krill yield program.

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** Presently unexploited.

**Forecast for 1994/95:**

Assessment Summary: *Dissostichus eleginoides*, Division 58.5.2

**Source of Information:** This report

Year	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>	Mean <sup>2</sup>
Recommended TAC						297			
Agreed TAC									
Landings	0	0	0	0	0	0			
Survey Biomass			17714	3179		11880			
Surveyed by			Australia						
Sp. Stock Biomass <sup>3</sup>									
Recruitment (age...)									
Mean F (....) <sup>1</sup>									

Weights in tonnes, recruits in .....

- 1 ... weighted mean over ages (...)
- 2 Over period 1982 to 1992
- 3 From VPA using (.....)

**Conservation Measures in Force:**

**Catches:**

**Data and Assessment:** Biomass surveys by Australia according to random stratified design and calculated by MVUE. Precautionary TACs calculated by estimating  $\gamma$  from modified krill yield program. Assessment only applicable to trawl fishery on younger part of population.

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** Presently unexploited.

**Forecast for 1994/95:**

Assessment Summary: *Notothenia squamifrons*, Division 58.4.4

**Source of Information:** This report

Year	1989	1990	1991	1992	1993	1994	Max <sup>2</sup>	Min <sup>2</sup>	Mean <sup>3</sup>
Recommended TAC (Lena Bank)									
Agreed TAC									
Landings (Ob Bank <sup>a</sup> )	850	867	?	0	0	0	4999	0	1151
Landings (Lena Bank <sup>a</sup> )	3166	596	?	0	0	0	6284	0	1335
Landings (Combined <sup>b</sup> )	4016	1463	575	0	0	0	11283	027	2487
Survey Biomass (Ob Bank)	12700								
Survey Biomass (Lena Bank)									
Surveyed by	USSR								
Sp. Stock Biomass <sup>4</sup>	na								
Recruitment (age...)	na								
Mean F (.....) <sup>1</sup>									

Weights in tonnes, recruits in .....

<sup>1</sup> ... weighted mean over ages (...)

<sup>2</sup> Over period 1982 to 1992

<sup>3</sup> Assumes TAC of 267 tonnes for Ob Bank and 305 tonnes for Lena Bank was taken in 1991

<sup>4</sup> From VPA using (.....)

<sup>a</sup> From WG-FSA-92/5

<sup>b</sup> From SC-CAMLR-IX/BG/2

Part 2 (*Statistical Bulletin*)

**Conservation Measures in Force:** 2/III and 4/V

**Catches:** No catches since 1991

**Data and Assessment:** No new assessments performed for this species since 1992.

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** Unknown

**Forecast for 1994/95:**

**REPORT OF THE SIXTH MEETING  
OF THE WORKING GROUP ON KRILL**

(Cape Town, South Africa, 25 July to 3 August 1994)



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**REPORT OF THE SIXTH MEETING  
OF THE WORKING GROUP ON KRILL**  
(Cape Town, South Africa, 25 July to 3 August 1994)

INTRODUCTION

1.1 The Sixth Meeting of the Working Group on Krill (WG-Krill) was held at the Breakwater Lodge, Cape Town, South Africa, from 25 July to 3 August 1994. The meeting was chaired by the Convener, Mr D.G.M. Miller (South Africa).

1.2 The Working Group was welcomed to Cape Town by Mr G. de Villiers, the Director of Sea Fisheries Administration in South Africa.

REVIEW OF THE MEETING OBJECTIVES  
AND ADOPTION OF THE AGENDA

2.1 The Convener briefly outlined the major objectives of the meeting which had been set out in detail and circulated prior to the meeting in SC CIRC 94/6.

2.2 A Provisional Agenda had also been circulated prior to the meeting. There were no additions or amendments and the Agenda was adopted.

2.3 The Agenda is included in this report as Appendix A, the List of Participants as Appendix B and the List of Documents submitted to the meeting as Appendix C.

2.4 The report was prepared by Drs D. Agnew (Secretariat) and M. Basson (UK), Prof. D. Butterworth (South Africa), Drs W. de la Mare (Australia), I. Everson (UK), R. Hewitt (USA), E. Murphy (Invited Expert), S. Nicol (Australia) and J. Watkins (UK).

## REVIEW OF FISHERIES ACTIVITIES

### Fisheries Information

#### Data Submission

3.1 An analysis by the Secretariat of fine-scale krill catch data from the 1992/93 season (WG-Krill-94/6) revealed that some Polish catches were made to the north of the Convention Area in Division 41.3.2. The proportion of the total catch from outside the Convention Area was, however, small:

Subarea/ Division	1992/93 Total Catch (tonnes)	%
41.3.2	2 506	2.8
48.1	37 716	42.5
48.2	12 670	14.3
48.3	30 040	33.8
48.4	50	0.06
48.6	33	0.04
58.4.1	57 62	6.5

Paper WG-Krill-94/6 also included maps of fine-scale catches taken from Division 58.4.1 in 1992/93.

3.2 A full set of fine-scale krill catch data from 1974 to 1994 and krill catch data on a scale of 10 x 10 n miles from 1992/93 has now been supplied to the Secretariat by Japan. The Working Group noted this submission and acknowledged the utility of this data set.

3.3 A sample of commercial krill catch data from 1978 from the former Soviet Union was presented in WG-Krill-94/10. Only YUGNIRO (Ukraine) has historic catch data from Subarea 58.4 (from 1978 to 1984 and 1988). The high cost of preparing the data precluded the submission of a complete data set. The Working Group urged Members with available resources to aid with the analysis of fisheries data from the former Soviet Union (Russia and Ukraine) and recalled the initiative by the US to obtain funds to assist with these analyses (SC-CAMLR-XII, Annex 4, paragraph 3.20).

3.4 The Working Group noted that monthly catch data are being submitted in accordance with Conservation Measure 32/X. Data have arrived from Japan, Poland and Ukraine. In addition, Chile has submitted a full set of haul-by-haul data.

## Presentation of Data by CCAMLR

3.5 The CCAMLR Secretariat had reported to Members in January on krill catch levels and will continue to do so every six months.

3.6 The Working Group recommended that the *Statistical Bulletin* include details of effort on the same temporal and spatial scales as catch data and noted that the Secretariat was preparing a paper on this subject for the Scientific Committee.

### 1993/94 Catches

3.7 Japan has submitted monthly reports from July 1993 to June 1994 which give a total krill catch for this period of 62 315 tonnes. Poland fished from July to June and reported a total catch of 7 915 tonnes; Ukraine fished from March to May and reported a catch of 8 205 tonnes. Chile fished in Subarea 48.1 during March and April and reported a catch of 3 834 tonnes. There was no indication that Russia fished for krill in the Convention Area during 1993/94. The total reported krill catch for 1993/94 was 82 269 tonnes.

3.8 The Japanese 1993/94 fishery deployed six vessels and the catch was mainly taken in Subareas 48.1 and 48.3. In the summer, the catch came mainly from Subarea 48.1 and later in the season from Subarea 48.3. The Japanese catch was taken between January and May, and followed the general trend towards a later-season fishery in Subarea 48.1 over recent years.

3.9 One thousand tonnes of the Japanese catch was taken off Wilkes Land (Division 58.4.1) by one vessel. This vessel usually fishes for other species near New Zealand and targets krill stocks in Division 58.4.1 because of their operational proximity.

3.10 The Polish catch for 1991/92 and 1992/93 was reported by subarea in WG-Krill-94/9 although this paper gives no indication of catches which were reported to have been taken outside the Convention Area (WG-Krill-94/6). The Working Group seeks clarification from Poland on this omission.

3.11 Ukraine reported that from March to July 1994 two vessels landed a total catch of 9 618 tonnes in Subareas 48.2 and 48.3 (WG-Krill-94/33). This fishery will continue until August 1994 and further results will be submitted to CCAMLR as soon as they are available.

## Reports of Observers

### By-catch of Young Fish

3.12 The incidental catch of fish in the Japanese commercial krill catch in summer 1994 from Subarea 48.1 was reported in WG-Krill-94/25. A total of 77 specimens of 13 species were documented from 25 trawl catches. This level of by-catch is an order of magnitude less than the by-catch reported by Ukraine last year (WG-FSA-93/8).

3.13 Fish appeared more rarely in hauls from high density krill swarms, those targeted preferentially by the fishery. There were, however, only two samples where there were relatively high fish catches, so the data were suggestive rather than conclusive on this point.

3.14 The Working Group welcomed this data set on by-catch and considered the results very useful. The absence of *Champsocephalus gunnari* in the catches was noted despite its prevalence in the area. The Working Group encouraged other fishing nations to obtain comparable data sets from different areas and seasons and noted that some data may become available from Ukrainian, Polish and possibly Russian observers.

3.15 However, the method reported in WG-Krill-94/25 only used a subsample of 25 kg of the catch. The methodology for analysing the commercial krill catch for fish by-catch given in the *Scientific Observers Manual* recommends that standard samples of 40 to 50 kg of krill be taken from all sampled hauls. The Working Group therefore recommended that the standard method in the *Scientific Observers Manual* be followed in future studies.

### Length Frequency and Haul-by-haul Data

3.16 A study of the length frequency of krill sampled from the Japanese commercial catch in 1993 (WG-Krill-94/28) failed to note a change as the fishing season progressed, although in most seasons there has usually been a shift to smaller krill later in the season. Body lengths of krill from this area (Subarea 48.1) are generally greater further offshore.

3.17 The same study (WG-Krill-94/28) found that the Japanese fishing fleet operating off the South Shetlands moved from offshore in January closer to shore in April. Catch/tow and catch/trawling time in the same area both increased to mid-summer then declined again.

3.18 The Working Group encouraged the continued submission of length frequency and haul-by-haul information. These data are useful for assessing the overlap between the predators and the fishery and length at selection to the fishery.

#### Fishing Escapement Loss/Mortality

3.19 The Working Group noted that the Secretariat has not been sent, for validation purposes, the model of krill escapement from WG-Krill-93/34. The Working Group repeated the request for the submission of the model for validation.

3.20 The Working Group noted that there were two aspects to the study of escapement of krill from commercial trawls - experimental studies and modelling exercises. The Working Group, recognising the potential seriousness of escapement, encouraged the development of both approaches.

#### Development of CPUE Indices

3.21 Paper WG-Krill-94/14 presented an attempt to derive a composite index (SC-CAMLR-VII) of krill abundance using a combination of acoustic and fisheries data collected off Elephant Island. Three points arose from the study:

- the large changes in abundance and distribution of krill observed between the four acoustic surveys in this study have implications for future near-synoptic surveys;
- the frequency distributions of catch-per-fishing-time and krill density (measured acoustically) showed similar forms, although it was noted that the non-random movement of the fishing vessel may obscure this comparison; and
- search time could not be used to estimate other aspects of krill distribution because fishing operations were limited by processing efficiency rather than by availability of krill.

3.22 The Working Group noted that conclusions on search time from one area may not be generalised for other areas. For example, the composite index, including search time, was developed for the fishery off Wilkes Land (Division 58.4.1) and therefore may not be applicable to other areas such as the Peninsula (Subarea 48.1).

3.23 As the krill fishery develops, krill availability may change and search time may become a useful index. Feedback management will require some estimate of krill abundance. Acoustic surveys are too costly to be carried out frequently enough to regularly assess abundance for management purposes, so it is necessary to investigate other options for assessing availability of krill to the fishery through an index such as search time.

3.24 The Working Group noted that it had not received any information on whether it is practical to collect search time information from fishing vessels using techniques such as gathering information on ships' activities at random intervals (SC-CAMLR-XII, Annex 4, paragraph 5.31). The Working Group encouraged the development of a pilot study on the collection of such data, possibly on the fishery off Wilkes Land (Division 58.4.1) (see paragraph 3.30).

3.25 Dr T. Ichii (Japan) reported that he had examined the collection of search time information on a Japanese commercial fishing vessel off Wilkes Land. He drew similar conclusions to those made in respect of fishing off the Peninsula - i.e., search time was difficult to measure directly.

#### *Scientific Observers Manual*

3.26 There were no reports of the *Scientific Observers Manual* having been used.

3.27 The Working Group examined the list of research activities concerning krill outlined on pages 5 and 6 of the *Scientific Observers Manual* and considered that the activities listed under 4, 'Fishery for *Euphausia superba*', could be split into those which involved general observations of fishing operations (items (i), (ii) and (vii)) and those which involved specific tasks using samples from the commercial catch (items (iii), (iv), (vi) and (v)). The Working Group agreed that the latter tasks could be prioritised in the order specified above.

3.28 There appeared to be some contradiction between the priorities for observers' activities listed on pages 5 and 6 and those specified on page 7 of the manual. The Working Group sought direction from the Scientific Committee as to whether the listing on page 7 was in some form of priority order, and if not, whether the Scientific Committee might want to prioritise these activities.

3.29 Scientists with experience of fisheries activities reported that the workload suggested in the manual was very great and that observers would have to be selective in the tasks that they performed. It was suggested that a time management report from experienced observers might aid in the interpretation of the results from observations and would assist in the use of the manual.



3.30 It was further suggested that information on the ship's activities should be collected by the observer at 20 randomly selected intervals. A list of standard activities carried out on board ship could be assembled for the observer to record against each time interval, including: fishing, processing, hove to, trans shipping, relocating and searching. An example of a timesheet for collection of random samples over a month is attached (Table 1).

3.31 The Working Group urged Members to assess whether the measurements suggested for krill in the manual were appropriate and to report to future meetings of the Working Group any suggested changes, particularly in the light of any new prioritisation established by the Scientific Committee.

#### Future Plans

3.32 Scientists from the fishing nations present (Japan, Ukraine and Chile) reported that their nations' fishing plans for 1994/95 were similar in magnitude, season and area to the 1993/94 season. The Japanese fishery will continue at the same level due to limited market demand.

3.33 An Australian company is still interested in fishing for krill with one to four ships catching up to 80 000 tonnes, but it is uncertain whether this venture will proceed in the next year.

3.34 There is still no further information on India's interest in entering the krill fishery, which was reported at last year's meeting (SC-CAMLR-XII, Annex 3, paragraph 3.12), and the Working Group expressed interest in knowing India's plans.

3.35 Members expressed continuing interest in knowing the future plans of nations, particularly with regard to potential catch levels and areas.

#### ESTIMATION OF KRILL YIELD

##### Estimation of Krill Biomass

##### Krill Flux in Statistical Area 48 and Other Areas

4.1 Dr de la Mare presented the report of the Workshop on Evaluating Krill Flux Factors (Appendix D) held at the Sea Fisheries Research Institute, Cape Town, South Africa, from the 21 to 23 July 1994.

4.2 Although much of the data required for the workshop were available prior to the meeting, this data did not have sufficiently wide coverage to calculate all the fluxes set out in the terms of reference. Consequently, the workshop needed to identify areas for which it could carry out calculations. The computations required more time than anticipated. Therefore, the workshop report covers the calculations carried out but does not go into detail about their interpretation.

4.3 The oceanographic data provided to the workshop included CTD data from Mr M. Stein (Invited Expert) and Dr M. Naganobu (Japan) which were used to calculate geostrophic current velocities. Dr Murphy provided a set of current vectors based on the average values over the top 250 m for a single instant of time from the FRAM (Fine Resolution Antarctic Model, IOS, NERC, UK). Further limited data sets on buoy and iceberg tracks and local surface currents were also available.

4.4 The krill data used were from the FIBEX, SIBEX 1 and SIBEX 2 surveys. Dr Agnew provided interpolation software to allow the oceanographic and acoustic data to be combined.

4.5 After initial consideration of the problem in the workshop, it became clear that the calculation of fluxes over the CCAMLR subareas would not be possible or particularly useful. A number of small boxes were defined within the subareas, based on such criteria as data coverage, natural boundaries of oceanographic features and krill distribution. Krill and water fluxes were calculated across the boundaries of these boxes, allowing water and krill residence times to be estimated. Integrated values over areas covering a number of contiguous boxes were also generated.

4.6 The analyses provide a range of values which can be used to examine krill flux in relation to fishery and predator requirements in particular regions.

4.7 There is a lack of good quality acoustic and oceanographic data collected simultaneously over the same areas, and the geographical coverage of the data is generally poor. Furthermore, the data used for the complex calculations of krill flux were originally collected for other purposes.

4.8 The calculations were based on the assumption that krill are passive tracers in the water stream. The calculations were made by multiplying the current profile along a boundary by the krill density profile along the same boundary. Residence times (as defined in Appendix D) for krill greater than those for water would suggest that krill are actively maintaining their position (i.e., not passive tracers). Although comparable residence times for krill and water would not necessarily demonstrate that krill can be considered as passive tracers, comparability over a range of geographic scales would suggest that krill are behaving as passive tracers.

4.9 The results from the workshop tended to show comparable residence times for water and krill over a range of geographic scales, implying that krill may be behaving as passive tracers. However, care must be taken in interpretation of the data, as the main water flows may be separated from areas of high krill densities. This may be a particular problem in shelf and island regions.

4.10 Dr Naganobu noted that there may be considerable aggregations of krill close to the sea bottom on the slope to the north of the South Shetland Islands, a supposition based on several reports in the literature (WG-Krill-93/15). Krill rise to the surface during summer, indicating a 'seasonal vertical flux'. This would suggest that not only horizontal, but also vertical migration may constitute an important factor in the movement and concentration of krill. Consequently, more data on vertical flux should be collected.

4.11 Nonetheless, the results from the workshop do indicate that the horizontal transport of krill is an important factor in the overall stock distribution, and aspects of krill flux do need to be considered in the development of management procedures and in the advice given.

4.12 The impact of these results on the current views of the potential yield from the fishery needs to be assessed, and consideration needs to be given to whether the current catch limits require revision (see paragraph 5.2).

4.13 The development of further analytical methods was discussed. Mr Stein indicated that there were other CTD data that should be used, and inclusion of the wind-field and Ekman drift effects could be investigated. Mr Stein indicated that he would attempt to prepare a paper on this for the next meeting. Dr Murphy said that a second FRAM data set was available which was the mean of the last six years of the model run. This data set might more realistically take account of the fine-scale eddy field. This data set could be provided to CCAMLR to repeat the calculations carried out in the workshop.

4.14 The differences between the FRAM model output and geostrophic flows result from a range of effects such as the lack of wind-induced surface currents in the geostrophic analyses, the topographic resolution of the FRAM data and the variability evident in the CTD-based estimates.

4.15 There are also a number of other oceanographic data sets on which the Working Group would encourage further submissions. In particular, there is a large body of drifter and buoy data, mainly US data (e.g., FGGE data), which would be useful. Analyses of the data to determine regions of rapid water transport with little eddy activity and areas of high eddy activity and drifter retention would be extremely useful.

4.16 Dr E. Hofmann (USA) suggested that a suite of models should be developed. At one end of the scale are the detailed regional circulation models coupling biology and oceanography. These more complex models can be developed alongside less complex, more management orientated approaches. In this way questions can be asked at a range of levels to investigate particular aspects of the more complex models, and their outputs can be used as inputs to management. As an example of the type of coupled models that could be developed, reference was made to Capella *et al.* (1992)<sup>1</sup> and Hofmann *et al.* (1992)<sup>2</sup>.

4.17 The Working Group considered that restricted regional surveys, including direct current measurements, were needed in key areas, such as shelf and shelf-break regions, where the oceanographic regime is not well described by geostrophic calculations.

4.18 The Working Group agreed that restricted spatial scale repeat surveys of particular regions, of the AMLR or LTER type, which include both oceanography and biology, were particularly useful.

4.19 The Working Group noted the distinction between more applied and more basic research questions. The development of large-scale coupled biological-oceanographic circulation models was considered to be an important area of longer term research which the Working Group should monitor.

4.20 The flux analyses carried out indicate that small-scale isolated surveys are likely to give a misleading index of krill availability to restricted predator colonies. Near-synoptic surveys were still considered to have advantages for calculating catch levels, but large-scale flux patterns need to be considered in their design.

#### New Work on Acoustic Methods

4.21 Three papers were tabled dealing with aspects of krill target strength (TS) estimation, WG-Krill-94/12, 13 and 35.

4.22 Paper WG-Krill-94/13 reported measurements of zooplankton TS obtained at different frequencies. Two theoretical models were examined, a high-pass bent-cylinder model that indicated TS was dependent on animal volume and a ray bent-cylinder model in which TS is dependent on the

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<sup>1</sup> Capella, J.E., L.B. Quetin, E. Hofmann and R.M. Ross. 1992. Models of the early life history of *Euphausia superba* - Part II. Lagrangian calculations. *Deep-Sea Research*, 39 (7/8): 1201-1220.

<sup>2</sup> Hofmann, E.E., J.E. Capella, R.M. Ross and L.B. Quetin. 1992. Models of the early life history of *Euphausia superba* - Part I. Time and temperature dependence during the descent-ascent cycle. *Deep-Sea Research*, 39 (7/8): 1177-1200.

cross sectional area. Neither of these models incorporates orientation which is a confounding factor of sufficient complexity that while both models provide descriptions of the observed effects, neither provides a comprehensive explanation. The authors concluded that linear regressions of TS on the log of animal length or weight can be misleading.

4.23 The Working Group agreed that approaches using more than one frequency provided a more realistic approach to target identification. This had been examined in WG-Krill-94/12, where theoretical estimates of target strength were used in conjunction with field sampling to determine whether it was possible to distinguish between salps and krill. Although having similar acoustic properties, these two scatterers could be distinguished with reasonable success by the technique.

4.24 Paper WG-Krill-94/35, previously published in the *Journal of the Marine Acoustics Society of Japan*, discussed the conditions that are necessary for precise measurement of *in situ* TS. It was concluded that the conditions for detection of individual targets were unlikely to be met by numerical densities of krill greater than about one per resolution volume.

#### Review of Issues on Survey Design

4.25 Four papers, WG-Krill-94/14, 18, 20, 27, and the report of the Subgroup on Survey Design (SC-CAMLR-X, Annex 5, Appendix D) were discussed.

4.26 Paper WG-Krill-94/14 described a series of acoustic surveys in a limited area near Elephant Island which had been used to investigate spatial variability prior to the commencement of commercial krill fishing during the 1992 season. There was some concordance between the first three surveys, but the last survey indicated a major reduction in krill abundance. Commercial fishing soon after the last survey was characterised by high catch rates. This implied that the abundance of krill in the Elephant Island area can change rapidly, and when krill do come into the area, they are most often found at the same location.

4.27 Plans for an acoustic survey in Division 58.4.1 were discussed (WG-Krill-94/18). The primary aim of the survey will be to provide an estimate of standing stock which could be used as the basis for setting a precautionary catch limit for the area. Some information is available on the distribution of commercial catches in the region but little additional information is available. Planning the survey has highlighted the constraints imposed by incorporating regular series of CTD casts and net hauls into a study based mainly on acoustic observations.

4.28 Alternative strategies were discussed, such as undertaking intensive surveys in three smaller localities with broader scale surveys in between and then extrapolating to the overall area. No ideal alternative strategy was identified and the Working Group felt that if the survey were undertaken according to the submitted design the results would be suitable for providing a standing stock estimate to use as the basis for a precautionary catch limit. It was recognised that most of the krill in Division 58.4.1 were likely to be found south of 63°S.

4.29 Plans for a Japanese survey in Subarea 48.1 were discussed (WG-Krill-94/27). This study aims to investigate krill flux in the South Shetland Islands region, estimate the grazing impact of krill on other planktonic species and to study krill-predator interactions. Krill close to the bottom would be investigated using a deep echosounder and closing nets. It was reported that an acoustic doppler current profiler would be used for the study but could not be used in conjunction with the echosounder due to interference between the two instruments. This problem has been noticed by other researchers. The study would be undertaken in three phases during the period December 1994 to March 1995. The Working Group welcomed this initiative.

4.30 Guidelines for the design of surveys were summarised in WG-Krill-94/20 following the results of the meeting of the Subgroup on Survey Design (SC-CAMLR-X, Annex 5, Appendix D), and responses to a request for information were circulated by the Working Group Convener. The Working Group recognised the need to obtain unbiased estimates of biomass and variance from acoustic surveys. Because spatial data are rarely independent, it might be assumed that a strategy which gives an even coverage of the area would be the more effective. However, according to classical sampling theory this design would lead to a biased estimate of variance because samples would not be independent of each other unless the resource is assumed to be randomly distributed. As the latter is not likely to be true, an unbiased estimate of variance would only be possible using classical sampling theory with a random sampling design (with or without stratification).

4.31 The geostatistical approach exploits the existence of spatial correlation. Independence of samples is not a requirement under this approach. Variance is estimated in accordance with a model fitted to the covariance function or variogram.

4.32 When the inter-transect distance is greater than the range of spatial correlation, the variance estimated by both approaches is very similar.

4.33 The Working Group recognised that these approaches warrant further consideration and encouraged continued discussion to enable the group to recommend specific approaches to survey design and data analysis.

## Methodology Used on Recent Surveys

- 4.34 Four papers were discussed on this subject, WG-Krill-94/21, 32, 34 and WG-Joint-94/9.
- 4.35 Paper WG-Krill-94/21 reported recent surveys in the Prydz Bay region. The Working Group noted that the three-dimensional plots of the results indicated that there might be some spatial structure present along the transects, particularly close to the shelf break, which might warrant further investigation.
- 4.36 Paper WG-Krill-94/32 included results from two surveys using a 38 kHz system in the marginal ice zone. Noise margin levels were set by inspecting signal levels on an oscilloscope whilst operating in clear water; this resulted in different values being used for the two legs of the study. The survey design was of parallel transects, 20 minutes of longitude apart.
- 4.37 A 120 kHz system was available for this study but the results were considered by the authors to be unreliable due to low signal levels and an unexplained, approximately 20 log R, increase in mean volume backscattering strength with depth.
- 4.38 Paper WG-Krill-94/34 summarised biomass estimates from a variety of surveys from 1977 to 1992. Estimates based on net surveys were all at least an order of magnitude lower than the acoustic estimates, suggesting that avoidance is a significant problem with the former method. Without details of the individual surveys, the Working Group was unable to comment further.
- 4.39 Paper WG-Joint-94/9 included information on a series of four sequential surveys undertaken in the vicinity of Elephant Island during January and February 1994 as part of the AMLR Program. Two designs were used for the surveys, the first and last of which covered a large area with parallel transects spaced at 15 n mile intervals while the other two surveys covered a smaller area with transects spaced at 5 n mile intervals. It was accepted that these designs represented a compromise between the requirements for estimating abundance and its variance by the traditional methods and determining spatial structure.
- 4.40 Comparisons were made between biomass estimates calculated assuming that all zooplankton sound scatterers were krill, and those calculated by assuming that only distinct swarms contained krill. Biomass estimates differed by only 6 to 8%.
- 4.41 The Working Group agreed that reports of surveys should include not only the results of calibrations, but also the instrument settings used during the survey. It was noted that when

calibrations were undertaken away from the survey area, the sound speed and absorption coefficient volumes might not be appropriate for polar regions. During surveys, values of these parameters appropriate to the conditions should be used. There remains some uncertainty regarding how to compensate for noise.

#### Modelling the Distribution of Krill Aggregations

4.42 Two papers were discussed, WG-Krill-94/7 Rev. 1 and WG-Krill-94/31.

4.43 Paper WG-Krill-94/7 Rev. 1 described an approach to modelling the distribution of krill aggregations based on observations in the Southern Indian Ocean sector. The presence of krill in the surface 3 to 8 m during daylight early in the austral summer was noted by the authors. Such an occurrence can introduce bias into acoustic estimates of krill density, and hence abundance. At larger scales the distribution of aggregations was reasonably well described by an exponential function, but this was not the case at smaller scales. The Working Group noted these developments and encouraged further examination of the data, particularly since they were obtained in an area from which little information had been available in the past.

4.44 Paper WG-Krill-94/31 described the fitting of random-process models to the distribution of the centre-to-centre distances of krill aggregations detected on surveys undertaken aboard FFS *Walther Herwig* and FSV *Agulhas*. A total of twelve models were investigated, including both simple distributions and binary mixtures of these. The authors concluded that the best fit was obtained using a two-component Weibull mixture model or a log-transformed extreme value approach. It was agreed that one of the reasons that the models had been poor descriptors of the distributions was that at least two processes were being described: random diffusion and active aggregation.

#### Biomass Estimates from the Integrated Study Regions (see also Annex 7, paragraphs 3.8 to 3.18)

4.45 No new surveys for Statistical Area 48 suitable for use in revising the precautionary catch limit were reported.

4.46 Surveys were reported for parts of the CEMP Integrated Study Regions (ISRs) and the results are set out below.

4.47 Results from three surveys in the region of Prydz Bay are presented in WG-Krill-94/21. These cover areas which are part of the ISR. Biomass estimates are summarised below:



	Weight Density (g/m <sup>2</sup> )	Biomass (10 <sup>6</sup> tonnes) over 150 000 km <sup>2</sup>	CV (%)
1985	20.2	3.02	16
1991	16.6	2.47	17.6
1992	10.25	1.53	34.8
1993	7.7	1.15	23.7

4.48 A review of results of Ukrainian krill surveys in the vicinity of Prydz Bay are presented in WG-Krill-94/34. The results from acoustic surveys are summarised below:

Period	Area (km <sup>2</sup> )	Mean Biomass (g/m <sup>2</sup> )	Total Biomass (million tonnes)
February-March 1977	133 200	187.7	25.0
December 1977-January 1978	129 260	50.7	6.56
February-March 1978	129 000	65.8	8.49
February 1979	107 600	60.7	6.53
January 1980	133 000	20.5	2.72
January-March 1981	112 400	20.0	2.25
December 1981-January 1982	168 000	22.6	3.80
December 1982-January 1983	126 800	21.3	2.70
December 1983-January 1984	124 000	71.0	8.81
January-February 1984	345 000	17.5	6.04
February 1985	123 000	41.1	5.1
February 1986	94 000	36.6	3.44
February 1987	105 000	18.3	1.92
February-March 1988	42 000	48.0	2.0
February 1989	37 800	92.0	3.5
February-March 1990	53 800	167.0	9.0
January-February 1991			5.37
February-March 1992			2.58

4.49 Results of a series of acoustic surveys in early 1994 from within the Elephant Island region of the Antarctic Peninsula ISR were presented in WG-Joint-94/9 and are summarised below:

	Weight Density (g/m <sup>2</sup> )	Variance	Area (10 <sup>6</sup> m <sup>2</sup> )	Biomass (10 <sup>3</sup> tonnes)	CV (%)
17 to 28 January	9.63	1.06	41 673	401	11
29 January to 2 February	12.02	1.12	7 203	86	9
17 to 19 February	13.46	8.66	7 203	97	22
25 February to 9 March	8.61	3.71	41 673	359	22

4.50 The biomass from these four surveys was substantially lower than that from surveys in previous years. Mean values of density from previous years are summarised in the table below. It was noted that the high value in 1993 may in part be due to difficulties in differentiating between echo signals from salps and krill.

	Average Krill Density (g/m <sup>2</sup> )
1990	58.6
1991	26.3
1992	45.4
1993	111.4
1994	8.8

## Krill Yield Calculations

### Evaluation of Population Models

4.51 A number of papers were presented describing further work on the krill yield model of Butterworth *et al.* (1993). This model, which has been developed and used within the Working Group to relate krill yield to a pre-exploitation survey estimate of krill biomass (see paragraph 4.92), has been further developed according to specifications outlined in SC-CAMLR-XII, Annex 4, Appendix E.

4.52 Paper WG-Krill-94/5 reported that the computer code for the krill yield model had been updated to incorporate the recruitment module as developed in WG-Krill-93/13. Checking of the computer code was carried out intersessionally and at the meeting and it was concluded that the program was now correct.

4.53 Paper WG-Krill-94/23 detailed preliminary computations carried out for the krill yield model. This involved modifying the input distributions for the lengths at recruitment and maturity (according to the results of WG-Krill-94/4), natural mortality (M) and the extent of recruitment variability. Sensitivity tests were carried out to assess the consequences of avoidance of gravid females by the fishery and higher natural mortality for younger ages of krill.

4.54 Results of the sensitivity tests indicate that partial avoidance of gravid females leads to greater depletion of males, but lesser depletion of females, than for the comparative base case where gravid females are not avoided. This effect increases for large values of  $\gamma$ , the proportion of the unexploited biomass that can be taken as catch<sup>3</sup>.

4.55 The reproductive behaviour of krill is such that a single male produces sufficient spermatophores to fertilise more than one female. It is therefore unlikely that the heavier depletion of

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<sup>3</sup>  $\gamma$  is a value (corresponding to a decision criterion) which is computed by means of the krill yield model and used in the formula  $Y = \gamma B_0$  to obtain the yield, or catch, (Y) from an estimate of the pre-exploitation krill biomass,  $B_0$ .

males would adversely affect reproduction of the krill population at the levels of  $\gamma$  that have previously been considered appropriate by WG-Krill ( $\gamma \sim 0.1 - 0.165$ ; see paragraph 4.94).

4.56 Results of sensitivity tests (WG-Krill-94/42) also indicate that higher values of M for younger ages result in a krill population which is less resilient to higher harvesting intensities, i.e., higher values of  $\gamma$ . The assumption used in the tests was that M for ages 0, 1 and 2 is double that for older ages. The realism of this assumption was questioned, and the Working Group referred this question to the Joint Meeting of WG-Krill and WG-CEMP (WG-Joint). This discussion is presented in Annex 7, paragraphs 4.34 and 4.35).

## Evaluation of Demographic Parameters

### Estimation of Krill Recruitment Variability

4.57 At the WG-Krill meeting in 1993, a method for estimating the proportion of recruits in the population from data on length density distributions was presented (WG-Krill-93/12). This proportion is estimated by fitting a mixture distribution to a length density distribution. The proportion of 1-year-old recruitment is estimated as the ratio of 1-year-olds to all older animals, and the proportion of 2-year-old recruits similarly.

4.58 The average proportion of recruits and the variability about this average are estimated from a number of data sets. These two statistics are then used as inputs to the krill yield model to generate time series of (fluctuating) recruitment. One of the assumptions of the estimation method is that the length density distributions are representative of the length structure of a self-sustaining krill population for the range of age classes considered.

4.59 Results, in terms of the average and variance of the proportion of recruits, had been calculated in WG-Krill-93/12 from a subset of the data sets considered in the analysis. Estimates (of the recruitment proportion) that were close to zero were excluded.

4.60 At this meeting, an attempt was made to develop criteria for the exclusion of data sets from the estimation of recruitment proportion and variability. There were no obvious reasons for exclusion of any of the original data sets used in WG-Krill-93/12. Two modifications to the data sets were, however, suggested.

4.61 The *Walther Herwig* FIBEX survey included a number of samples made in the Weddell Sea, just to the southeast of the Antarctic Peninsula, and it was suggested that data from this area should be excluded. The main reason for this exclusion is the different mean length of the krill age group 1+

compared to the krill from the Peninsula area, suggesting an origin from different populations. Inclusion of these data is thought to violate the assumption of representativeness of a single population.

4.62 The second suggestion was to exclude all data for sizes below 20 mm because of possible net selectivity problems. Only data obtained from RMT8 nets were considered, and this type of gear is likely to select animals greater than 20 mm in length. Selectivity at the upper end of the size distribution is unlikely to have a serious effect on estimates, whereas selectivity at the lower end of the size distribution is far more likely to do so.

4.63 Further data sets for use in the estimation of recruitment variability were requested in SC-CAMLR-XII, Annex 5, Appendix E, and nine more data sets were submitted. At the present meeting, these new data sets were analysed together with a re-analysis of the original data sets, incorporating the suggestions noted above (paragraphs 4.61 and 4.62).

4.64 Estimates of recruitment proportion were obtained for 1-year-olds (18 data sets) and for 2-year-olds (17 data sets)<sup>4</sup>. These values were combined into three estimates of the average and variance of recruitment proportion, based on: (i) 1-year-old recruitment; (ii) 2-year-old recruitment; and (iii) 1- and 2-year-old recruitment combined (see below). Full details of the results are given in Appendix F.

	1-year R	2-year R	Combined
Number of estimates	18	17	35
Mean R estimate	0.404	0.557	0.415
Standard deviation	0.456	0.126	0.442
CV of distribution	1.128	0.226	1.067

Note: combined statistics reflect inverse variance weighting.

4.65 The mean recruitment proportions are similar, but the standard deviations (SDs), and, hence, coefficients of variation (CVs), are much higher for 1-year-old recruitment than for 2-year-old recruitment. The combined results are dominated by estimates for 1-year-old recruitment, because values are combined by inverse variance weighting.

4.66 The high CVs for the 1-year-old recruitment proportion and for the combined sets of estimates imply that these distributions are U-shaped with high probabilities of observing values close to zero and values close to 1. These distributions are more variable than a uniform distribution,

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<sup>4</sup> Results are for all data sets analysed in WG-Krill-93/12 and all nine new data sets (paragraph 4.63); see Appendix F.

which has a CV of about 0.3. On the other hand, a CV less than 0.3 would imply a bell-shaped distribution, and this would be the case for the results based on 2-year-old recruitment.

4.67 Although it is possible that the recruitment proportion distribution for krill is U-shaped rather than bell-shaped, it is unlikely that it would be as extreme as suggested by the results. If mortality is in a range compatible with the expected life-span of krill, then one would not expect frequent occurrences of recruitment much larger than the numbers in several older age classes, and one would therefore not expect a high probability of a recruitment proportion close to 1. There is a high probability that recruitment proportions will be close to zero.

4.68 There is, however, an apparent contradiction in that the results for 1-year-old recruitment suggest a U-shaped distribution, whereas results for 2-year-old recruitment suggest a bell-shaped distribution. There are two possible explanations for this.

4.69 First, the basic assumptions of the recruitment method may be violated, which would lead to unreliable results. The assumptions are that:

- (i) length density distributions are representative of the length structure of a self-sustaining population;
- (ii) the length structure can be described by a mixture distribution with increasing age, leading to a monotonic increase in mean length-at-age; and
- (iii) krill do not shrink naturally.

At least one set (1+ year-olds or 2+ year-olds) may, for example, not be representative of the length structure of a self-sustaining population.

4.70 In this regard, it was noted that there were possible reasons for excluding some of the data from two of the surveys included in the new analysis (the German surveys in 1982 and 1983, code-named GER1982 and GER1983). These data sets gave estimates of 1-year-old recruitment proportion close to 1, which was thought to be due to over-sampling of small krill in the Bransfield Strait, or from the shelf area. The spatial segregation of krill of different age/size classes is well-documented for this area (e.g., WG-Krill-94/22), and could lead to non-representative length density distributions. This concern may also be expressed for some other surveys and should be considered before future discussion of matters mentioned in paragraphs 4.64 and 4.66 to 4.68.

4.71 Paper WG-Krill-94/22 presents estimates of recruitment proportion using distribution mixture analysis for the same two surveys, but including data from the vicinity of Elephant Island only. The surveys in this area are thought to cover the distribution range of all krill life stages and size groups.

4.72 Due to limited time, the recruitment variability analysis could not be repeated at the meeting excluding all, or some, of the data from the German surveys in 1982 and 1983. These surveys are not included in the estimates of 2-year-old recruitment.

4.73 The second possible explanation for the different shapes of recruitment distribution suggested by the 1-year and 2-year-old recruitment proportions, is that natural mortality for krill between ages 1 and 2 may differ from that at greater ages, reflecting also large variability, possibly as a result of density dependence. If this is the case, then it would be reasonable to use estimates based on 2-year-old recruitment in the yield model, since the fishery does not take 1-year-olds.

4.74 The krill yield model was run with the new estimates of average recruitment proportion and variability. Both sets of results, those based on 1- and 2-year-old recruitment combined, and those based only on 2-year-old recruitment were used. Results are discussed in paragraph 4.101 below.

4.75 The algorithm that generates krill recruitment in the yield model, using the estimates of average recruitment proportion and variability, is based on the assumption that the distribution of recruitment proportion is bell-shaped. A bootstrap re-sampling procedure was therefore applied instead to provide results for analyses including the 1-year-old recruitment proportions.

4.76 Paper WG-Krill-94/15 raised two points regarding the method of estimating recruitment variability and its implementation. First, concern was expressed whether net samples were likely to provide representative samples. Criteria for the exclusion of data (paragraphs 4.61 and 4.62) were discussed; only data from RMT8 nets, which are likely to fully select for animals above 20 mm, were considered, and data on size classes below 20 mm were excluded.

4.77 The second concern was that, at high recruitment proportions (around 0.7 and above), the simulated variance is higher than the 'true' variance. In response, it was noted that currently the average values of recruitment proportion are around 0.5 and most values are below 0.7, so this problem is unlikely to have a great effect on results.

4.78 It would, however, be possible to try to modify the algorithm to improve its performance at high levels of recruitment. The Working Group agreed that this could not be done during the meeting, but should be given attention before its next meeting.

## Krill Natural Mortality and Growth

4.79 Paper WG-Krill-94/16 presented growth and mortality estimates for krill from the Prydz Bay area. Results are consistent with previous estimates. It was noted that although growth estimates were obtained by fitting mixture distributions to length frequency data, these data could not be used directly for the estimation of recruitment proportion because this requires length density distributions. The data are, however, recorded in sufficient detail to construct length density distributions.

4.80 The author noted that there is some evidence of spatial segregation by age in the samples. To the north of the Antarctic divergence, mainly 4+ animals are found, whereas all age classes are represented south of the divergence. This should be considered if the data are to be used for the estimation of recruitment proportion in the future.

4.81 The data described in this paper are not in the CCAMLR database, and Prof. V. Yakovlev (Ukraine) indicated that the main problem in submitting the data to CCAMLR is lack of finance for extracting and preparing the data. The Working Group emphasised that the data would be very valuable to the work of WG-Krill.

4.82 In general discussion of the estimation of von Bertalanffy growth parameters, the negative correlation between  $\kappa$  and  $L_{inf}$  was noted<sup>5</sup>. If the curvature in the mean size-at-age plot is not evident, then it is easier to determine the product ( $\kappa \cdot L_{inf}$ ) than either parameter on its own.

4.83 Paper WG-Krill-94/17 presents results of a study investigating whether krill shrink in the wild. If krill do shrink, then current estimates of growth rate may be positively biased. Estimates of recruitment variability, and hence mortality, may also be affected. The study considers the number of crystal cones in the eyes as a possible index of age. The crystalline cone count may not decline with shrinkage, and may therefore give a more reliable index of age than that provided by length.

4.84 Preliminary results indicate some evidence for shrinkage in the wild, though further experiments are under way to validate basic assumptions and hypotheses. The method and study were brought to WG-Krill's attention at this early stage, because of their potential importance.

4.85 Dr V. Siegel (Germany) suggested that changes in crystal cone counts during maturation should also be examined, since changes in eye shape have been observed in spawning males. The eye shape returned to a pre-spawning shape after spawning.

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<sup>5</sup>  $\kappa$  = kappa, growth rate; for instance in the von Bertalanffy equation  $\text{Length} = L_{inf}(1 - e^{-\kappa(a+t_0)})$

## M/ $\kappa$ Distribution

4.86 At last year's meeting a request was made for a comparative analysis of ratios of natural mortality to von Bertalanffy growth rate for species other than krill (SC-CAMLR-XII, Annex 4, Appendix E). The main reason for this request was to enable the correlation between M and  $\kappa$  to be incorporated into the krill yield model. Prior to the development outlined in paragraph 4.52, the model used a fixed value of  $\kappa$  (0.45) with a range of values of M.

4.87 Paper WG-Krill-94/11 presented results of a wide range of M/ $\kappa$  ratios for crustaceans, including euphausiids. These estimates had to be extracted directly from the literature, and most estimates are therefore for tropical exploited species. A major problem associated with euphausiids is the lack of estimates of natural mortality. The range of values for M/ $\kappa$  is very wide and would lead to unrealistic values of  $\kappa$  for krill if used with the current range of mortality values generated in the length density distribution analyses.

4.88 The main conclusion from this paper was that M/ $\kappa$  cannot be obtained reliably from a comparative analysis. The Working Group agreed that the way forward would be to look at the properties of the yield model with regard to correlation between M and  $\kappa$ . Two options should be considered. First, the current ratio of (average) M over  $\kappa$  should be used to generate a  $\kappa$ -value for each M in the simulation. This would imply that each  $\kappa$ -value is simply some constant multiplied by the realised M.

4.89 The second option is to add some 'noise' or variability around this linear dependence. In each case, the effect of the correlation between M and  $\kappa$  on the results from the model needs to be investigated.

## Maturity and Recruitment to the Fishery by Length

4.90 Paper WG-Krill-94/4 presented revised estimates for size at 50% maturity ( $l_{m50}$ ) and size at 50% recruitment ( $l_{r50}$ ) to the fishery. Results indicate that the krill yield model should sample from uniform distributions with the following parameters:

$$l_{r50} = U[30, 39] \text{ with a width of 9 mm}$$

$$l_{m50} = U[32, 37] \text{ with a width of 6 mm}$$

where U[ ] indicates uniform distribution with upper and lower bounds.



4.91 The Working Group agreed that estimates of the range for  $l_{m50}$  were likely to be reliable, since they are derived directly from biological information on maturity. Estimates of the range for  $l_{r50}$ , on the other hand, were subject to the combined effects of gear selectivity and fishing operations. The Working Group therefore suggested that sensitivity tests with regard to  $l_{r50}$  be conducted at this meeting using the updated estimates of recruitment variability (see paragraphs 4.108 and 4.109).

#### Criteria for Selecting an Appropriate Value for $\gamma$

4.92 Over the past several years, the Working Group has been developing the krill yield model. This is used to provide values for the proportion of a survey estimate of the pre-exploitation krill biomass that can be harvested under a given set of criteria. The proportionality coefficient is called  $\gamma$ , and catch limits are calculated as the product of  $\gamma$  and an estimate of the pre-exploitation krill biomass,  $B_0$  (see footnote to paragraph 4.54).

4.93 Last year the Working Group had one decision rule for selecting a value of  $\gamma$ : choose  $\gamma$  so that the probability of the spawning biomass dropping below 20% of its pre-exploitation median level over a 20-year harvesting period is 10%. This decision rule was aimed at protecting the krill stock by not allowing the spawning biomass to drop to very low levels at which the chance for successful recruitment may be impaired. Although the probability of 10% is somewhat arbitrary, it is consistent with values used in managing other fisheries.

4.94 This decision rule, however, derives from a single-species approach. The Working Group had some initial discussions in 1993 aimed at establishing decision rules that would accord some protection to krill predators as required under Article II. Further discussions were held at this year's meeting, both in WG-Krill and the joint meeting with CEMP (Annex 7, paragraph 5.31).

4.95 In terms of predators, it is appropriate to devise a decision rule on the basis of the median level of krill escapement, defined as the ratio of median krill biomass under exploitation to the corresponding median pre-exploitation level. In a single-species management context, an escapement level of about 50% is usually considered to be appropriate. The highest level of escapement (i.e., 100% - the best situation for the predators) is achieved when there is no harvest. Given that a final decision has yet to be reached in CEMP regarding appropriate levels of escapement for predators, the Working Group suggested that a value halfway between these two bounds (i.e., at 75%) should be used as a preliminary target level, as also agreed at WG-Joint (Annex 7, paragraphs 4.33 and 4.34).

4.96 The second decision rule, aimed at protecting predator requirements, is therefore: choose  $\gamma$  so that the median krill escapement at the end of a 20-year period is 75%.

4.97 Each decision rule would lead to the selection of a value of  $\gamma$ , and these values are likely to be different. The third rule for deciding between these two values of  $\gamma$  is to select the lower, more conservative value. This means that the  $\gamma$ -value associated with the ‘limiting factor’ in the system would be selected.

4.98 The following decision rules were therefore defined:

- (i) choose  $\gamma_1$ , so that the probability of the spawning biomass dropping below 20% of its pre-exploitation median level over a 20-year harvesting period is 10%;
- (ii) choose  $\gamma_2$ , so that the median krill escapement over a 20-year period is 75%;
- (iii) select the lower of  $\gamma_1$ , and  $\gamma_2$  as the level of  $\gamma$  for calculation of krill yield.

#### Yield Estimates

4.99 Results from the krill yield model with the updated estimates of average recruitment proportion and its variability are presented below. Three sets of results are summarised: last year’s results (last); results for 1- and 2-year-old recruitment combined (1-2+); and results for 2-year-old recruitment only (2+). Results are given for the two values of  $\gamma$  that were used at last year’s meeting (SC-CAMLR-XII, Annex 4, paragraph 6.3).

Parameter		$\gamma = 0.1$			$\gamma = 0.165$		
		Last	1-2+	2+	Last	1-2+	2+
Probability spawning biomass falls below 0.2 $K_{sp}$ over 20-year period	(Prob)	0.02	0.89	0.02	0.10	0.93	0.14
Median spawning biomass after 20 years	(Med)	0.78	0.10	0.78	0.62	0.03	0.64
Lower 5% -ile spawning biomass after 20 years (Low)		0.41	0	0.43	0.24	0	0.20

4.100 Results for the recruitment parameters derived from 1- and 2-year-old recruitment combined (1-2+) are very different from the other two sets of results because of the much higher CV and U-shaped nature of the recruitment distribution.

4.101 The values of Prob, Med and Low at different levels of  $\gamma$  for the updated recruitment parameters are given below.

$\gamma$	This year 1+ and 2+			This year 2+ only		
	Prob	Med	Low	Prob	Med	Low
0	0.66	1	0.07	0	1	0.68
0.016	0.76	0.61	0.003	0	0.97	0.65
0.032	0.80	0.43	0.0002	0	0.94	0.62
0.048	0.84	0.30	0	0.001	0.89	0.58
0.064	0.86	0.22	0	0.002	0.87	0.55
0.080	0.87	0.16	0	0.008	0.83	0.48
0.096	0.88	0.12	0	0.017	0.79	0.43
0.112	0.90	0.07	0	0.04	0.76	0.39
0.128	0.91	0.06	0	0.06	0.72	0.33
0.144	0.92	0.05	0	0.09	0.68	0.26
0.160	0.93	0.04	0	0.13	0.65	0.22
0.176				0.17	0.61	0.17
0.192				0.22	0.57	0.13

4.102 Given the reservations expressed with regard to the combined results for 1- and 2-year-old recruitment, and in particular the inclusion of the two German data sets for 1982 and 1983 which are thought to be unrepresentative, and the apparent inconsistencies (see paragraph 4.64) in results for 1- and 2-year-old recruitment, the Working Group agreed that at this stage it is most appropriate to consider yield calculations based on 2-year-old recruitment only.

4.103 The first decision rule resulted in  $\gamma_1 = 0.149$  and the second decision rule  $\gamma_2 = 0.116$ . Full results (using 2-year-old recruitment) for both  $\gamma$  values are given below:

Statistic		First Decision Rule	Second Decision Rule
		P = 0.10 $\gamma_1 = 0.149$	M = 0.75 $\gamma_2 = 0.116$
Probability of spawning biomass falling below 0.2 over 20-year harvest period	(Prob)	0.10	0.04
Median spawning biomass level at the end of 20 years	(Med)	0.68	0.75
Lower 5%-ile spawning biomass	(Low)	0.25	0.38

4.104 It was noted that these two values of  $\gamma$  lie between the values of 0.1 and 0.165 used previously.

4.105 The third decision rule, which indicates that the lower of the two  $\gamma$ -values should be chosen, implies that a  $\gamma$ -value of 0.116 should be used in calculations of catch levels.

4.106 The sensitivity of results to the distribution of size at 50% recruitment to the fishery was investigated. Calculations for the 2+ estimates of M and recruitment variability from this meeting have been repeated for 5 mm upward and downward variations in the distribution assumed for length at 50% recruitment ( $l_{r50}$ ), which is currently taken from a distribution U[30,39] mm.

4.107 The values of  $\gamma$  corresponding to the two criteria identified as a basis for management recommendations are given below.

$l_{r50}$	$\gamma$		
	U[25, 34] mm	U[30, 39] mm	U[35, 44] mm
Prob = 0.10	0.131	0.149	0.214
Med = 0.75	0.109	0.116	0.128

4.108 Paragraph 4.107 shows that most changes in  $\gamma$  are not too substantial (~10%) for the changes in  $l_{r50}$  used. The Working Group agreed that there was a need to determine whether the ranges of distributions used in the sensitivity tests were likely to reflect the real situation.

4.109 Dr Agnew said that, having analysed the data, he felt that the real situation was indeed covered by the sensitivity analyses. He indicated that it would be possible to quantify the likely bounds on estimates of  $l_{r50}$  to determine whether the 95% confidence interval from the estimates falls within the ranges tested above. This would be facilitated by more length frequency samples from the fishery, particularly from Ukrainian and Chilean fishing vessels, becoming available.

4.110 The analyses presented in WG-Krill-94/4 were based on samples from the Japanese and former Soviet fisheries which used 15 to 17 mm and 12 mm mesh sizes respectively. Precise information on the mesh size used by the Ukrainian fishery was requested.

#### Review of Precautionary Catch Limits

4.111 Discussion under this item is reflected in Section 5 and Table 2.

## Precautionary Limits on Krill Catches in Various Areas

### Estimates of Potential Yield

5.1 The meeting agreed that, as in the past, calculations of precautionary limits on catches should be made using the formula  $Y = \gamma B_0$ , where  $B_0$  is an estimate of the pre-exploitation krill biomass, and  $\gamma$  is a value (corresponding to certain decision criteria) which is computed by means of the krill yield model. In terms of the decision rules agreed above (see paragraph 4.98), the current best estimate for  $\gamma$  is 0.116.

5.2 There was considerable discussion on whether survey estimates of  $B_0$  (in Subareas 48.1, 48.2 and 48.3, for example) should be adjusted upward to allow for krill flux through these subareas. Details of this discussion, and its implications for management, are reported in Appendix E.

5.3 The outcome of these discussions was that making no 'flux adjustment' to survey estimates for  $B_0$  constituted a sufficient and conservative basis for management, provided that the regions for which precautionary limits were set did not contain more than one self-sustaining stock. This approach would allow catch limits to be set for all subareas or divisions in the Antarctic for which biomass estimates are available.

5.4 An alternative approach of making adjustments for flux for certain subareas would necessitate zero catch limits being set in other subareas - particularly those upstream of the subareas concerned, for example. This option could not be implemented immediately and further analyses would be necessary if it is to be pursued.

5.5 The meeting accordingly applied the approach of paragraph 5.3 to calculate precautionary catch limits. The results are given in Table 2.

5.6 Conservation Measure 46/XI specifies subarea maxima that currently apply in addition to the present overall precautionary catch limit of 1.5 million tonnes of krill in Statistical Area 48 (Conservation Measure 32/X). A number of views were put forward as to how the revised calculation of a limit of 4.1 million tonnes for Statistical Area 48 (see Table 2) should be subdivided.

5.7 The first view was that the revised precautionary limit of 4.1 million tonnes should replace the existing 1.5 million tonnes figure, and be subdivided as reflected by column A in Table 2. This

approach follows from the rationale given in Appendix E, which implies that the limits for subareas should be based solely on biomass estimates for those subareas (so that, *inter alia*, zero limits apply in subareas where there has as yet been no survey). Advocates of this approach queried the use of historic catch data as a guide towards subdivision, arguing that this was not a sound approach in the longer term, as the fact that a particular level of catch has been maintained over a limited period constitutes no guarantee that it is sustainable.

5.8 One reservation expressed concerning this approach was that it was unreasonable to reduce the existing limits for Subareas 48.4 and 48.5 from 75 000 tonnes to zero. Another was that the resultant decrease for Subarea 48.3 from 360 000 to 180 000 tonnes was inappropriate, as it was an artefact of the low coverage of this subarea achieved in the FIBEX survey used to provide the  $B_0$  estimate.

5.9 In response to these concerns, proponents of the approach in paragraph 5.7 argued that:

- (i) these low values provided an appropriate incentive to organise surveys of these subareas (for the first time, or on a more extensive basis than previously);
- (ii) the approach, consistently applied, obviated the need for restriction of consideration to the results from near-synoptic surveys in setting precautionary catch limits - hence other surveys in, for example, Subarea 48.3 in addition to FIBEX could be considered in refining the estimate of  $B_0$  for that subarea;
- (iii) the situation for subareas with zero limits (because of the absence of a prior survey) might be reconsidered in the context of limited allowances for exploratory fisheries;
- (iv) further flux studies might provide evidence of a sufficiently large transfer of krill between, say, Subareas 48.2 and 48.3 to negate an hypothesis that these subareas contained effectively separate self-sustaining stocks, thus allowing them to be combined for the purpose of setting precautionary catch limits.

(The meeting did not have sufficient time to pursue analyses which might have allowed options (ii), (iii) or (iv) to be further examined.)

5.10 The second view concurred with the revision of the overall precautionary catch limit to 4.1 million tonnes. However, according to this view the matter of subdivision had already been discussed at length at previous meetings, and the sub-division proportions for each subarea then agreed (SC-CAMLR-XII, Annex 4, Table 5) should be applied pending further detailed consideration

of this matter (since little time had been available to study the rationale advanced in Appendix E at this meeting). These percentages are based on taking the average of the proportion of FIBEX survey estimates and the proportion of the historic catch in a subarea of Statistical Area 48 and adding 5%. The results of such a subdivision, and the percentages upon which it is based, are shown under column B in Table 2.

5.11 A reservation concerning this second view was that the percentages adopted for subdivision had been agreed in the context of an overall limit of 1.5 million tonnes for Statistical Area 48. It was argued that this agreement had not been intended to extend to a higher figure for this limit, as was now under consideration.

5.12 A third view was that the likely levels of fishing for the next season were considerably less than the 'subdivision trigger' level of 0.62 million tonnes in Conservation Measure 46/XI. Accordingly, there was no immediate need to revise either the trigger level or the 1.5 million tonnes overall limit of Conservation Measure 32/X for Statistical Area 48.

5.13 The Working Group had insufficient time to discuss these views further.

5.14 Concern has previously been expressed that krill fishing has occurred in Division 58.4.1, but that a survey of the krill biomass in that region has yet to take place. The meeting was therefore pleased to hear (WG-Krill-94/18) of plans by the Australian Antarctic Division for a survey of this division during the 1995/96 summer season.

5.15 Comments on the detailed proposals of WG-Krill-94/18 are recorded in paragraph 4.27. The meeting endorsed the overall proposal which would provide key information.

5.16 Drs de la Mare and Nicol stated that they would welcome the participation of vessels from other countries in the survey, as this would improve survey intensity and synopticity. Dr Naganobu advised that Japan was giving consideration to this possibility. The CCAMLR Secretariat could facilitate the coordination necessary if a multi-national survey becomes likely. In the meantime Dr Nicol would be the contact person for information.

5.17 The Scientific Committee had accorded a high priority to the refinement of the biomass estimate for Division 58.4.2 (SC-CAMLR-XII, paragraph 2.83). Two papers, WG-Krill-94/21 and 34, presented estimates of krill biomass for areas within Division 58.4.2. Due to differences in coverage, estimates could not easily be related to the biomass in the whole of Division 58.4.2 and it is also not easy to relate these estimates to the original FIBEX estimate previously used by WG-Krill.

5.18 The Working Group had insufficient time to discuss this matter further.

#### Possible Ecological Effects on Catch Limits

5.19 The Working Group noted the precautionary catch limits using the new estimate of  $\gamma = 0.116$ , obtained from the three decision rules agreed upon at this meeting. The estimates of biomass for Subareas 48.1, 48.2, 48.3 and 48.6 have not been changed, since no new information has been received.

5.20 WG-CEMP (SC-CAMLR-XII, Annex 6, paragraph 5.33) had addressed certain questions to WG-Krill. These were considered by WG-Joint (Annex 7, paragraphs 4.7 to 4.16).

#### Refining Operational Definitions of Article II

5.21 The Working Group agreed that substantial progress had been made in the refinement of operational definitions, in particular on the three decision rules for the selection of  $\gamma$  (paragraph 4.98).

5.22 The Working Group recognised the need for operational definitions that considered the needs of predators as well as prey, and in this regard welcomed the adoption of a value of krill escapement of 75% (Annex 7, paragraphs 4.32 and 4.33). The Working Group recommended that such operational definitions should be developed.

5.23 The Working Group recommended that the interim decision rules for the selection of an exploitation rate in calculating precautionary catch limits be considered for adoption by the Scientific Committee. The Working Group noted that the krill yield model has been refined and that the key parameters in that model were now based on analyses of data. The Working Group also noted that the revised precautionary catch limit for Statistical Area 48 has been calculated using agreed data and methods. The major problem facing the Working Group is in providing advice on the allocation of a precautionary limit to subareas within Statistical Area 48 (see paragraphs 5.7 to 5.13). The two basic approaches to allocation each result in some anomalies. The Working Group recommended that the Scientific Committee consider this matter further with a view to clarifying the basic approach to be followed and possible means of resolving the anomalies in the selected approaches.



## Data Requirements

5.24 Standard data requirements of the Working Group are given in Table 3. Two additional items were discussed.

5.25 The Working Group received an offer from Chile to present data on trawl start times and duration. The Working Group agreed that this data would be useful. Analyses such as catch/towing hour could show seasonal trends. In addition, the data would be of use in fishery behaviour models. The Working Group therefore recommended that such data should be presented to the next meeting.

5.26 As requested by CCAMLR-XII (paragraph 6.10), the Working Group discussed the implications of a 50-tonne research catch as a trigger level for Conservation Measure 64/XII. Experience from a German research cruise utilising commercial krill trawls indicated possible catches of up to 400 tonnes of krill. The Working Group recommended that other researchers using commercial types of trawl submit similar information, which would then enable WG-Krill to review the situation at its next meeting.

## Access to and Use of Data within CCAMLR

5.27 The Convener outlined briefly the principles of access to data and use of data within CCAMLR (WG-Krill-94/19).

5.28 Some concern was expressed where collaborative analyses, to be carried out during the intersessional period, were sanctioned by the Working Group during its meeting.

5.29 The Working Group reiterated that:

- (i) analyses presented as Working Group documents are not considered to be public documents; and
- (ii) if the final aim of the analysis is formal publication, then the onus is on the person(s) undertaking the analysis to obtain the necessary permission from the originators of the data at the outset of any collaborative undertaking.

5.30 The Working Group agreed that it is highly desirable that in cases outlined in paragraph 5.29 that this permission be obtained during the relevant Working Group or subgroup meeting.

## Future Work and Organisation of WG-Krill

### Review of Terms of Reference

5.31 A discussion of this item is given in the Report of the Joint Meeting of WG-Krill and WG-CEMP (Annex 7, Section 6).

### Future Organisation of Work

5.32 The report of the Joint Meeting of WG-Krill and WG-CEMP identified three areas of further work which have implications for WG-Krill:

- (i) the determination of krill flux;
- (ii) the determination of options for decision rules for calculating appropriate levels of krill harvesting; and
- (iii) the functional relationships between predators and prey.

5.33 In addition, ongoing activities of WG-Krill that need to continue through the intersessional period are listed in Table 4.

## OTHER BUSINESS

6.1 The Working Group noted that in recent years the catch of *E. superba* in the Convention Area has been smaller than that of *Euphausia pacifica* off the west coast of Japan. The catch of *E. pacifica* will reportedly fall to 90 000 tonnes this year, with management of this fishery being based on market demand rather than on biomass estimates. Mr Ichii agreed to contact those involved with the management of the *E. pacifica* fishery to investigate whether there were matters of common interest to scientists involved in the management of these krill fisheries.

## ADOPTION OF THE REPORT

7.1 The report of the Sixth Meeting of WG-Krill was adopted.

## CLOSE OF THE MEETING

8.1 In closing the meeting the Convener, Mr Miller, thanked participants, rapporteurs and the Secretariat for ensuring a successful and productive meeting. In particular he thanked Dr V. Shannon, Director of the Sea Fisheries Research Institute for his assistance and support in organising the whole suite of Flux, Krill, CEMP and joint meetings, and all his staff who had worked tirelessly to effect its success. He stated that holding these meetings in South Africa was of great personal satisfaction to him.

8.2 Mr Miller then informed the meeting that it was his intention to step down from the position of Convener at the close of the 1994 Scientific Committee meeting. He thanked all participants, past and present chairmen of the Scientific Committee and other Working Groups, and all staff of the Secretariat for making his years as Convener, from 1989 to 1994, productive, pleasurable and satisfying. He particularly congratulated the Working Group on the direction which it was taking and the progress it had made towards responsible scientific support of the Commission and the Convention.

8.3 Dr Shannon congratulated Mr Miller on successfully concluding the meeting, and thanked all participants for their support in its deliberations in South Africa. The Executive Secretary also extended thanks and congratulations to Mr Miller on behalf of CCAMLR.

8.4 Dr Everson then delivered a vote of thanks to the Convener from the Working Group and presented him with an engraved avian statuette.

8.5 The Convener then closed the meeting.

Table 1: CCAMLR Observer Program. Random times of day to be used when recording fishing vessel activity. Activity type should be recorded in the boxes provided.

Activity codes:

- F = Fishing (haul in progress)
- S = Vessel searching/steaming
- P = Vessel stopped while processing of previous catch is completed
- A = Vessel stationary either at anchor or hove to
- T = Transshipping catch
- R = Vessel repositioning in preparation for next haul

day	1	2	3	4	5	6	7	8	9	10									
date:	date:	date:	date:	date:	date:	date:	date:	date:	date:	date:									
0:51		0:49		0:23		0:17		0:18		0:57		1:51		0:51		1:07		0:02	
1:12		2:37		1:13		0:28		0:26		1:55		2:01		3:33		2:36		2:36	
2:18		2:46		4:40		1:36		2:08		2:49		2:49		4:24		3:06		3:15	
3:17		4:23		6:41		3:45		2:12		3:17		3:08		5:50		3:18		3:29	
3:59		6:23		7:15		6:02		4:32		4:13		4:02		6:10		3:39		4:12	
6:09		6:25		7:27		6:44		4:49		4:15		4:25		12:06		5:30		5:27	
6:44		6:48		7:59		7:49		5:40		7:36		4:54		14:50		5:41		10:04	
8:17		8:41		8:02		8:24		7:41		8:38		5:13		14:59		6:45		10:28	
10:36		8:57		8:39		10:25		8:17		8:49		7:13		15:55		7:13		10:29	
10:40		9:30		9:04		10:28		9:47		13:22		8:35		16:10		7:36		11:16	
11:35		10:43		10:46		11:38		10:53		14:02		8:58		17:26		7:39		11:19	
11:47		10:54		13:21		15:12		15:16		14:49		9:06		17:50		11:00		11:35	
12:43		11:42		13:33		16:03		16:25		14:58		9:46		18:58		14:42		11:51	
13:09		12:10		14:20		16:48		17:01		15:11		12:13		19:53		16:20		14:32	
13:23		15:32		15:53		17:37		17:19		18:47		15:31		19:56		16:48		17:12	
16:22		15:51		17:55		20:02		18:05		22:17		17:41		20:14		17:35		18:09	
18:14		16:22		19:14		21:47		18:47		22:59		18:56		21:02		17:46		18:50	
19:10		18:26		20:27		22:11		19:43		23:07		18:57		21:27		17:56		20:48	
20:09		19:20		23:22		22:14		20:16		23:35		19:02		21:30		19:07		21:50	
21:34		20:12		23:56		23:12		20:57		23:56		23:20		23:38		21:12		23:15	

Table 1 (continued)

day	12	13	14	15	16	17	18	19	20
11	12	13	14	15	16	17	18	19	20
date:	date:	date:	date:	date:	date:	date:	date:	date:	date:
0:18	0:09	0:21	0:23	1:03	1:07	0:38	0:18	1:41	1:26
2:39	0:17	0:29	1:40	1:07	1:42	1:01	2:27	2:18	3:45
3:34	0:44	0:49	2:51	2:11	2:46	1:33	5:38	3:22	4:02
3:41	3:02	3:55	3:15	2:37	2:56	3:07	10:12	4:36	4:22
5:28	3:58	4:03	3:41	3:02	6:22	3:08	13:34	4:40	5:02
6:44	5:27	4:03	4:04	3:14	8:36	8:41	15:32	4:51	5:28
6:49	7:18	5:25	4:19	4:46	8:55	9:12	15:45	5:18	5:39
7:42	10:42	7:27	4:42	7:01	9:39	10:04	16:18	8:26	12:34
9:30	10:45	8:08	4:58	7:52	11:34	10:58	16:43	9:08	13:19
10:29	12:37	9:44	6:34	9:21	11:46	11:30	18:26	9:22	13:32
10:42	13:10	11:07	8:12	9:36	15:16	12:34	19:06	9:53	14:04
11:26	13:54	12:45	10:59	11:03	15:23	12:48	20:32	11:29	14:14
14:22	16:31	14:19	13:54	12:25	16:22	13:23	20:44	12:48	14:44
14:48	16:50	15:02	14:04	12:47	16:55	15:02	21:10	12:51	15:21
17:55	19:35	16:50	16:09	14:17	17:11	16:34	21:26	14:33	15:23
18:11	20:37	16:50	16:21	17:03	17:44	18:47	21:48	17:18	17:19
18:34	20:49	18:25	18:07	18:15	20:17	20:58	22:38	17:24	18:15
19:44	22:09	22:01	18:32	18:24	21:29	22:36	23:04	19:58	20:56
21:09	23:12	22:33	21:07	20:29	23:03	22:50	23:27	23:15	21:42
22:06	23:32	23:31	23:54	21:18	23:17	23:18	23:34	23:50	22:03

Table 1 (continued)

day	22	23	24	25	26	27	28	29	30	31											
date:	date:	date:	date:	date:	date:	date:	date:	date:	date:	date:											
0:58		0:19		1:08		0:05		0:48		1:57		0:04		1:55		0:27		0:32		0:32	
1:24		1:57		1:47		2:10		0:54		5:34		0:45		3:09		0:30		0:54		2:38	
1:34		3:06		2:23		2:56		0:54		5:55		2:48		3:59		2:56		1:31		2:39	
2:41		5:56		4:47		3:58		2:15		6:45		5:25		5:21		3:07		2:08		2:40	
4:23		6:34		6:00		4:43		2:28		7:34		8:26		7:37		3:27		2:21		3:26	
6:26		6:58		6:21		5:33		6:14		8:46		9:19		9:19		3:57		4:15		3:31	
8:13		7:27		7:22		5:40		8:50		10:20		14:02		9:34		4:52		9:19		4:15	
11:16		7:43		8:30		7:11		10:38		11:00		14:31		10:55		6:55		9:59		4:54	
11:40		8:28		9:35		7:36		10:48		13:26		14:38		12:13		7:03		10:16		6:0	
15:05		8:55		10:21		7:39		13:17		14:19		14:49		13:43		8:41		11:42		6:39	
15:18		10:08		11:36		7:55		13:18		14:26		15:19		14:52		10:37		12:06		8:0	
16:10		11:51		12:16		9:13		14:24		16:10		16:22		15:35		16:53		13:37		10:1	
16:20		12:58		14:15		15:02		14:41		17:03		16:36		16:21		16:55		14:48		12:18	
17:00		14:10		15:51		18:25		16:44		17:59		16:46		17:27		17:50		17:09		12:38	
17:45		14:25		16:23		19:40		18:23		19:55		17:16		18:05		19:42		17:47		13:14	
19:18		16:25		18:13		19:51		18:33		20:17		19:22		19:42		20:22		19:19		15:43	
19:51		19:09		18:23		20:21		18:44		20:55		20:54		20:21		22:48		20:26		16:34	
20:21		21:09		21:52		21:14		19:51		21:06		20:55		21:57		23:08		20:34		22:41	
21:24		23:02		23:17		21:49		19:55		22:18		21:07		22:31		23:10		20:48		23:19	
23:28		23:32		23:38		21:56		20:48		22:39		23:17		23:53		23:14		21:39		23:58	

Table 2: Precautionary limits on krill catches in various areas, based on the formula  $Y = \gamma B_0$ , where  $\gamma = 0.116$  (see paragraph 4.105). Units are  $10^6$  tonnes. Two methods of calculation of catch limits by subarea are given: (A) allocation proportional to biomass estimate for subarea; and (B) allocation on basis of previous recommendation (see SC-CAMLR-XII, Annex 4, Table 5).  $B_0$  values are taken from SC-CAMLR-XII, Annex 4, Table 4.

Subarea/ Division	$B_0$		$Y = \gamma B_0$	Catch Limit by Subarea			1993/94 Catch
				A	B		
48.1	13.6}	30.8	3.57	1.58	1.39	(34%)	0.045
48.2	15.6}			1.81	2.01	(49%)	0.019
48.3	1.5}			0.18	1.07	(26%)	0.019
48.4	-			0	0.21	(5%)	0
48.5	-			0	0.21	(5%)	0
48.6	4.6			0.53	0.53	0.49	(12%)
Total 48	35.4		4.10				0.083
58.4.2	3.9		0.45				

Table 3: Data requirements. This table lists the requests of WG-Krill-93 and additional requests of the Sixth Meeting of the Working Group.

Data Requested by WG-Krill-93	Data/Work Submitted	Data Requested by WG-Krill-94
Examination of the precision of estimates of krill length/weight relationships	Not done	Continued requirement
Demographic data, especially as parameters for the yield model	WG-Krill-94/4, 11, 16, 17	-
Krill flux data	See WS-Flux report (Appendix D)	Additional data for continued work on flux required (paragraphs 4.13 to 4.15)
Length frequency data submission	Length frequency data from Japanese fishery	Continuing requirement, especially from Chile and Ukraine, that data be submitted to the CCAMLR Database (paragraphs 4.81 and 4.109)
Haul-by-haul data	Chile only	Continued requirement from other fleets
Finer scale data submission	Japanese 10 n mile x 10 n mile data reporting	-
Estimates of biomass for ISRs	WG-Krill-94/21, WG-Joint-94/9	Continued requirement
Monthly catch reporting	Proceeding	-
Data on amount and viability of krill passing through a net	Model in WG-Krill-93/34 had not been sent to Secretariat	Validation of assumptions of WG-Krill-93/34 recommended (SC-CAMLR-XII, Annex 4, paragraphs 3.36 and 3.38) - continued requirement (paragraph 3.19)
Historical fine-scale catches	Information provided by Ukraine WG-Krill-94/10	Progress and assistance for submission of historical fine-scale data encouraged (paragraph 3.3)
Minimum data requirements from acoustic surveys required (SC-CAMLR-XI, Annex 4, Appendix H)	Compliance	-
Net haul density data should be submitted for calculation of recruitment	German and Japanese data submitted (paragraph 4.63)	-
Data on by-catch of fish in krill trawls	WG-Krill-94/25	Continued requirement - see future work Trawl start times and duration; from Chile (paragraph 5.25) Information on catch quantities in research surveys (paragraph 5.26)



Table 4: Future work requirements. This table lists the requests of WG-Krill-93 and additional requests of the Sixth Meeting of the Working Group.

Work Requested by WG-Krill-93	Data/Work Submitted	Future Work Requested by WG-Krill-94
Operational definitions of Article II partulary decision rules	Paragraph 4.98	Specific intersessional work requested on determining options for decision rules (WG-Joint report and paragraphs 5.22 and 5.32)
Refinement of parameters and model of functional relationships	See WG-Joint report (SC-CAMLR-XIII/5)	Continued requirement (paragraph 5.32)
Further validation of R/M model and input parameters (Appendix E)	WG-Krill-94/6	-
Further work on acoustic methodologies, especially on upward-looking and multi-frequency transducers encouraged (paragraphs 4.17 and 4.20)	Number of papers (paragraphs 4.21 to 4.24)	Continued requirement
Survey designs	WG-Krill-94/20; also paragraphs 4.25 to 4.33	Future work should take into account considerations in paragraph 4.33
Further detailed quantitative analysis of overlap of predators and fishery in all CCAMLR areas requested	This topic was addressed by the joint meeting	-
Further consideration of the <i>Scientific Observers Manual</i>	Japanese data (WG-Krill-94/25)	Suggested use of random time table 1 to examine ship activities (paragraph 3.33)
Evaluate CPUE index	WG-Krill-94/14	Further work encouraged
Yield model	WG-Krill-94/4, 5, 11, 23, 42	Modify algorithm for estimates of recruitment proportion (paragraph 4.26) and various sensitivity analyses (paragraphs 4.89 and 4.91)
Liaison between fishermen, biologists and managers	None	Continued requirement
Investigations of the scale and frequency of surveys applicable to feedback management approaches	None	Continued requirement

Table 4 (continued)

Work Requested by WG-Krill-93	Data/Work Submitted	Future Work Requested by WG-Krill-94
Subdivision of results from existing surveys in line with WG-Krill-92 (SC-CAMLR-XI, Annex 4, Appendix D)	-	Continued requirement
Modelling to evaluate feedback control management options and spatial effects related to localised predator aggregations	-	Continued requirement
A workshop on krill flux should be held in 1994 (paragraph 4.10)	Flux workshop held	Additional work on hydrographic data (paragraphs 4.13 and 4.15) and krill flux (paragraph 5.32)
-	-	New work on tables for <i>Statistical Bulletin</i> (paragraph 3.6)
-	-	Information on mesh size on Ukrainian vessels (paragraph 4.110)

**AGENDA**

Working Group on Krill  
(Cape Town, South Africa, 25 July to 3 August 1994)

1. Welcome
2. Introduction
  - (i) Review of Meeting Objectives
  - (ii) Adoption of Agenda
3. \*Review of Fisheries Activities
  - (i) Fisheries Information
    - (a) Data Submission
    - (b) Catch Levels
    - (c) Location of Catches
    - (d) Reports of Observers
      - (i) By-catch of Young Fish
      - (ii) Length Frequency/Haul-by-haul Data
      - (iii) Use of Draft Observer Manual
  - (ii) Other Information
    - (a) Fishing Escapement Loss/Mortality
    - (b) Development of CPUE Indices
    - (c) Future Fishing Plans
4. Estimation of Krill Yield
  - \* (i) Krill Flux in Statistical Area 48 and Other Areas
    - (a) Results of Flux Workshop
    - (b) Immigration/Emigration Rates
    - (c) Residence Times
    - (d) Influence of Hydrography
    - (e) Effects on Estimates of Yield
  - (ii) Estimation of Effective Biomass
    - (a) Techniques
    - (b) Statistical Area 48

- (c) Other Areas
    - (d) Future Near-synoptic Survey(s) in Statistical Area 48
      - (i) Results from *Ad Hoc* Correspondence Group
  - (iii) Refinement of Yield Estimate Calculations
    - (a) Evaluation of Population Models
    - (b) Evaluation of Demographic Parameters
      - (i) Estimation of Recruitment Variability
      - (ii) Criteria for Selecting  $\gamma$
  - (iv) Review of Precautionary Catch Limits
    - (a) Statistical Area 48
    - (b) Other Statistical Areas
5. Advice on Krill Fishery Management
- (i) Precautionary Limits on Krill Catches in Various Areas
    - (a) Estimates of Potential Yield
    - (b) Possible Ecological Effects on Catch Limits
  - (ii) Refining Operational Definitions of Article II
  - (iii) Other Possible Approaches and Their Development
  - (iv) Data Requirements
  - \*(v) Future Work and Organisation of WG-Krill
    - (a) Review of Terms of Reference
    - (b) Future Organisation of Work
6. Other Business
7. Adoption of Report
8. Close of Meeting.

[\* To be considered as far as possible prior to joint meeting with WG-CEMP]

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(Cape Town, South Africa, 25 July to 3 August 1994)

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## LIST OF DOCUMENTS

Working Group on Krill  
(Cape Town, South Africa, 25 July to 3 August 1994)

WG-Krill-94/1	AGENDA
WG-Krill-94/2	LIST OF PARTICIPANTS
WG-Krill-94/3	LIST OF DOCUMENTS
WG-Krill-94/4	PARAMETERS FOR THE STOCHASTIC KRILL DYNAMICS MODEL (SKDM): SELECTIVITY AND MATURITY D.J. Agnew (Secretariat)
WG-Krill-94/5	INCORPORATION OF A MODEL OF KRILL RECRUITMENT INTO THE BUTTERWORTH <i>ET AL.</i> STOCHASTIC KRILL DYNAMICS MODEL (SKDM) D.J. Agnew (Secretariat)
WG-Krill-94/6	FINE-SCALE CATCHES OF KRILL IN AREA 48 REPORTED TO CCAMLR FOR THE 1992/93 FISHING SEASON Secretariat
WG-Krill-94/7 Rev. 1	TO THE PROBLEM OF ASSESSMENT OF PROBABILITY OF FINDING ANTARCTIC KRILL CONCENTRATIONS IN DIVISION 58.4.2 V.N. Yakovlev, V.A. Bibik and L.M. Kokoz (Ukraine)
WG-Krill-94/8	VACANT
WG-Krill-94/9	POLISH KRILL FISHERY IN THE 1991/92 AND 1992/93 SEASONS RESULTS OF CATCHES AND BIOLOGICAL INVESTIGATIONS Józef Sosinski and Zdzislaw Cielniaszek (Poland)
WG-Krill-94/10 Rev. 1	ANALYSIS OF KRILL FISHING BY SOVIET FISHING VESSELS IN THE COOPERATION SEA (DIVISION 58.4.2) IN 1978 BY FINE-SCALE DATA V. Yakovlev and V.A. Bibik (Ukraine)
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W. de la Mare (Australia)
- WG-Krill-94/19            ACCESS TO AND USE OF DATA WITHIN CCAMLR  
(Prepared by the Convener, WG-Krill)
- WG-Krill-94/20            SUGGESTED OUTLINE FOR THE DESIGN AND IMPLEMENTATION OF FUTURE NEAR-SYNOPTIC KRILL SURVEYS  
Submitted by Denzil G.M. Miller (Convener WG-Krill)
- WG-Krill-94/21            ESTIMATION OF THE BIOMASS OF KRILL IN PRYDZ BAY DURING JANUARY/FEBRUARY 1991, FEBRUARY/MARCH 1992 AND JANUARY/FEBRUARY 1993 USING ECHO INTEGRATION  
T. Pauly and I. Higginbottom (Australia)
- WG-Krill-94/22            RECRUITMENT VARIABILITY OF ANTARCTIC KRILL (*EUPHAUSIA SUPERBA*)  
V. Siegel (Germany) and V. Loeb (USA)
- WG-Krill-94/23            YET FURTHER KRILL YIELD COMPUTATIONS  
R.B. Thomson and D.S. Butterworth (South Africa)

- WG-Krill-94/24 FURTHER CALCULATIONS OF THE EFFECTS OF KRILL FISHING ON PREDATORS  
D.S. Butterworth and R.B. Thomson (South Africa)
- WG-Krill-94/25 FISHES CAUGHT ALONG WITH THE ANTARCTIC KRILL IN THE VICINITY OF THE SOUTH SHETLAND ISLANDS DURING THE AUSTRAL SUMMER MONTHS OF 1994  
Tetsuo Iwami (Japan)
- WG-Krill-94/26 NUMERICAL MODEL OF ECOSYSTEM INCLUDING *EUPHAUSIA SUPERBA* DANA AS A KEY SPECIES IN CIRCUMPOLAR REGION  
Michio J. Kishi and Mikio Naganobu (Japan)
- WG-Krill-94/27 THE PLAN FOR THE 7TH ANTARCTIC RESEARCH CRUISE BY THE RV *KAIYO MARU* OF THE JAPANESE FISHERIES AGENCY IN 1994/95  
M. Naganobu, T. Ichii, S. Kawaguchi, T. Ogishima and Y. Takao (Japan)
- WG-Krill-94/28 CPUES AND BODY LENGTH OF ANTARCTIC KRILL DURING 1992/93 SEASON IN THE FISHING GROUNDS NORTH OF LIVINGSTON ISLAND  
S. Kawaguchi, T. Ichii and M. Naganobu (Japan)
- WG-Krill-94/29 HYDROGRAPHIC FLUX IN STATISTICAL AREA 88 OF CCAMLR IN THE PACIFIC SECTOR OF THE SOUTHERN OCEAN  
Mikio Naganobu (Japan)
- WG-Krill-94/30 CHANGE OF SEX RATIO OF KRILL (*EUPHAUSIA SUPERBA*) FROM AUSTRAL EARLY SUMMER TO MIDSUMMER IN 1983/84 IN THE VICINITY OF PRYDZ BAY, ANTARCTICA  
M. Naganobu and S. Kawaguchi (Japan)
- WG-Krill-94/31 MODELLING THE SPATIAL DISTRIBUTION OF ANTARCTIC KRILL (*EUPHAUSIA SUPERBA* DANA)  
A.W.A. Murray (UK) and D.G.M. Miller (South Africa)
- WG-Krill-94/32 BIOLOGICAL ACOUSTIC SURVEY IN THE MARGINAL ICE EDGE ZONE OF THE BELLINGSHAUSEN SEA  
Alistair W.A. Murray, Jonathan L. Watkins and Douglas G. Bone (UK)
- WG-Krill-94/33 OPERATION RESULTS OF UKRAINIAN VESSELS AT ANTARCTIC KRILL FISHERY IN SUBAREAS 48.2 AND 48.3 IN MARCH-JUNE 1994. KRILL SIZE COMPOSITION  
V.A. Bibik and V.N. Yakovlev (Ukraine)
- WG-Krill-94/34 A REVIEW OF THE ANTARCTIC KRILL (*EUPHAUSIA SUPERBA* DANA) BIOMASS IN THE COOPERATION SEA (= PRYDZ BAY REGION, DIVISION 58.4.2)  
E.A. Pakhomov (Ukraine)

WG-Krill-94/35                    CONDITIONS FOR THE PRECISE MEASUREMENT OF FISH TARGET STRENGTH  
*IN SITU*  
Kouichi Sawada and Masahiko Furusawa (Japan), Neal J. Williamson  
(USA)

WG-Krill-94/36                    REPORT OF THE WORKSHOP ON EVALUATING KRILL FLUX FACTORS  
(Cape Town, South Africa, 21 to 23 July 1994)

OTHER DOCUMENTS

WG-CEMP-94/10                    SPATIAL STRUCTURE OF THE SOUTHERN OCEAN ECOSYSTEM: PREDATOR-  
PREY LINKAGES IN SOUTHERN OCEAN FOOD WEBS  
E.J. Murphy (UK)

WG-Krill-93/12                    ESTIMATING KRILL RECRUITMENT AND ITS VARIABILITY  
W.K. de la Mare (Australia)

WG-Krill-93/13                    MODELLING KRILL RECRUITMENT  
W.K. de la Mare (Australia)

WG-Krill-93/42                    FURTHER COMPUTATIONS OF THE CONSEQUENCES OF SETTING THE  
ANNUAL KRILL CATCH LIMIT TO A FIXED FRACTION OF THE ESTIMATE OF  
KRILL BIOMASS FROM A SURVEY  
D.S. Butterworth, G.R. Gluckman, R.B. Thomson and S. Chalis (South  
Africa), K. Hiramatsu (Japan) and D.J. Agnew (Secretariat)

WG-Krill-93/43                    POSSIBLE EFFECTS OF DIFFERENT LEVELS OF KRILL FISHING ON PREDATORS  
- SOME INITIAL MODELLING ATTEMPTS  
D.S. Butterworth and R.B. Thomson (South Africa)

SC-CAMLR-X  
APPENDIX D                        REPORT OF THE WORKING GROUP ON KRILL - SUBGROUP ON SURVEY  
DESIGN  
(Yalta, USSR, 18 to 20 July 1991)

**REPORT OF THE WORKSHOP ON  
EVALUATING KRILL FLUX FACTORS**

(Cape Town, South Africa, 21 to 23 July 1994)

**REPORT OF THE WORKSHOP ON  
EVALUATING KRILL FLUX FACTORS**  
(Cape Town, South Africa, 21 to 23 July 1994)

The Workshop on Evaluating Krill Flux Factors was held from 21 to 23 July 1994 in the Sea Fisheries Research Institute, Cape Town, South Africa. Dr Vere Shannon, Director of the Institute, welcomed participants.

2. A Preliminary Agenda, circulated prior to the meeting, was adopted. Dr W. de la Mare (Australia) was elected Chairman for the meeting. Terms of reference for the workshop were given in SC-CAMLR-XII, paragraph 2.29. Further specification of the data and analyses required were given in SC-CAMLR-XII, Annex 4, Appendix D.

3. The Agenda, lists of participants and papers submitted to the workshop are given as Attachments A, B and C. The report was prepared by Drs D. Agnew (Secretariat), M. Basson (UK), W. de la Mare (Australia), R. Hewitt and E. Hoffman (USA) and E. Murphy and Mr M. Stein (Invited Experts).

DATA AVAILABILITY AND PREPARATION

4. The data required for the workshop to proceed were outlined in SC-CAMLR-XII, paragraph 2.30. This section describes the available data and their preparation for the meeting.

5. Krill acoustic survey data were available from the BIOMASS experiments which covered the following areas:

FIBEX: *Odissey* - small area north of South Georgia, and another to the east of Subarea 48.2.  
*Dr Eduardo L. Holmberg* - western Subarea 48.2, including areas to the west and north of the South Orkneys.  
*Walther Herwig* - large area overlapping Subareas 48.1, 48.2 and Division 41.3.2 north of the Convention Area.  
*Itzu Mi* - Drake Passage and Bransfield Strait.

FIBEX cruises took place from January to March 1981.

SIBEX 1: *Polarstern* - area surrounding Elephant Island; October to November 1983.  
*Professor Siedlecki* - Drake Passage and Bransfield Strait south to Anvers Island;  
December to January 1983/84.

SIBEX 2: *John Biscoe* - Drake Passage and Bransfield Strait south to Anvers Island; January to  
February 1985.

*Capitan Alcazar* - Bransfield Strait; January to February 1985.

*Walther Herwig* - Peninsula south to 68°S; March to April 1985.

*Polarstern* - around Elephant Island; November to December 1984.

6. These data were prepared prior to the meeting by the Data Manager using the same techniques as have been used in previous analyses (WS-Flux-94/4) (see also Trathan *et al.* (1992))<sup>1</sup>. The data available to the workshop were therefore latitude, longitude, krill density, integration interval distance, top and bottom integration depths and a day/night flag for each integration interval stored in the database. Most data sets had integration depths of 150 to 200 m.

7. Data on current velocity were available from two sources:

- a single time slice (FR2191) of the FRAM (Fine Resolution Antarctic Model) was provided at a resolution of 0.5° longitude x 0.25° latitude for Subareas 48.1, 48.2 and 48.3 south to 64.5°S by Dr Murphy. Data available were latitude, longitude, speed (cm/sec) in northerly and easterly directions. Prior to use by the workshop, they were converted to the standard latitude, longitude, direction and speed, averaged over the top 250 m; and
- geostrophic current velocities derived from CTD samples were provided by Mr Stein and Dr M. Naganobu (Japan). These data covered three years of sampling by Germany off the Antarctic Peninsula (1986, 1987 and 1990), a number of samples from Subarea 48.2 and two years sampling by Japan and Germany in the vicinity of the Subarea 48.1/48.2 boundary (1988 and 1992). All data were provided in the standard format of latitude, longitude, direction and speed, and averaged over the upper 200 m. Maximum reference depth for the calculations was 800 m. Interpolated flow vectors for the German data were presented in WS-Flux-94/6.

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<sup>1</sup> Trathan, P.N., D.J. Agnew, D.G.M. Miller, J.L. Watkins, I. Everson, M.R. Thorley, E. Murphy, A.W.A. Murray and C. Goss. 1992. Krill biomass in Area 48 and Area 58: recalculations of FIBEX data. In: *Selected Scientific Papers (SC-CAMLR-SSP/9)*. CCAMLR, Hobart, Australia: 157-181.



8. Figure 1 shows the extent of all these data sets together with krill catch distribution by fine-scale area.

#### ANCILLARY DATA

9. A number of additional data sources were available to the group, including passive tracer streamlines derived using the FRAM (WS-Flux-94/9), ship displacement trajectories (WS-Flux-94/10), buoy paths (WS-Flux-94/8) and iceberg drift paths (WS-Flux-94/6).

10. Latitude, longitude and date of buoy positions were extracted from Figure 8 of WS-Flux-94/8, and average speeds between consecutive positions were calculated. A comparison of these data with hydrodynamic data is presented in Table 1.

11. Iceberg drift speeds in WS-Flux-94/6 did not contain any information on direction. Average speed across boundaries of subareas (see paragraph 13) was nonetheless calculated for comparison with other data. On the basis of Figure 1 in WS-Flux-94/6, a general direction of 30° was assumed. Results are given in Table 3.

#### ESTIMATION OF KRILL AND WATER TURNOVER AND RESIDENCE TIMES

##### General Methodology

12. Krill flux and residence times were calculated following the methods detailed in Appendix D of SC-CAMLR-XII, Annex 4, and applied and developed in WG-Flux-94/15.

13. Inward flows into an area were termed as positive and outward flows as negative. The flux of krill  $V_D$  across a boundary of an area was expressed as the product of the profile of krill density along a boundary and the profile of water transport across that boundary.

$$V_D = \sum_{j=1}^n \delta_j f_j \quad (1)$$

where  $n$  = number of intervals along a boundary

$\delta_j$  = density of krill in each interval (t km<sup>3</sup>)

$f_j$  = water transport across each interval (km<sup>3</sup> hr<sup>-1</sup>)

The krill influx was given by adding together the values for the inflow boundaries

$$V_I = \sum_{V_m > 0}^b V_m \quad (2)$$

where  $b$  is the number of boundaries, and the total efflux

$$V_o = \sum_{V_m < 0}^b V_m \quad (3)$$

Residence times (days) based on the inflow or outflow were calculated by dividing the krill biomass in the area by the relevant flux.

Inflow-based residence time

$$R_I = \frac{B}{V_I} \quad (4)$$

Outflow-based residence time

$$R_o = \frac{B}{V_o} \quad (5)$$

where  $B$  = krill biomass (tonnes).

14. Similar formulae were used to calculate water replacement times using water flows and water volume in the area in place of krill flux and biomass.

#### Calculation of Flux Rates and Residence Times in Subareas 48.1, 48.2 and 48.3

15. A number of small boxes were defined within subareas, using criteria such as data coverage and natural boundaries of oceanographic features and krill distribution (Figure 2).

16. Krill and water flux across each of the boundaries of the boxes defined in Figure 2 was calculated using programs developed by the Secretariat (WS-Flux-94/4). Krill density along each boundary and water speed normal to that boundary (i.e., directly across the boundaries) were calculated at interpolation points at intervals of 5 n miles along the boundary by weighted averaging of nearest data using the computer program described in WS-Flux-94/4. Weighting was by inverse distance and, for acoustic data, integration interval distance. For krill density calculations, all data

within a 30 n mile radius of an interpolation point were used, whereas for water flow the nearest nine data points were used.

17. This procedure was used for all acoustic data, the FRAM data and some of the CTD data. Some water flow vectors, however, were calculated directly from lines of CTD stations using linear interpolation because boundary effects rendered the inverse distance procedure unsuitable. Only those acoustic integration intervals taken during daylight hours were used for krill density calculations.

18. Krill density boundary vectors were calculated for FIBEX, SIBEX 1 and SIBEX 2 data separately. Water flow vectors were calculated for the FRAM data set and for the separate years of available geostrophic flow data. Figure 3 shows an example of krill density and flow vectors along a boundary (boundary 8, between boxes D and F). Krill and water flux across the boundary were calculated simply as the product of these vectors ( $t\ hr^{-1}$  and  $km^3\ hr^{-1}$ ).

19. Table 3 gives water flow rates across each of the boundaries in Figure 2, calculated using a number of data sets. The results of calculations of flux, using all the available combinations of acoustic data and hydrographic data are given in Table 4.

20. In order to calculate krill residence times, an estimate of the total biomass of krill in a box was required (paragraph 12). Similarly, for calculation of water residence times, total effective volume of water in a box was required.

- For krill, mean krill density ( $g\ m^{-2}$ ) in each box was calculated using a simple mean of all acoustic density data in that box, weighting by integration distance (Table 5). For this reason, biomass estimates in Table 5 are slightly higher than those calculated by Trathan *et al.* (1992) using a transect-based method.
- For water, the relevant depth of the water column was taken to be 200 m for CTD derived data and 250 m for FRAM data.

21. Equations for calculation of residence times from a combination of boxes were developed (Attachment D) and used to calculate residence times for both water and krill for individual boxes (Table 6) and groups of boxes (Table 7).

## Results

22. Generally, water flux values derived from the FRAM model were up to four times larger than those obtained from direct observations. This might reflect the incorporation of wind-induced surface currents to the model. The flux rates derived from observed data represent only the geostrophic component of the current field, based upon the given vertical density field. Additional analyses of the actual windfield data, as collected during the CTD measurements, should be undertaken to estimate the amount of wind-driven surface currents.

23. There was some seasonal variability in the estimates of water flow from the CTD data which was not resolved by the single time slice from FRAM. A further discrepancy was that the southwestward flowing Antarctic Coastal Current was not apparent in the FRAM data.

24. The only area of consistency between FRAM and observational data seems to be in the Bransfield Strait. Data derived from direct observations indicate that the inflow and outflow were balanced for this area. However, inflow and outflow were not balanced in the FRAM data. This might reflect the fact that water mass transport in the region is mostly confined to the upper hundreds of metres since the deep parts of the Bransfield Strait are blocked by ridges. These topographic features prevent deep reaching, consistent flow to the northeast and are not well described in the FRAM model.

25. Concerning inflow and outflow of individual boxes calculated from the FRAM data, boxes A, D, F and H might serve as examples where for the upper 200 m the influx of water masses is fairly consistent with the outflow.

## RECOMMENDATIONS AND FUTURE WORK

26. Discussion of the significance of these results, recommendations to the Scientific Committee and suggestions for future work was left to the WG-Krill meeting.

## CONCLUSION

27. The Chairman thanked all participants for a hard-working and successful workshop.

Table 1: Ancillary data on buoy speeds (derived from WS-Flux-94/8).

Section	Direction	Buoy Speed (cm/s)	FRAM Average Speed (cm/s)	Sub-section Coordinates
3	151.6°	-13.0	8.3	61 - 61.5 W
3	151.6°	11.4	12.1	59.9 - 61W
6	90°	20.3	7.9	61.05 - 61.2 S
7	0°	4.6	3.5	53.9 - 54.2 W
7	0°	-12.9	2.5	53 - 53.9 W
14	0°	10.3	0.9	51 - 51.2 W
14	0°	6.4	-2.2	49.9 - 51 W

Table 2: Areas and boundaries for the regions shown in Figure 4.

Region	Boundary Sections	Area (km <sup>2</sup> )
A	0, 2, 3b, 3	39 466
B	1, 2, 4	31 106
C	4, 5, 10	30 465
K	3a, 3b, 5, 6	45 739
D	6, 7, 8, 9	40 759
E	9, 10, 11, 12	22 206
F	8, 12, 15, 13, 14	56 448
G	t1, t2, t3	30 343
H	t3, 22, 24, 25, 23, 21	70 852
I	24, 26, 28, 27	50 149
J	31, 32, 33, 34	34 452

Table 3: Water flow rates ( $\text{cm sec}^{-1}$ ) across boundaries shown in Figure 2, from the FRAM data set, a number of hydrographic datasets (CTD samples) and iceberg track data. Negative flows are in a direction diametrically opposite to that shown.

Section	Distance (n miles)	Flow Direction	FRAM	CTD 1986	CTD 1987	CTD 1988	CTD 1990	CTD 1992	Iceberg
0	80	64.0	8.1	1.7	0.1		5.2		
1	50	64.0	3.9	-1.1	-0.1		-0.2		
2	140	59.3	0.2				0.2		
3	150	151.9	0.3						
3a	185	61.3	1.4						
3b	75	68.7	8.8						
4	80	70.9	7.7		6.8		7.3		
5	35	0	5.6				2.6		
6	120	90	8.6	3.8	4.4		4.8		
7	100	0	3.8						5.5
8	120	90	11.3	2.3			0.4		3.1
9	95	0	6.8				0.1		9.9
10	50	90	3.1	6.0			7.1		
11	55	0	5.2						7.0
12	70	90	0.3				1.3		3.3
13	190	90	7.2						4.3
14	90	0	1.6						5.7
15	80	0	1.6						7.3
t1	190	0	2.8						5.7
t2	215	65.4	-1.2						
t3	90	90	3.2			5.0			5.6
21	120	90	8.9						2.8
22	100	0	-2.6						9.5
23	90	0	0.4						13.0
24	110	90	9.7			3.2		1.6	3.4
25	95	90	4.9					1.9	5.3
26	130	0	6.7						8.3
27	120	0	3.2						5.0
28	110	90	5.9			3.1			3.5
31	40	90	-2.8						
32	125	0	3.9						9.1
33	95	90	-5.9						5.5
34	55	180	-2.8						

Table 4: Apparent krill flux and water flow rates across sections for various combinations of krill survey and oceanographic data sets. Negative fluxes are in a direction diametrically opposite to that shown.

Section	Data Set	Direction ( $^{\circ}$ )	Krill Flux (tonnes $h^{-1}$ )	Water Flux ( $km^3h^{-1}$ )
0	SIBEX 2*FRAM	64.0	80.8	8.7
	SIBEX 2*G86		17.4	1.8
	SIBEX 2*G87		1.0	0.2
	SIBEX 2*G90		52.7	5.5
1	SIBEX 2*FRAM	64.0	30.6	2.6
	SIBEX 2*G86		-10.7	-0.7
	SIBEX 2*G87		-3.0	-0.1
	SIBEX 2*G90		-4.5	-0.1
2	SIBEX 1*FRAM	329.3	43.2	-0.4
	SIBEX 1*G90		-8.9	-0.4
	SIBEX 2*FRAM		-7.5	-0.4
	SIBEX 2*G90		-15.4	-0.4
3	FIBEX*FRAM	331.9	1.3	-0.5
	SIBEX 2*FRAM		16.7	-0.5
3a	FIBEX*FRAM	331.3	83.1	-3.3
	SIBEX 1*FRAM		-39.1	-3.3
	SIBEX 2*FRAM		-28.5	-3.3
3b	FIBEX*FRAM	68.7	664.1	8.8
	SIBEX 1*FRAM		861.1	8.8
	SIBEX 2*FRAM		195.1	8.8
4	FIBEX*FRAM	70.9	6005.4	8.2
	FIBEX*G87		3787.6	7.3
	FIBEX*G90		4833.9	7.8
	SIBEX 1*FRAM		206.7	8.2
	SIBEX 1*G87		230.5	7.3
	SIBEX 1*G90		234.1	7.8
	SIBEX 2*FRAM		530.5	8.2
	SIBEX 1*G87		324.5	7.3
	SIBEX 2*G90		378.8	7.8
5	FIBEX*FRAM	0	511.4	2.6
	FIBEX*G90		151.3	1.2
	SIBEX 1*FRAM		18.0	2.6
	SIBEX 1*G90		12.9	1.2
	SIBEX 2*FRAM		168.5	2.6
	SIBEX 2*G90		94.2	1.2
6	FIBEX*FRAM	90.0	619.7	13.8
	FIBEX*G86		980.2	6.0
	FIBEX*G87		1309.2	7.1
	FIBEX*G90		1438.0	7.6
	SIBEX 1*FRAM		93.0	13.8
	SIBEX 1*G86		32.4	6.0

Table 4 (continued)

Section	Data Set	Direction (°)	Krill Flux (tonnes h <sup>-1</sup> )	Water Flux (km <sup>3</sup> h <sup>-1</sup> )
	SIBEX 1*G87		38.9	7.1
	SIBEX 1*G90		38.2	7.6
	SIBEX 2*FRAM		312.0	13.8
	SIBEX 2*G86		166.3	6.0
	SIBEX 2*G87		213.2	7.1
	SIBEX 2*G90		215.5	7.6
7	FIBEX*FRAM	0	1007.6	5.1
	SIBEX 1*FRAM		50.8	5.1
	SIBEX 2*FRAM		58.7	5.1
8	FIBEX*FRAM	90.0	3556.1	18.1
	FIBEX*G86		741.8	3.7
	FIBEX*G90		153.0	0.6
	SIBEX 1*FRAM		0	18.1
	SIBEX 1*G86		0	3.7
	SIBEX 1*G90		0	0.6
	SIBEX 2*FRAM		0	18.1
	SIBEX 2*G86		0	3.7
	SIBEX 2*G90		0	0.6
9	FIBEX*FRAM	0	3826.3	8.7
	FIBEX*G90		43.1	0.1
	SIBEX 1*FRAM		26.3	8.7
	SIBEX 1*G90		0.4	0.1
	SIBEX 2*FRAM		251.4	8.7
	SIBEX 2*G90		2.2	0.1
10	FIBEX*FRAM	90.0	1462.1	2.1
	FIBEX*G87		3790.5	5.6
	FIBEX*G90		4932.9	6.7
	SIBEX 1*FRAM		8.4	2.1
	SIBEX 1*G87		28.7	5.6
	SIBEX 1*G90		34.8	6.7
	SIBEX 2*FRAM		82.4	2.1
	SIBEX 2*G87		210.6	5.6
	SIBEX 2*G90		258.0	6.7
11	FIBEX*FRAM	0	2538.3	3.8
	SIBEX 1*FRAM		33.8	3.8
	SIBEX 2*FRAM		153.1	3.8
12	FIBEX*FRAM	90.0	172.2	0.3
	FIBEX*G90		652.0	1.3
13	FIBEX*FRAM	90.0	2566.2	18.3
14	FIBEX*FRAM	0	204.4	1.9
15	FIBEX*FRAM	0	78.2	1.7



Table 4 (continued)

Section	Data Set	Direction ( $^{\circ}$ )	Krill Flux (tonnes $h^{-1}$ )	Water Flux ( $km^3h^{-1}$ )
t1	FIBEX*FRAM	0	449.8	7.1
t2	FIBEX*FRAM	335.8	1458.0	3.4
t3	FIBEX*FRAM	90.0	2546.7	3.9
	FIBEX*G88		3969.1	5.6
21	FIBEX*FRAM	90	1712.8	14.3
	FIBEX*G88		354.6	2.7
22	FIBEX*FRAM	180.0	2554.9	3.5
23	FIBEX*FRAM	0	6596.9	0.5
24	FIBEX*FRAM	90.0	13308.7	14.2
	FIBEX*G88		3052.0	4.7
	FIBEX*G92		2074.6	2.4
25	FIBEX*FRAM	90.0	11406.3	6.2
	FIBEX*G92		5295.9	2.4
26	FIBEX*FRAM	0	1564.3	11.7
27	FIBEX*FRAM	0	3116.9	5.2
28	FIBEX*FRAM	90.0	1898.2	8.6
	FIBEX*G88		1322.9	4.6
31	FIBEX*FRAM	270.0	179.6	1.5
32	FIBEX*FRAM	0	1002.3	6.6
33	FIBEX*FRAM	270.0	1889.1	7.5
34	FIBEX*FRAM	0	1553.8	2.1

Table 5: Biomass estimates for the regions in Figure 2 from the various surveys.

Region	Biomass from Survey (000s tonnes)		
	FIBEX	SIBEX 1	SIBEX 2
A	54	722	116
B	3 502	262	187
C	2 178	226	525
K	1 924	155	229
D	7 848	107	274
E	2 531	50	162
F	1 907	-	-
G	1 764	-	-
H	10 265	-	-
I	2 495	-	-
J	1 725	-	-

Table 6: Apparent krill and water retention times in the regions based on both influx and efflux rates, for various combinations of survey and oceanographic data sets.

Region	Data Set	Water Retention Time (days)		Krill Retention Time (days)			
		Influx	Efflux	Influx	Efflux		
A	SIBEX 2*FRAM	44.7	44.8	60.0	22.1		
B	SIBEX 2*FRAM	108.2	39.7	205.3	14.7		
C	FIBEX*FRAM	38.8	67.1	15.1	46.0		
	SIBEX 1*FRAM			45.6	355.7		
	SIBEX 2*FRAM			41.3	87.2		
	FIBEX*G90			32.4	32.2	18.8	17.9
	SIBEX 1*G90			40.2	197.3		
	SIBEX 2*G90			57.8	62.1		
K	FIBEX*FRAM	32.3	34.5	68.2	114.1		
	SIBEX 1*FRAM			7.0	69.5		
	SIBEX 2*FRAM			24.4	30.6		
E	FIBEX*FRAM	39.2	25.8	26.4	26.4		
	SIBEX 1*FRAM			49.7	---		
	SIBEX 2*FRAM			28.7	---		
	FIBEX*G90			---	170.6	---	151.8
D	FIBEX*FRAM	18.9	18.3	73.6	71.7		
	SIBEX 1*FRAM			37.4	87.8*		
	SIBEX 2*FRAM			20.3	195.1*		
	FIBEX*G90			44.0	---	220.8	---
	SIBEX 1*G90			115.5	---		
	SIBEX 2*G90			52.6	---		
F	FIBEX*FRAM	29.2	29.1	20.9	28.7		
G	FIBEX*FRAM	44.6	43.7	163.4	18.4		
H	FIBEX*FRAM	33.3	36.1	31.9	17.3		
I	FIBEX*FRAM	26.9	25.8	6.3	30.0		
J	FIBEX*FRAM	37.7	44.2	20.9	60.8		

\* No krill density estimates were available on section 8 for SIBEX 1 and 2 (see second page of Table 4, column 4). Therefore these retention times are probably biased upwards.

Table 7: Apparent krill and water retention times in combined regions based on both influx and efflux rates, for various combinations of survey and oceanographic data sets.

Combined Regions	Data Set	Water Retention Time (days)		Krill Retention Time (days)	
		Influx	Efflux	Influx	Efflux
ABKCDE	SIBEX 2*FRAM	115.5	93.0	212.7	---
KDCEF	FIBEX*FRAM	79.0	80.4	73.6	176.9
KCDE	FIBEX*FRAM	60.2	61.7	65.5	125.2
	SIBEX 1*FRAM			19.7	---
	SIBEX 2*FRAM			54.7	---
HI	FIBEX*FRAM	46.1	47.6	32.2	35.8

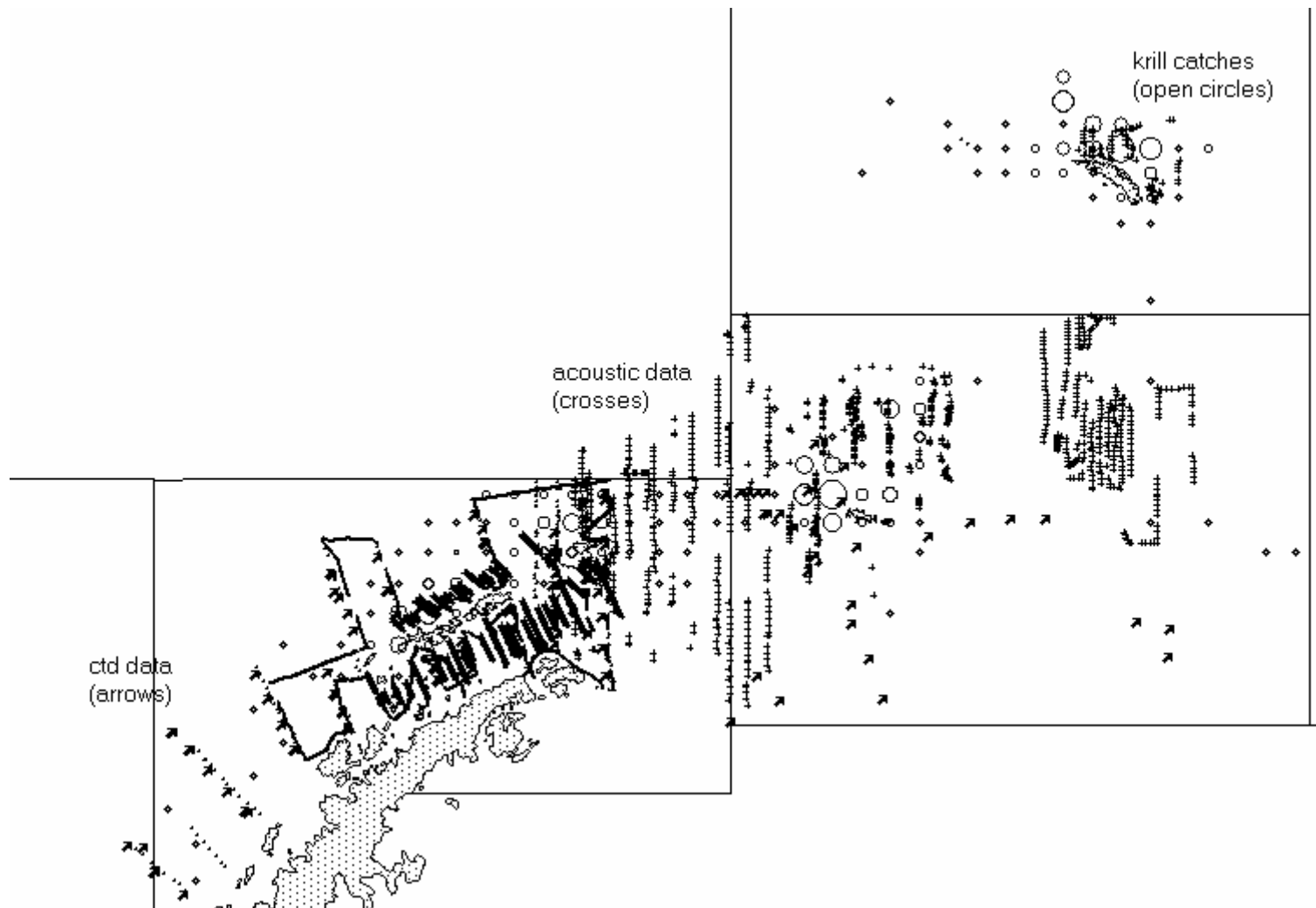


Figure 1: Acoustic CTD data available to the workshop overlaid with the distribution of krill catches over the last 10 years.

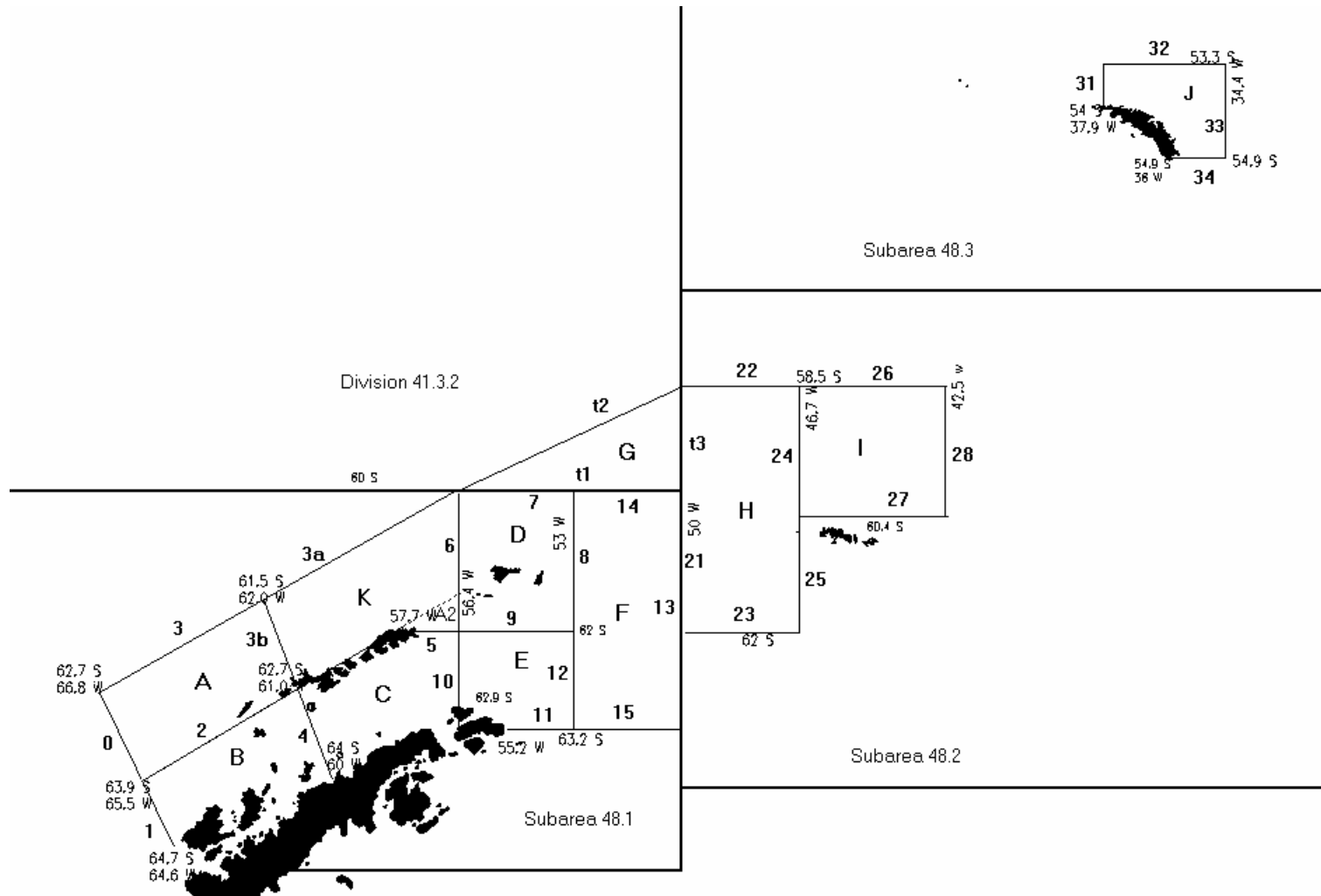


Figure 2: Boxes and boundaries (bold) defined for krill and water flux calculations. Boundary positions are marked.

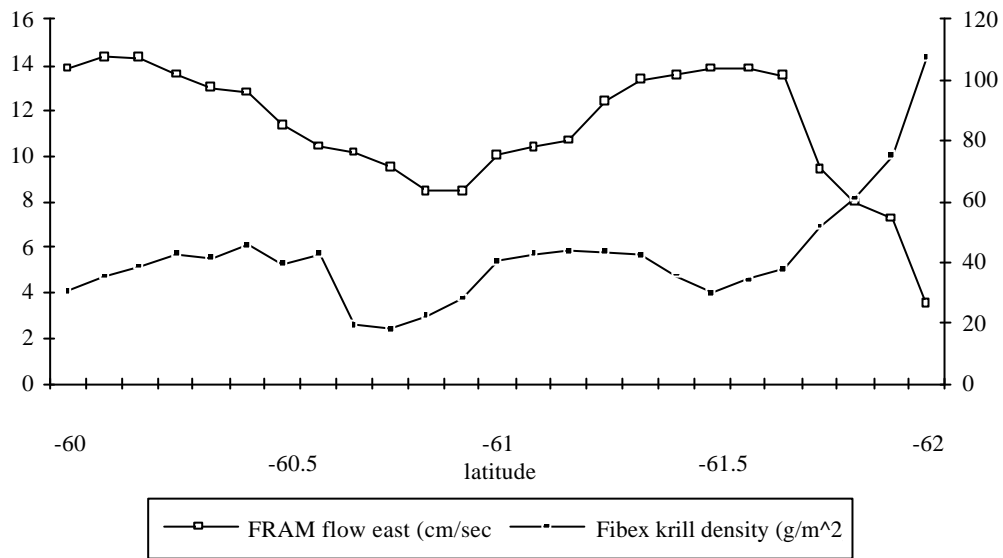


Figure 3: Example of water flow and krill density calculated along a boundary (boundary 8). These data were combined to yield a total flux for that boundary. Left hand y-axis is cm/sec.

**AGENDA**

Workshop on Evaluating Krill Flux Factors  
(Cape Town, South Africa, 21 July to 23 July 1994)

1. Introduction
  - (i) Appointment of Chairman
  - (ii) Appointment of Rapporteurs
  - (iii) Adoption of the Agenda
  
2. Review of Data and Analyses
  - (i) Krill Acoustic Data Specified in Appendix D (SC-CAMLR-XII, Annex 4)
  - (ii) FRAM Oceanographic Data Specified in Appendix D (SC-CAMLR-XII, Annex 4)
  - (iii) Primary Oceanographic Data
  - (iv) Additional Data and Analyses
  
3. Composite Flux Analysis
  - (i) Subarea 48.1
  - (ii) Subarea 48.2
  - (iii) Subarea 48.3
  
4. Implications and Recommendations to WG-Krill
  
5. Close of Meeting.

**LIST OF PARTICIPANTS**

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(Cape Town, South Africa, 21 July to 23 July 1994)

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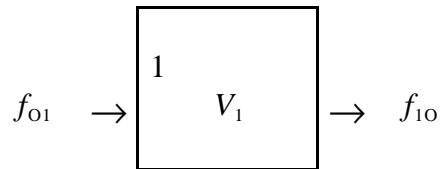
**LIST OF DOCUMENTS**

Workshop on Evaluating Krill Flux Factors  
(Cape Town, South Africa, 21 July to 23 July 1994)

WS-Flux-94/1	AGENDA
WS-Flux-94/2	LIST OF PARTICIPANTS
WS-Flux-94/3	LIST OF DOCUMENTS
WS-Flux-94/4	ACOUSTIC DATA FOR THE 1994 KRILL FLUX WORKSHOP Secretariat
WS-Flux-94/5	USE OF CURRENT VELOCITY DATA FROM FRAM TO INVESTIGATE THE LARGE SCALE TRANSPORT OF KRILL IN THE SCOTIA SEA E.J. Murphy (UK)
WS-Flux-94/6	LARGE SCALE CIRCULATION IN THE SOUTH ATLANTIC: ESTIMATES FROM GIANT ICEBERG DRIFT RATES P.N. Trathan and C. Symon (UK)
WS-Flux-94/7	COMPARISON OF GEOSTROPHIC VELOCITIES FROM SUBAREA 48.1 William K. de la Mare (Australia)
WS-Flux-94/8	REFERENCE MATERIALS ON STATISTICAL AREA 48 FOR KRILL FLUX WORKSHOP Mikio Naganobu (Japan)
WS-Flux-94/9	STREAM LINES IN THE FRAM VELOCITY FIELD: SPEEDS AND DIRECTIONS FROM PASSIVE TRACERS E.J. Murphy (UK)
WS-Flux-94/10	TRACER TRAJECTORIES FROM THE WESTERN SHELF OF SOUTH GEORGIA: SHIP DISPLACEMENT DATA E.J. Murphy, I. Everson and C. Goss (UK)

## RETENTION/RESIDENCE TIMES

## 1-BOX SYSTEM - Example



$V_1$  = volume (e.g., water volume) in box 1 (e.g., km<sup>3</sup>)

$f_{O1}$  = input from 'outside' into box 1 (e.g., in km<sup>3</sup>/day)

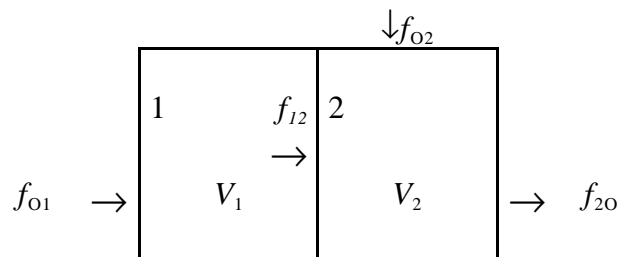
$f_{1O}$  = outflow from box 1 to the 'outside' (e.g., in km<sup>3</sup>/day)

The subscript 'O' refers to 'outside'

$T_1$  = turnover for box 1 =  $\frac{f_{O1}}{V_1}$

$r_1$  = residence time in box 1 =  $\frac{V_1}{f_{O1}}$  (e.g., in days)

## 2-BOX SYSTEM - Example



$V_s$  and  $f_s$  as above: all  $f_s > 0$  (if  $f_{ij} < 0 \Rightarrow f_{ji} = -f_{ij}$  to get a positive flow)

$r_1$  = residence time in box 1 =  $\frac{V_1}{f_{O1}}$

$r_2$  = residence time in box 2 =  $\frac{V_2}{f_{12} + f_{O2}}$

If we ignore the subdivision then the overall  $R$  (residence time) is:

$$R = \frac{(V_1 + V_2)}{f_{O1} + f_{O2}} = \frac{V_1}{f_{O1} + f_{O2}} + \frac{V_2}{f_{O1} + f_{O2}}$$

Can we write  $R$  in terms of  $r_1$  and  $r_2$ ?

Yes,

$$R = \frac{V_1}{f_{O1} + f_{O2}} \cdot \left( \frac{f_{O1}}{f_{O1}} \right) + \frac{V_2}{f_{O1} + f_{O2}} \cdot \left( \frac{f_{12} + f_{O2}}{f_{12} + f_{O2}} \right)$$

which can be re-organised as:

$$\begin{aligned} R &= \frac{V_1}{f_{O1}} \cdot \left( \frac{f_{O1}}{f_{O1} + f_{O2}} \right) + \frac{V_2}{f_{12} + f_{O2}} \cdot \left( \frac{f_{12} + f_{O2}}{f_{O1} + f_{O2}} \right) \\ &= r_1 \underbrace{\left( \frac{f_{O1}}{f_{O1} + f_{O2}} \right)}_{\text{call this } w_1} + r_2 \underbrace{\left( \frac{f_{12} + f_{O2}}{f_{O1} + f_{O2}} \right)}_{\text{call this } w_2} \\ &= r_1 \cdot w_1 + r_2 \cdot w_2 \end{aligned}$$

where the  $w_1, w_2$  are called pooling weights.

Note:

- (i) any weight can be less than or greater than 1 (e.g., if  $f_{12} > f_{O1}$  then  $w_2$  will be  $> 1$ );
- (ii)  $R = r_1 + r_2$  only if  $w_1 = 1$  and  $w_2 = 1$ ; i.e. residence times in the boxes can only be added directly, that is unweighted, when  $f_{O2} = 0$  and  $f_{12} = f_{O1}$ .

N-BOX SYSTEM: GENERAL CASE

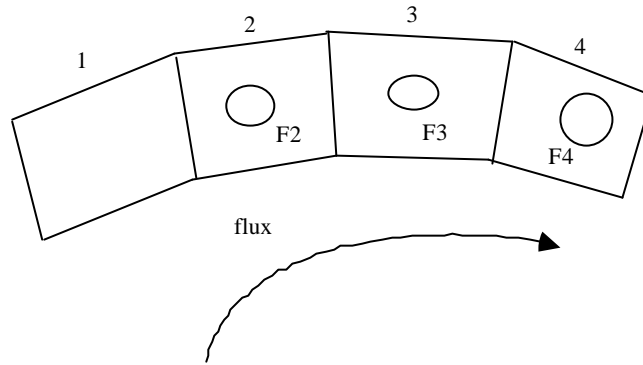
$$R = \sum_{i=1}^N r_i \cdot w_i$$

where each  $r_i = V_i / \sum_{j=0}^N f_{ji}$

$$\text{and } w_i = \frac{\sum_{j=0}^N f_{ji}}{\sum_{j=1}^N f_{Oj}} = \frac{\text{all inputs to box } i \text{ (from 'anywhere')}}{\text{all inputs to the system from OUTSIDE (N boxes)}}$$

**INITIAL CONSIDERATION OF METHODS TO INCORPORATE  
KRILL FLUX INTO THE CALCULATION OF CATCH LIMITS**

Consider a connected set of  $n$  management areas as shown in the figure below, with a net clockwise flux of krill at constant rate  $f$ . We wish to find a way of allocating catch limits such that  $\sum y_i \leq g \sum_{i=1}^n B_i$  where  $y_i$  is the limit set in each area and  $B_i$  is the unexploited biomass in area  $i$ . To illustrate the factors to be considered, let us suppose that areas 2, 3 and 4 each contain one fishing ground at  $F_2$ ,  $F_3$  and  $F_4$  respectively. Let  $\tau_{i, i+1}$  be the average time taken for krill to travel from  $F_i$  to  $F_{i+1}$ . Let the length of the fishing season be  $t$ .



If there is no fishing immediately upstream of  $F_2$  and ignoring production which occurs during the fishing season, the potential yield which can be taken on this ground is given by

$$Y_2 = \gamma f t \quad (1)$$

By definition the average residence time in area  $i$  is

$$T_i = \frac{S_i}{f} \quad (2)$$

where  $S_i$  = stock biomass in area  $i$ , and hence

$$Y_2 = \frac{g S_2 t}{T_2} \quad (3)$$

The estimate can be inflated in the ratio  $t/T_2$ . This means, however, that the potential yield from at least part of one or more areas upstream has been allocated to area 2. Therefore upstream areas cannot be fished until upstream of the point where

$$\begin{aligned} \mathbf{g} \sum S_i &\geq Y_1 \\ i &\in \{\text{contiguous areas upstream of } 2\} \end{aligned} \quad (4)$$

If it is assumed that  $Y_2$  is all taken in fishing ground  $F_2$ , then the limit in area 3 is that part of this stock not fished in the span between  $F_2$  and  $F_3$ ; given by

$$Y_3 = \mathcal{V} \delta_{2,3}$$

where

$$\begin{aligned} \delta_{2,3} &= \tau_{2,3} & ; \tau_{2,3} < t \\ \delta_{2,3} &= t & ; \tau_{2,3} = t \end{aligned}$$

Similarly

$$Y_4 = \mathcal{V} \delta_{3,4}$$

and so on until the area is reached from which fishing must be excluded in accordance with (4) above. Therefore

$$\sum_{i=1,n} Y_i = \mathbf{g} \mathcal{V} \sum \delta_{i,i+1} \quad (5)$$

The total yield which we allow to be taken is

$$Y = \mathbf{g} \sum B_i \quad (6)$$

which can be written as

$$Y = \mathbf{g} \mathcal{V} \sum T_i$$

Clearly

$$\sum \delta_{i,i+1} \text{ is } \leq \sum T_i$$

and hence

$$\sum y_i \leq Y,$$

which meets the basic requirement.

Now consider what happens if we ignore the effects of flux. Clearly the total yield is still given by equation (6). The yield in area  $i$  is given by:

$$Y_i = \gamma \cdot S_i \tag{7}$$

For areas 2, 3 and 4, the total yield taking flux into account is

$$Y_{2,3,4} = \mathbf{g}^f \left( t + \sum_{i=2}^3 \delta_{i,i+1} \right)$$

Clearly if

$$t + \sum_{i=2}^3 \delta_{i,i+1} \approx \sum_{i=2}^4 T_i \quad (\text{which requires that } T_i < t), \tag{8}$$

then

$$Y_{2,3,4} \approx \mathbf{g}^f \sum_{i=2}^4 T_i \approx \mathbf{g} \sum_{i=2}^4 f T_i$$

and, substituting equation 2,

$$Y_{2,3,4} \approx \mathbf{g} \sum_{i=2}^4 S_i$$

which is the yield calculated if the flux factor is ignored (equation 7). The only component of potential yield missed is due to the difference between the biomass not incorporated from the upstream side and any biomass surveyed downstream of the fishing ground in area 4. This is the

approach currently taken for Statistical Area 48 where the approximation given in (8) is assumed to hold.

In summary, if the unmodified rule, i.e. ignoring flux, is used globally, the total precautionary catch limit is correct. If the flux factor is taken into account, some areas may have the catch from upstream areas added into them, with the proviso that no other catches can be taken from those upstream areas. The allowable catch in downstream fishing grounds depends on the average time taken for krill to be transported from the upstream ground to the downstream ground, and whether there is some 'unused' catch from the upstream ground available for catching at the downstream ground. However, given that reliable data on the average time taken for krill to move between fishing grounds is not yet available, and noting that for a series of contiguous areas the overall results from not taking flux into account may not differ by relatively much, it should be sufficient, but conservative overall, to proceed by making no corrections for krill flux. This is because in contiguous areas, the flux-modified limits may result in changed allocation between areas, but within a total which is only modified by addition from the flux into the one area at the upstream end.



**FULL RESULTS FROM THE RE-ANALYSIS  
OF RECRUITMENT PROPORTION  
(paragraph 4.64)**

Table F.1: Proportions of recruits for a range of net surveys obtained by fitting mixture distributions (using method of de la Mare, 1994<sup>1</sup>).  $R(1)$  is the proportion of recruits to the population age 1+.

1-Year-Old Recruitment			
Survey	$R(1)$	Std. Error	CV of Length-at-age
HEFX	0.142	0.0347	0.122
NDFX	0.167	0.0468	0.096
SIFX	0.370	0.0422	0.153
NDS2	0.528	0.0475	0.117
ADBEX1	0.001	0.0010	0.117
ADBEX2	0.016	0.0273	0.087
AAMBER	0.025	0.0174	0.085
AA2	0.314	0.0113	0.150
KROCK	0.064	0.0269	0.103
GER1978	0.043	0.0653	0.074
GER1982	0.936	0.0025	0.100
GER1983	0.937	0.0156	0.105
GER1984	0.114	0.0463	0.114
GER1985	0.027	0.0441	0.095
GER1986	0.317	0.0217	0.113
GER1987	0.863	0.0417	0.152
GER1989	0.057	0.0390	0.095
KMS1	0.001	0.0031	0.100
2-Year-Old Recruitment			
Survey	$R(2)$	Std. Error	CV of Length-at-age
MDFX	0.286	0.0645	0.071
HEFX	0.360	0.1183	0.096
NDFX	0.096	0.0592	0.091
SIS1	0.968	0.0540	0.169
NDS2	0.320	0.0560	0.157
NDS2	0.431	0.0877	0.119
ADBEX1	0.561	0.0851	0.110
ADBEX2	0.557	0.2715	0.084
AAMBER	0.231	0.1300	0.084
AA2	0.556	0.0063	0.083
KROCK	0.020	0.1307	0.095
GER78	0.109	0.1130	0.106
GER84	0.827	0.0557	0.114
GER85	0.099	0.0572	0.064
GER86	0.982	0.0323	0.194
GER89	0.465	0.0370	0.065
KMS1	0.211	0.283	0.106

Table F.2: Summary statistics.

	1+	2+	Combined
Number of estimates	18	17	35
Mean <i>R</i> estimate	0.404	0.557	0.415
Standard error	0.012	0.010	0.006
Standard deviation	0.456	0.126	0.442
CV of distribution	1.128	0.226	1.067

Figures demonstrating goodness of fit for each data set are held at the Secretariat.

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<sup>1</sup> de la Mare. 1994. Estimating krill recruitment and its variability. *CCAMLR Science*, Vol. 1: 55-69.

**REPORT OF THE WORKING GROUP FOR THE  
CCAMLR ECOSYSTEM MONITORING PROGRAM**

(Cape Town, South Africa, 25 July to 3 August 1994)

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**REPORT OF THE WORKING GROUP FOR THE  
CCAMLR ECOSYSTEM MONITORING PROGRAM**  
(Cape Town, South Africa, 25 July to 3 August 1994)

INTRODUCTION

1.1 The Ninth Meeting of the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP) was held at the Breakwater Lodge, Cape Town, South Africa, from 25 July to 3 August, 1994. The meeting was chaired by the Convener, Dr J.L. Bengtson (USA).

1.2 The Working Group was welcomed to Cape Town by Mr G. de Villiers, the Director of Sea Fisheries Administration in South Africa.

ADOPTION OF THE AGENDA

2.1 A Provisional Agenda had been circulated prior to the meeting. With one minor amendment under 'Other Business', namely, 'Coordination of CEMP Sites Protection within the Antarctic Treaty System', the revised Agenda was adopted.

2.2 The Agenda is included in this report as Appendix A, the List of Participants as Appendix B and the List of Documents submitted to the meeting as Appendix C.

2.3 The report was prepared by Drs I. Boyd (UK), P. Boveng (USA), J. Croxall (UK), B. Fernholm (Sweden), K. Kerry (Australia), P. Penhale (USA) and W. Trivelpiece (USA).

REVIEW OF MEMBERS' ACTIVITIES

3.1 In previous years, summaries of Members' activities have been provided in Tables 1, 2, and 3 (e.g., SC-CAMLR-XII, Annex 6) of the Working Group's report. At the present meeting, it was agreed that although these tables offered a useful summary of the considerable work undertaken within CEMP, because of the increasing length of these tables and a desire to shorten the annexes to the Scientific Committee's report, these tables should not be included in future reports. Instead, it was agreed that these tables should be updated annually and circulated as a background paper to: (i) the Scientific Committee, (ii) Working Group meetings concerned with CEMP, and (iii) recipients

of the CEMP Newsletter (see paragraph 3.8). Such a paper had been prepared by the Secretariat this year as SC-CAMLR-XIII/BG/2.

3.2 Participants at the present meeting provided brief reports on their recent and prospective activities as part of CEMP. A compilation of these reports is attached at Appendix D.

3.3 The reports of new developments in CEMP-related research by Norway, South Africa and Italy were particularly welcomed. Dr T. Øritsland (Norway) reported that Norway has recently made commitments to fund research supporting the objectives of CEMP. Proposals are currently being developed for possible studies on Antarctic fur seals and chinstrap and macaroni penguins (Bouvet Island), Antarctic petrels (continued at Dronning Maud Land), and crabeater seals (Weddell Sea). Dr J. Cooper (South Africa) noted that South African scientists have initiated a CEMP-related study on macaroni and gentoo penguins at Marion Island. Drs S. Focardi (Italy) and Kerry described the planned Australian and Italian bilateral CEMP-related project on Adélie penguins at Edmonson Point.

3.4 The Working Group noted that, as in previous years, it was disappointed not to have the benefit of the participation of scientists from several countries known to be conducting research of direct relevance to CEMP. It was considered particularly unfortunate that scientists from the very active marine mammal and bird research groups in Germany, France and New Zealand were unable to be present at the meeting. Relevant papers were tabled on behalf of German marine mammal and bird researchers who had been unable to secure funds to support their attendance. Researchers from France (who have initiated a 5-year program at Crozet specifically addressed at CEMP) and New Zealand (who are undertaking important population ecology studies) have expressed a desire to participate at CEMP meetings but have not yet succeeded in obtaining funding to attend.

3.5 It was also noted that scientists from several countries are undertaking seabird research related to CEMP. The projects focus on penguins at Deception Island (Spain), penguins at King George Island (Poland), petrels near Casey Station (the Netherlands in collaboration with Australia) and penguins near Syowa Station (Japan).

3.6 Based on the information available to it, the Working Group noted with regret that Brazil's involvement with CEMP predator-related research had apparently come to an end.

3.7 The Working Group recommended that the Scientific Committee strongly encourage Members not yet active in CEMP and/or not yet represented by their scientists at CEMP meetings to facilitate the participation of their scientists in the work of CEMP.

3.8 At its 1993 meeting, the Working Group had recommended that a short CEMP newsletter be circulated to scientists in the SCAR and CCAMLR communities. The Convener reported that he had been unable to prepare such a newsletter on time, but that he would endeavour to develop and circulate a newsletter following the 1994 meeting of the Scientific Committee. Dr Penhale offered to help with the production of this newsletter.

## MONITORING PROCEDURES

### Predator Monitoring

#### Sites and Species

4.1 No new requests had been received for CEMP sites to be accorded protection under Conservation Measure 18/IX.

4.2 It was noted that a draft management plan for an Antarctic Specially Managed Area (ASMA) was submitted to the Commission jointly by the Delegations of Brazil and Poland (CCAMLR-XII/BG/13). This proposal is in accordance with Article 6(2) of Annex V to the Protocol on Environmental Protection to the Antarctic Treaty; this Protocol is yet to come into force. The area proposed included important research sites of relevance to CEMP in Admiralty Bay, King George Island. This proposal and its implications for CEMP are discussed under Other Business (paragraphs 10.6 to 10.10) and in Appendix E.

4.3 South African scientists advised that they had commenced a monitoring program on gentoo and macaroni penguins at Marion Island. CEMP Standard Methods are being used in these studies. Although these species do not feed on krill during the breeding season, it was agreed that the program would make a valuable contribution to CEMP. The Working Group welcomed this program and noted that among the benefits would be an increased understanding of the biology of these species, which would help in the interpretation of data from other monitoring sites and also provide further insights into penguin-myctophid fish interactions. Myctophid fish are also subject to harvesting within the Convention Area.

#### Field Research and Data Collection Procedures

4.4 Members reported on new developments, potential problems and recommended techniques or solutions of relevance to CEMP activities. Papers were tabled and discussed, relating to:



- (i) revisions or additions to specific, existing standard methods for monitoring predator parameters;
- (ii) revisions or additions to procedures for determining the sex of penguins (relevant to several standard methods);
- (iii) prospective development of standard methods for monitoring at-sea behaviour of birds and seals, especially using time-depth recorders (TDRs);
- (iv) potential impact of field procedures on penguins and seals; and
- (v) new techniques or results relevant to CEMP activities or directed research.

#### Revisions to Existing Standard Methods

4.5 In accordance with the agreed procedures for proposed modifications to existing standard methods (SC-CAMLR-XI, Annex 7, paragraphs 4.5 to 4.7), two papers were circulated in advance of the meeting to the CEMP *Ad Hoc* Subgroups on Monitoring Methods and on Statistical Aspects (WG-CEMP-94/6 and 7).

4.6 In WG-CEMP-94/6, Dr Croxall made specific recommendations for revisions to the text of the standard methods for the black-browed albatross (B1, Breeding Population Size; B2, Breeding Success; and B3, Age-specific Recruitment and Survival). The proposed revisions, arising from a recent, major review of the population dynamics of black-browed albatrosses, consisted primarily of additional text and references to publications, describing and clarifying the methods used to obtain the black-browed albatross data presently on deposit in the CCAMLR database.

4.7 In response to a request made by WG-CEMP last year (SC-CAMLR-XII, Annex 6, paragraph 4.6), Dr Trivelpiece submitted proposed revisions to Standard Method A4, Age-specific Recruitment and Survival in Penguins (WG-CEMP-94/7). The proposed revisions supplement the existing sections on general procedures for data collection and potential problems to be considered. They also include examples of methods, presently in use by one research group, for data processing, analysis and presentation of results.

4.8 No objections or substantial changes to the proposed revisions to Standard Methods A4, B1, B2 or B3 were raised by the *ad hoc* subgroups on methods and statistics.

4.9 The Working Group noted that because the standard methods for black-browed albatrosses have only recently been included in CEMP, and because Standard Method A4 for penguins requires substantial time before demographic rates can be estimated for the initially-banded cohorts, all the methods addressed by WG-CEMP-94/6 and 7 have heretofore remained less complete and detailed than the other predator monitoring methods. It was also noted, however, that WG-CEMP is nearing the point of agreeing standard formats for submission of data from these methods. It was, therefore, agreed that it would be beneficial at this time to include in the text for those methods, examples of the procedures being followed by research groups within CEMP. A subgroup (Drs Croxall and Trivelpiece) revised the texts of both proposals, taking into account suggestions and editorial comments from Members at the meeting. It was agreed that the resulting text should be transmitted to the Secretariat for inclusion in the standard methods.

#### Revisions to Procedures for Determining the Sex of Penguins

4.10 Two papers were tabled to provide WG-CEMP with additional methods for determining the sex of penguins (*CEMP Standard Methods*, Appendix 2), a procedure that significantly enhances the utility of data for several CEMP parameters, especially weight on arrival (A1) and age-specific survival and recruitment (A4).

4.11 Paper WG-CEMP-94/8 included a proposal by Dr Kerry, supported by a recently published study, to supplement the existing procedures for determining the sex of Adélie penguins. The additional procedure is based on the observation that, at Béchervaise Island, only the male Adélie penguins are found on nests between 15 and 21 days following laying of the first egg. This allows males to be identified (and females when they return to a nest occupied by a known male) easily and with little disturbance to the colony.

4.12 Paper WG-CEMP-94/25 provided a discriminant function for determining the sex of chinstrap penguins using morphometric measurements. This method, which correctly classified 94.6% of penguins in the study sample, completes *CEMP Standard Methods* Appendix 2, inasmuch as at least one method is now available for each of the penguin species monitored by CEMP. It was agreed to include the information summarised in paragraphs 4.9 and 4.10 in the revision of *CEMP Standard Methods*, Appendix 2.

4.13 The Working Group noted that two other papers provided information that may be useful in future refinements of sex-determination methods. Paper WG-CEMP-94/24 presented a single, generalised discriminant-score method of sex-determination for all fulmarine petrel species. It may

be possible to devise an analogous procedure for the CEMP penguin species. Paper WG-CEMP-94/41 presented a method of determining the sex of Antarctic petrels. It was noted that both of these papers would prove useful for any future efforts to establish standard methods for these petrel species.

4.14 The Working Group noted that since the most recent edition of the *CEMP Standard Methods* handbook, which was produced in November 1992, substantial revisions to all penguin methods have been prepared as a result of the inclusion of the gentoo penguin as a selected species. Together with the revisions approved at this meeting, the Working Group felt that enough new material was to hand to justify printing and circulating a set of all existing revisions. The Working Group recommended that the Scientific Committee request the Secretariat to undertake this work, if possible prior to the forthcoming Antarctic field season.

#### Prospective Development of Standard Methods for Monitoring At-sea Behaviour of Predators

4.15 Since its 1991 meeting, WG-CEMP has considered the feasibility of incorporating into the monitoring program indices of predator foraging performance, based on at-sea behaviour (SC-CAMLR XII, Annex 6, paragraphs 4.10 to 4.21). To best take advantage of the considerable experience of Antarctic and other researchers in the use of TDRs (the primary instruments for quantifying diving behaviour), it was suggested at the outset that a workshop would be most fruitful. Until recently, however, there were sufficient developments pending from another workshop and publications in press to warrant postponement of a CEMP workshop on the topic (SC-CAMLR-XII, Annex 6, paragraph 4.12). In the meantime, Members were requested to provide summaries of TDR data collected thus far, to better assess the need for a CEMP workshop and the prospects for development of standard methods.

4.16 Summaries of TDR data (both published and unpublished results) were received (e.g., WG-CEMP-94/4) during the intersessional period from six research groups and were collated by Dr Boveng into tables presented as WG-CEMP-94/18. The Working Group noted that these summaries indicated that :

- (i) vast quantities of data from studies spanning the past 16 years have already been collected for several species, but with great variation in the techniques and devices used;

- (ii) because of such variation, it may not be possible to devise standard methods to apply in a *post hoc* fashion to these past data, particularly those already published, without substantial re-analysis;
- (iii) there remains a great deal of data collected more recently that has not yet been analysed, providing good scope for efficient application of any standard methods that may be developed in the near future; and
- (iv) because of the volume of data and the breadth of accumulated experience with TDRs on CEMP predator species, a workshop or other effort to devise standard monitoring methods should draw primarily on those data and experience rather than a previously considered alternative of giving equal balance to studies on species inside and outside the Antarctic.

4.17 It was also noted that most of the information anticipated from other workshops and publications (paragraph 4.15, above) had become available and that the outcomes had provided sufficient background to establish guidelines for WG-CEMP's work on the topic. Accordingly, an *ad hoc* subgroup, led by Dr Boyd, was asked to draft guidelines for consideration and to indicate which items would be most appropriately addressed by a workshop or by other means.

4.18 Regarding guidelines for the development of standard methods of foraging performance based on at-sea behaviour, the Working Group agreed that it is of priority to:

- (i) recommend the most appropriate methods for the deployment of TDRs for each species being considered (presently Adélie, chinstrap, gentoo and macaroni penguins, Antarctic fur seals and crabeater seals). Particular attention should be given to:
  - (a) shape and size of TDR;
  - (b) method of attachment;
  - (c) site of attachment; and
  - (d) effects of the TDR on the behaviour of individuals, including the latent effects of handling stress.
- (ii) recommend methods of data collection, with specific recommendations concerning:
  - (a) deployment duration;
  - (b) the timing of deployment within the breeding cycle of individual species;
  - (c) the sampling protocol, specifically the frequency of sampling;

- (d) methods for standardisation of the zero-offset correction; and
  - (e) definition of 'bin' size for satellite-linked TDRs.
- (iii) develop standard parameters as indices of foraging effort which are likely to reflect intra- and interannual variation in prey availability. Consideration should be given to changes in behaviour at three spatial and temporal scales:
- (a) *dive*, e.g., dive depth and duration, surface interval, ascent/descent rate, time spent feeding during dives (bottom time), dive shape;
  - (b) *bout*, e.g., bout duration, mean depth, proportion of time spent submerged, diving frequency, interval between bouts; and
  - (c) *foraging trip*, e.g., transit times, foraging times, total vertical distance dived, proportion of time spent submerged.

Evaluation of prospective standard parameters should include consideration of the minimum sample sizes required to provide the statistical power necessary to test for changes in parameters, based on current knowledge of the inter- and intra-individual variability in those parameters (e.g., WG-CEMP-94/19).

- (iv) Develop standard software for the calculation of indices of foraging effort from commonly available TDR data. Consideration should be given to:
- (a) format and content of historical data; and
  - (b) foreseeable developments in TDR technology, e.g., the potential inclusion of swim velocity as a parameter.

4.19 It was agreed that the first two items (deployment methods and data collection protocol) would be most efficiently addressed by tasking one or two individuals with developing draft text to be reviewed at the next meeting of WG-CEMP. Drs Boveng (seals) and Trivelpiece (penguins, in contact with Drs Rory Wilson and Boris Culik, University of Kiel) offered to draft methods for the deployment of TDRs. Drs Boyd and Croxall undertook to draft standard protocols for data collection.

4.20 The fourth item (development of standard software) would be best addressed by an individual or small group, in correspondence with potential users of the software. It was noted that producing this software would be facilitated by the fact that nearly all CEMP researchers using TDRs

have obtained the instruments from a single manufacturer (Wildlife Computers, Woodinville, Washington, USA), thereby rendering a common output format for the raw data. Dr Boyd informed WG-CEMP that the first steps had already been taken to develop such software and he would welcome guidance for its further development.

4.21 It is anticipated that the work implicit in guidelines (i), (ii) and (iv) above will be completed in 1995. The Working Group agreed, however, that a workshop will be required to develop standard methods and indices of foraging effort as set out in guideline (iii) above. There is a need to:

- (i) examine and evaluate the specific methods used to analyse data on the foraging behaviour of predators with a view to their potential adoption as indices of foraging effort;
- (ii) ensure that the analyses which are developed can be applied to historical data, at least in part, and to carry out analyses of example data sets; and
- (iii) provide detailed guidelines for statistical procedures and standard analytical software which will eventually be available for use by all parties.

4.22 The Working Group therefore recommended to the Scientific Committee that the workshop should be held in the intersessional period following the 1995 meeting of the Commission. Details of the workshop, including terms of reference and venue, will be prepared by the *ad hoc* subgroup, led by Dr Boyd. The Working Group requested that allowance should be made in the forward estimates for 1995/96 in the budget of the Scientific Committee.

4.23 The nature of the data on foraging trip duration of Adélie penguins was discussed with particular reference to the fact that the standard deviations approach, or exceed, the mean values in almost all years at all three sites from which these data have been reported. Studies by Drs Trivelpiece and Kerry (see paragraph 4.29) have shown that, depending on the location of prey and the stage of the breeding season, Adélie penguins may make long trips to the edge of the continental shelf or shorter, more localised, trips. The resulting bimodality in foraging trip duration would account for some of the variation in the data.

#### Potential Impact of Field Procedures on Birds and Seals

4.24 At its last meeting WG-CEMP considered a draft report of the 'Workshop on Researcher-Seabird Interactions', held in July 1993 in Minnesota, USA (SC-CAMLR-XII, Annex 6,

paragraphs 4.23 to 4.26; WG-CEMP-93/20). The *Ad Hoc* Subgroup on Monitoring Methods had been asked to review the final version of this report when made available during the intersessional period, and to recommend any appropriate modifications to the CEMP Standard Methods (SC-CAMLR-XII, Annex 6, paragraph 4.25).

4.25 Dr Trivelpiece, co-convenor of the workshop and member of the *Ad Hoc* Subgroup on Monitoring Methods, compiled recommendations (WG-CEMP-94/40) from the final workshop report that were specific to the banding procedures of Standard Method A4 (Age-Specific Annual Survival and Recruitment) and lavaging procedures of Standard Method A8 (Chick Diet). Both recommendations were phrased in precautionary language and were to be added to the sections entitled 'Problems to Be Considered'. It was agreed that the proposed wording should be added to the text of Standard Methods A4 and A8.

4.26 Dr Trivelpiece noted that WG-CEMP-94/40 also referred to sections of the workshop report pertaining to effects of the use of TDRs and to impacts of general disturbance at research sites. The Working Group noted that the report's recommendations regarding TDR effects on seabirds should be considered as part of CEMP's effort to develop standard methods for foraging performance (paragraph 4.15).

4.27 A specific effect of TDRs on the foraging behaviour of Antarctic fur seals was described in WG-CEMP-94/22. In that study, durations of foraging trips and attendance visits of seals carrying TDRs and radio transmitters were about 10% greater than those of seals carrying only radio transmitters. This relatively slight effect has not been detected before, possibly because large sample sizes are required. The exact cause of the increased durations is unknown, but the effect might be reduced or eliminated by using smaller instruments as they become available. It was agreed that these results should be taken into account when developing standard methods utilising TDRs (paragraph 4.18).

#### New Techniques or Results Relevant to CEMP Monitoring or Directed Research

4.28 Dr Boyd summarised WG-CEMP-94/12. Milk delivered to pups by Antarctic fur seals was measured, in terms of volume and energy content, and related to foraging trip duration. Both the volume and total energy of milk delivered during visits ashore increased in direct proportion to foraging trip duration, showing that females which make long foraging trips (five to six days) deliver more milk to their pups than those which make short foraging trips (two to three days). However, when averaged over the whole of lactation, milk delivery to pups will be similar for individuals making long and short trips.

4.29 Paper WG-CEMP-94/13 examined the validity of using heart rate to measure field metabolic rate in black-browed albatrosses. Albatrosses were made to walk on a treadmill within a respirometer. Simultaneous measurements were made of heart rate, oxygen consumption (respirometry) and CO<sub>2</sub> production (doubly-labelled water). A good concordance was found between these measurements of metabolism. There was a good curvilinear relationship between heart rate and metabolic rate, and it was concluded that heart rate was an appropriate measure of metabolic rate in albatrosses so long as grouped means were used.

4.30 As a matter related to further development of Standard Method A8, the Working Group was informed by Dr Croxall that the SCAR Bird Biology Subcommittee had recommended that a comprehensive review of penguin lavaging be commissioned from Dr G. Robertson (Australia). WG-CEMP requested that a draft of this review be circulated to the *Ad Hoc* Subgroup on Monitoring Methods for consideration of modifications to Standard Method A8. The Working Group also noted that it would be helpful to have a similar review for methods of monitoring the diet of procellariiforms. The Convener was requested to ask Dr A. Veit (University of Washington, USA) if he would be prepared to undertake such a review in time for consideration at the Working Group's next meeting.

4.31 At its last meeting, WG-CEMP considered papers presented by Lic. R. Casaux (Argentina), describing the diet composition of piscivorous blue-eyed shags, estimated from examination of regurgitated casts (pellets) at Nelson Island, South Shetland Islands (SC-CAMLR-XII, Annex 6, paragraphs 4.29 to 4.33). The shags' diet included juvenile members of both harvested and unexploited fish species, suggesting the possibility of monitoring littoral fish populations by recording changes in shag diet. It was noted at that meeting, however, that experience with diet studies of other shag species showed discrepancies between actual diets and those estimated from pellets and, therefore, appropriate validation studies would be required before embarking on such a monitoring program.

4.32 At the present meeting, Lic. Casaux presented results of a preliminary validation study (WG-CEMP-94/29), wherein a captive blue-eyed shag at King George Island was fed local fish species and the composition of otoliths in the pellets was compared with the known composition of the diet. The results of this study confirmed that fish species are differentially represented by otoliths in the pellets. The Working Group welcomed this effort and encouraged the authors to develop the method further, if possible, by increasing the sample size and more realistically simulating natural feeding conditions.



4.33 Lic. Casaux extended the results presented last year with two additional studies of blue-eyed shag diet. In WG-CEMP-94/31, stomach contents of shags at Nelson Island were compared with the contents of pellets from the same colony. The more labour-intensive method of stomach content analysis reduces errors arising from erosion or loss of otoliths during digestion. Therefore, this method may provide additional information useful for improving the accuracy of pellet analysis, at a lower cost and effort than actual feeding trials. In WG-CEMP-94/32, blue-eyed shag diet derived by pellet analysis at Half-Moon Island, South Shetland Islands, was presented. This complemented similar information from Nelson Island presented last year (see paragraph 4.31).

4.34 The Working Group noted that, as reflected in the Scientific Committee's report (SC-CAMLR-XII, paragraph 8.6), several Members, including Australia, France, Norway and South Africa, have current and recent research projects on fulmarine petrels, including Antarctic and cape petrels. These Members, in conjunction with other Members as appropriate, were urged to undertake as a matter of some priority the development of standard methods for monitoring those species. Dr F. Mehlum (Norway) offered to coordinate this effort, to invite the participation of Dr J. van Franeker (the Netherlands) and others, and to circulate any draft methods to the *Ad Hoc* Subgroup on Methods.

4.35 Dr Bengtson noted that recent results from studies at Seal Island of cape petrel fledgling size and breeding success (WG-CEMP-94/21) emphasised the importance of determining breeding chronology for the proper interpretation of other parameters.

4.36 Dr Croxall introduced WG-CEMP-94/15, which reported on studies may may lead to the inclusion of data from other krill-eating predators into CEMP (here, specifically, the Antarctic prion at South Georgia). The evaluation of the breeding biology and diet of Antarctic prions in three consecutive years, which included one year (1991) when krill availability to predators was very reduced at South Georgia, indicated that although Antarctic prions were excellent samplers of zooplankton (being able to switch to amphipods and copepods when krill were unavailable), this very adaptability resulted in little observable interannual variation in most aspects of their breeding biology and ecology.

4.37 Dr Kerry presented WG-CEMP-94/33, which described the foraging strategy of Adélie penguins at Béchervaise Island. It was shown by satellite tracking, time-depth recording and stomach contents analysis that during the chick rearing period, birds make a series of short trips of 15 to 18 km within the shelf zone, returning with amphipods, *Euphausia crystallorophias* or *Pleuragramma antarcticum*. These trips are interspersed with journeys of 100 to 120 km to the shelf break, from which birds return with predominantly *E. superba*. The observation that Adélie

can forage in different zones requiring different travelling times has implications for the interpretation of CEMP parameters on foraging trip duration and diet.

4.38 Paper WG-CEMP-94/27 reports innovative work by German scientists at Ardley Island, King George Island, suggesting potential for using penguins, appropriately instrumented, to record environmental data (e.g., water temperature) and indices of prey distribution and availability (based on simultaneous recording of location and of prey ingestion events). Although considerable further work would need to be undertaken to refine and validate the data being collected (particularly on prey ingestion), the Working Group felt that these approaches held considerable promise for acquiring data on the physical and biological environment at scales particularly relevant to predator foraging behaviour. Continuation of this research program at Ardley Island would be a valuable contribution to CEMP's work in developing potential new monitoring indices.

4.39 Dr Croxall noted that a recently published study (WG-CEMP-94/23) by J. Ulbricht and D. Zippel (Germany) presents results relevant to the interpretation of Standard Method A2 (Penguin Incubation Shift Duration). Because Adélie penguins are able significantly to prolong fasting, apparently without detrimental effects, the incubation shift duration of that species may not be as closely related to prey availability and conditions as previously thought. Members are encouraged to examine existing data and to provide input on this topic to the Working Group.

4.40 Dr Kerry presented two papers (WG-CEMP-94/34 and 35), co-authored by Dr J. Clarke, intended to raise awareness of and encourage investigation of infectious diseases and parasites of CEMP monitoring species. Agents of disease, though rarely evident, may often be present in the population at sub-clinical levels. Various types of stress on a population may lead to increased presence of disease symptoms or parasite load. Because there is very little information available to CEMP on these topics, the authors suggested noting the presence of disease and parasites and perhaps later incorporating monitoring procedures into CEMP.

4.41 The Working Group welcomed these very informative papers. It was noted that there are two approaches that may be relevant to better understanding the effects of diseases and parasites on populations. One approach is to document the incidence of acute disease or parasite outbreaks so that these can be taken into account in the interpretation of changes in variables or indices. A second, but much more difficult, approach is to attempt to identify cause-effect linkages between chronic (sub-clinical) infestations and their demographic effects. It was noted that, based on the considerable literature for terrestrial animal populations, the prospect for accomplishing this in a marine context within CEMP seemed remote at present.

4.42 The Working Group agreed that, at present, only the first approach is likely to be appropriate within CEMP. Drs Kerry and Cooper agreed to prepare for the next meeting procedures necessary for collecting diagnostic samples if and when an outbreak of disease or parasite infestation is observed in a seabird colony. The Working Group noted that in an event of such an outbreak or increased infestation, there may be interest in whether any contaminant or pollutant has contributed to the outbreak. It was therefore suggested that this effort include consultation with Dr Focardi to ensure that sample collection procedures included those necessary for *post hoc* testing for contaminants.

### Prey Monitoring

4.43 WG-CEMP noted the valuable paper on recruitment variability of Antarctic krill (WG-Krill-94/22), based on data from 1975 to 1994 for the Antarctic Peninsula area (chiefly around Elephant Island). The paper provides recruitment indices for 16 years. The Joint Meeting of WG-Krill and WG-CEMP (WG-Joint) had noted that these indices would be applicable throughout Subareas 48.1 and 48.2, but that their application to Subarea 48.3 needed further investigation. WG-CEMP noted that these recruitment indices offered considerable scope for assessing relationships between krill and predators using appropriate time series of data.

4.44 Further discussion of these matters can be found in paragraphs 5.7 to 5.20 of the report of the Joint Meeting (Annex 7).

### Environmental Monitoring

#### Remote Sensing

4.45 Data on sea-ice extent were presented in WG-CEMP-94/16 by the Secretariat. These data were derived from the Joint Ice Centre (JIC) weekly ice charts for the split-years 1988 to 1990 as requested by CEMP. Listed were the dates of ice movement southward and northward past each CEMP site and the ice-free periods. The data as presented were noted but not discussed in detail, as additional information on the presence of ice around the site and the distance to consolidated pack-ice needs to be compiled (as set out in SC-CAMLR-XI, Annex 7, paragraphs 4.30 to 4.32).

4.46 The Secretariat is planning to bring the extraction and presentation of historical sea-ice data up to the present over the next two years. Additional funds may be required if the project extends beyond 1995.

4.47 Dr K.-H. Kock (Germany) informed the Working Group that the IWC (International Whaling Commission) was investigating the relationship between the edge of sea-ice and the sighting of whales, and that satellite data were being used to evaluate sea-ice. The Convener was asked to request details of this program with particular emphasis on the analysis of the sea-ice data. Dr Trivelpiece noted that analysis of JIC ice data was being undertaken by a research student at the University of California, Santa Barbara, and that he would investigate the matter and report back to the Working Group.

4.48 It was noted that although the data compiled by the Secretariat from JIC charts appeared to provide useful information, it was important, where possible, to compare these data with land-based observations and other data for specific sites. Members with relevant data were asked to compare these with the JIC data.

4.49 Dr Øritsland drew attention to the importance of good quality sea-ice images from the AVHRR satellite data in determining the edge of the fast-ice and the distribution and dynamics of the unconsolidated pack-ice. It was noted that several Members are collecting and archiving such images.

## REVIEW OF MONITORING RESULTS

### Predator Data

#### Status of Data Submissions

5.1 The Secretariat submitted WG-CEMP-94/16 which summarised current and past data submitted to CEMP for designated monitoring species and sites. A summary of the 1994 submission is given in Table 5.1. Data had been submitted from five national programs which included a total of 46 sets of data for 11 parameters and eight sites (Table 1). The Working Group welcomed the inclusion of Adélie penguin data from the new monitoring site at Terra Nova Bay submitted by Italy.

5.2 It was noted that Argentina had not submitted any data since 1990. It was confirmed that Argentina still had an active monitoring program at Jubany Station on King George Island and that the data for 1994 will be submitted together with 1995 data. The meeting encouraged the continuance of these data contributions because they are from an area where there is currently little coverage.

5.3 Overall, the lack of submission of data to CEMP, which had been noted in 1993, (SC-CAMLR-XII, paragraphs 8.16 and 8.17) has not improved. No historical data were submitted by any Member in 1994.

5.4 In general, there was good congruence between data submitted to CEMP and the data appearing in WG-CEMP-94/16. The Working Group suggested that, when possible, the Secretariat should forward draft copies of the annual summary of indices and trends (i.e., WG-CEMP-94/16) to the contributors in advance of the meeting to ensure that data are checked for accuracy.

#### Report on Indices and Trends

5.5 Individuals responsible for the data submissions from each of the monitoring sites updated the appropriate sections of Table 5 from the 1993 WG-CEMP report (Table 2). This table is the first attempt to examine CEMP data for trends across years and among and within sites for the various indices. It has been updated annually since 1992.

5.6 Although statistical methods described in the *CEMP Standard Methods* had been used to compare various indices, it was noted that most of these comparisons showed highly statistically significant differences between years for most parameters at all sites. Doubts were expressed about the validity of the statistical tests and the relevance of some of the comparisons being undertaken. It was agreed that the issue of which statistical procedures would be most appropriate, in addition to how trends should be illustrated, should be passed to the Statistics Subgroup for consideration during the intersessional period in consultation with the Data Manager.

5.7 The Working Group noted that the application of appropriate statistical analyses to the data collected by CEMP is viewed as a high priority. Considerable progress has been made with procedures for data collection, submission to CEMP and collation and index calculation by the Secretariat. The Working Group is now in a position to begin quantitative evaluations of these data.

#### Environmental Data

5.8 Patterns of sea-ice distribution were reported in WG-CEMP-94/16.

5.9 There were no reports of other notable environmental events, such as severe storms, affecting CEMP monitoring sites in 1994.

## ECOSYSTEM INTERACTIONS

### Matters Arising from the Joint Meeting with WG-Krill

6.1 The Working Group noted that the proposed terms of reference for the proposed new Working Group joining WG-CEMP and WG-Krill provided for the longterm continuity of CEMP initiatives addressing ecosystem interactions.

6.2 Discussion of this topic can be found in Section 6 of the report of the Joint Meeting (Annex 7).

### Estimation of Prey Requirements of Predators

6.3 The WG-CEMP meeting in 1993 reviewed recent progress with this topic, formerly accorded high priority by the Scientific Committee (SC-CAMLR-XII, Annex 6, paragraphs 7.1 to 7.7).

6.4 In order to keep this topic fully up to date, the Working Group had requested Members to table relevant publications (SC-CAMLR-XII, Annex 6, paragraph 7.6).

6.5 Paper WG-Joint-94/14 reviewed approaches by the ICES study group on seabird/fishery interactions which was dealing with the same topic as that under consideration by WG-CEMP. The document is a useful review of the state of the art (1993) and, although the detail is principally applicable to the North Sea situation, most of the approaches are very similar indeed to those developed within WG-CEMP.

6.6 Paper WG-Joint-94/15 provides a recently published annual and seasonal quantitative assessment of energy and food consumption by all penguins (king, macaroni, rockhopper, gentoo) at the Prince Edward Islands (Subarea 58.7).

## ECOSYSTEM ASSESSMENT

7.1 Under this agenda item WG-CEMP is required to determine annually the magnitude, direction and significance of trends in each of the predator parameters being monitored; evaluate annually these data by species, sites and regions; consider conclusions in light of relevant information (e.g., prey and environment); and formulate appropriate advice to the Scientific Committee.

7.2 In 1992 and 1993 the assessment procedure included: (i) a review of background information available to the Working Group in submitted papers; and (ii) evaluation of predator, prey, environmental and fishery data.

7.3 This year the general review of background information took place largely in the Joint Meeting. Therefore attention in WG-CEMP was confined chiefly to assessments of predator, prey and environmental data.

7.4 Last year WG-CEMP had recommended that the table summarising the assessments of these data should, at least for the predator parameters, be replaced by one recording the calculated year-to-year changes together with the statistical significance of any differences (SC-CAMLR-XII, Annex 6, paragraph 6.37).

7.5 In addition, WG-CEMP agreed that from the 1994 meeting:

- (i) the formal annual assessment of predator data would be confined to data on parameters collected annually and submitted [to the CEMP database] by the due date according to the approved standard methods;
- (ii) data on other predator parameters (i.e., those not subject to CEMP Standard Methods) collected annually by standard procedures and tabled at WG-CEMP for examination would also be considered for similar annual assessment. These data and assessments would be clearly indicated as distinct from those in (i), above; and
- (iii) other predator data, whether for approved parameters or not, or whether collected annually or not, would receive separate consideration.

7.6 The recommendations in paragraphs 7.4 and 7.5 were endorsed by the Scientific Committee (SC-CAMLR-XII, paragraph 8.27).

7.7 In the absence of summarised data on the magnitude of the year-to-year changes (in WG-CEMP-94/16) and the potential problems identified with the calculation of statistical significances, the tasks set out in paragraph 7.4 could not be undertaken this year.

7.8 WG-CEMP noted that resolving this situation was amongst its highest priorities. Therefore it requested that the statistics subgroup should, by intersessional meeting and correspondence:

- (i) evaluate all the current analytical methods and advise on necessary changes;

- (ii) identify any changes that would require modifications to the nature of the submitted data; and
- (iii) propose appropriate ways of preparing tables and graphs to illustrate best the nature and significance of interannual changes and trends in the submitted data.

7.9 In the meantime, it was only feasible at the present meeting to update SC-CAMLR-XII, Annex 6, Table 5 in a similar fashion to that of the two previous years. In doing this it was agreed that data actually submitted to the database should be clearly distinguished from other data considered in these evaluations.

7.10 The updated table assessing predator, prey and environmental data since 1988 (Table 2 - which was Table 5 in WG-CEMP's previous two reports) was then reviewed by the Working Group.

7.11 Some general observations were made:

- (i) data are currently being submitted to the CEMP database for five sites only, two in the Antarctic Peninsula (Subarea 48.1) ISR (Anvers Island and Seal Island), one network site in Subarea 48.2 (Signy Island), one in the South Georgia (Subarea 48.3) ISR (Bird Island) and one in Division 58.4.2 (Béchervaise Island). The need for more of the data apparently being collected by CEMP Standard Methods to be submitted to the database was emphasised;
- (ii) for some of the parameters which are currently being submitted to the CEMP database, historical data exist which were also collected by CEMP Standard Methods. Members are urged to submit these data as soon as possible;
- (iii) Table 2 includes summaries of several sets of quantitative data collected annually by consistent procedures (but not CEMP Standard Methods). Members collecting these data were strongly encouraged to propose standard methods that would allow these data to be submitted to the CEMP database; and
- (iv) valuable data are known to exist for some CEMP selected species (e.g., crabeater seal, cape and Antarctic petrels) for which no standard methods have yet been proposed. Members conducting research on these species were requested to prepare standard methods and/or to submit relevant data for the consideration of CEMP.



7.12 Discussion then turned to more specific points concerning the data summarised in each of the sub-tables of Table 2.

7.13 At Anvers Island, Antarctic Peninsula (Table 2.1), the data indicated a fairly typical year, although fledging mass of Adélie penguins was 10% lower than in the three previous years.

7.14 At Cape Shirreff, Livingston Island, South Shetland Islands (Table 2.2), the census data indicated that fur seal populations are still increasing and that chinstrap penguin breeding populations may have been slightly smaller than in the previous year. Environmental conditions were apparently normal and no ice was reported at sea in the area during the summer.

7.15 At Admiralty Bay, King George Island (Table 2.3), gentoo penguin populations remained high and enjoyed average breeding success; Adélie penguin populations remained low (but had increased slightly) and had a very productive breeding season; chinstrap penguins had intermediate success. All data were indicative of a fairly typical good year.

7.16 At Ardley Island/Stranger Point, King George Island (Table 2.4), the few data available suggested a fairly typical year.

7.17 At Seal Island, Elephant Island (Table 2.5), virtually all data indicated a normal-to-good year for predators. The only possible exception was the relatively low fledging mass of chinstrap penguins. Diet samples indicated that krill was widely available.

7.18 There was considerable interest in seeking further information on the situation in the Seal Island area where, as far as predator indices were concerned, 1994 was a normal breeding season, whereas observed local krill biomass estimated from research surveys was only one fifth of the values of previous years (these data are included in Table 2.5). More detailed investigation of the information on krill distribution and biomass is currently underway. The Working Group drew attention to the valuable opportunity provided by a five-year time-series of data on various aspects of prey and predator performance. It recommended that a comparative investigation of the whole data set be undertaken with particular attention to the circumstances and conditions prevailing in 1991 ('normal' krill biomass, poor predator performance) and 1994 (low krill biomass, good predator performance) against the background of the other three years where such anomalies do not appear to exist.

7.19 At Signy Island, South Orkney Islands (Table 2.6), penguin breeding population sizes were normal but breeding success was within the lowest quartile of values recorded over the last fifteen years. Poor breeding success could not be linked to the prolonged presence of sea-ice; no data on penguin diets were available.

7.20 At Bird Island, South Georgia (Tables 2.7 and 2.8), breeding populations of penguins, albatrosses and fur seals were only just below average. With the exception of macaroni penguins, breeding success of all these krill predators was exceptionally low - and for fur seals the lowest ever recorded. Diet studies indicated that krill availability to these predators was also very low and that these species had taken significant quantities of other crustaceans and fish in 1994. Macaroni penguins were feeding predominantly on the amphipod *Themisto gaudichaudii*; the resulting reduction in meal size and energy content was reflected in chicks fledging at a mass some 15 to 20% lower than in previous years.

7.21 The highly anomalous breeding season of 1993/94 at South Georgia followed the most successful breeding season for a decade there in 1992/93. Data (apart from those submitted to CEMP) indicate that krill availability did not change markedly until some time in the July to September 1993 period, which may explain why breeding population sizes in 1994 were relatively normal. To identify the causes of the exceptionally bad year for krill predators at Bird Island will require analysis and examination of the extensive data available on prey and environment (deriving from the BAS research cruise JR06 conducted during December to February 1993/94) together with other, broader scale, information on prey and environmental conditions.

7.22 At Béchervaise Island (Table 2.9) the data so far available indicate an average-to-good year for Adélie penguins. Of note was that incubation shift duration for both males and females has become progressively shorter over the last three years; the reason for this is unknown.

7.23 The overall conclusion of WG-CEMP was that 1993/94 had been a rather unusual year in the South Atlantic sector. Thus:

- (i) throughout Subarea 48.1 predators enjoyed a year of average-to-good productivity and reproductive performance despite, at least in the part of Subarea 48.1 around Elephant Island, local estimates of krill biomass being substantially lower than normal;
- (ii) at the South Orkney Islands - the only site in Subarea 48.2 for which data were available - penguin breeding populations were normal but breeding success was substantially reduced; and
- (iii) at South Georgia, very low krill biomass was reflected in exceptionally low reproductive performance and breeding success for all krill predators (especially fur seals) except macaroni penguin. Even for the latter, able to switch diet from krill to *T. gaudichaudii*, the abnormally low fledging weights of chicks may ultimately result in poor survival rates for this year's cohort.

7.24 The Working Group recommended that a concerted effort be initiated to investigate the biological and physical characteristics of the marine environment that existed in these three subareas during 1993/94 in order to help explain the apparently very different patterns of predator performance and prey availability/abundance.

7.25 The Working Group recognised that it would take some time to undertake this comparative work. It drew attention to the growing importance of retrospective re-assessment of predator, prey and environmental data whenever relevant information becomes available. It is crucial to the furtherance of CEMP objectives to maintain effective liaison on these topics among the different groups of scientists involved in analysis of data from the different sources.

#### CCAMLR POLICY ON DATA ACCESS AND USE

8.1 WG-CEMP considered that WG-Krill-94/19 provided a very useful explanation of how the CCAMLR policy on data access and use actually operated, and of the principles that should guide the interpretation of this policy.

8.2 WG-CEMP noted that following the procedures set out in WG-Krill-94/19 should prevent some of the difficulties that have arisen in the last couple of years concerning the status of data in documents not actually tabled at CCAMLR meetings but circulated intersessionally for analyses to be presented at subsequent CCAMLR meetings.

#### ORGANISATION OF FUTURE WORK

##### Desirability of Expanding the Scope of CEMP and its Priorities and Needs

9.1 The Convener, in opening this agenda item, reviewed the history of the formation and development of CEMP. He pointed out that although the terms of reference of WG-CEMP are broad and that its scope includes all interactions between predators and harvestable resources, the Working Group had, since its inception, focused on the interactions of krill and its major predators in the context of the actual and potential harvest of krill. He noted that this work had progressed extremely well and that data on predators, and to a much lesser extent, prey, had been collected according to standard methods over several years and were being analysed by the Working Group.

9.2 The need for expanding CEMP, at least to consider interactions between fish and fish predators, had been raised at the meeting of the Working Group in Korea (SC-CAMLR-XII, Annex 6, paragraphs 4.34 and 4.35). The Working Group had agreed to discuss this matter further at the present meeting.

9.3 One example of approaches relevant to the quantitative assessment of fish-predator interactions and to the potential use of fish predators in providing useful data on the relative abundance and other characteristics of their prey is provided by the work on blue-eyed shags by Lic. Casaux and his colleagues (WG-CEMP-94/29, 31 and 32).

9.4 A second example of recent and current relevant research is the suite of research programs (by Australia at Macquarie and Heard Islands, France at Crozet Islands, South Africa at Marion Island and Sweden at South Georgia) investigating interactions between king penguins and myctophid fishes.

9.5 Myctophids are also important in the diet of macaroni and gentoo penguins at Marion and Crozet Islands and in the diet of the white-chinned petrels at South Georgia (as demonstrated in WG-CEMP-94/14).

9.6 A third example of relevant initiatives relates to *P. antarcticum*, already a selected prey species within the CEMP Program. For Adélie penguins breeding on the Antarctic continent this fish is an important element of their diet, which is currently being studied within the CEMP Program at Béchervaise Island. Considerable research on interactions between Weddell seals and *P. antarcticum* have been and are being conducted by US and German scientists, particularly in the Ross and Weddell Seas.

9.7 These examples demonstrate the considerable amount of current research relevant to quantification of interactions between harvestable fish species and their predators. Most of this research is currently not available for discussion within CCAMLR.

9.8 The Working Group agreed that very valuable monitoring and directed research could be undertaken on predators of fish, particularly those fish species that have been or may be of commercial interest, and that it would be profitable to widen the scope of CEMP in this regard. This, however, should be carefully planned and should not dilute the considerable effort required to maintain the existing CEMP Program. Therefore the Working Group encouraged Members with interest in these topics to participate in further discussions on this matter.

9.9 The Working Group drew the attention of the Working Group on Fish Stock Assessment (WG-FSA) to these developments.

## ORGANISATION OF THE WORKING GROUP

9.10 The Working Group discussed briefly its possible structure. It noted particularly the importance of a very close link with WG-Krill in determining the functional relationship between krill and its major predators and the overall role of both Working Groups in providing advice concerning management of the krill harvest.

9.11 Two options for organisation were noted: (i) maintenance of both WG-Krill and WG-CEMP, and (ii) merging the two Working Groups. It was noted that having two separate groups which met at a separate time allows scientists to attend meetings of both and would probably allow an overall greater attendance at both. The major disadvantage of this arrangement is that the Working Groups tend to operate separately and there is the potential for lack of understanding of one another's requirements.

9.12 There was general agreement that the most desirable system would be the merging of the two Working Groups in such a way as to enable free exchange of information and views but to have the ability for technical aspects of CEMP to be addressed by subgroups. It was felt that many subgroups within a new joint working group would likely benefit by including experts on predators and prey among their members. Further discussion of this topic was held over for joint discussions with WG-Krill, the results of which are found in the report of the Joint Meeting (Annex 7).

## OTHER BUSINESS

### IUCN Assessment of Marine Protected Areas

10.1 At its 1993 meeting, the Working Group discussed the IUCN initiative to assess the world's protected marine areas and identify priority areas for conserving global marine biodiversity. The Convener and Dr Penhale had been asked to pursue this matter further and report to the present meeting. They reported that, at least at the present time, it seemed unlikely that financial support for CEMP activities could be obtained through this initiative. However, it was noted that Dr D. Vergani (Argentina) had offered, via correspondence, to attempt to obtain more information about this program and report to the Working Group at a future meeting.

## SCAR APIS Program

10.2 The Convener introduced the Draft Implementation Plan of SCAR's Antarctic Pack Ice Seals (APIS) Program (WG-CEMP-94/20). This program had been welcomed by the Scientific Committee (SC-CAMLR-XII, paragraphs 9.2 to 9.9), which noted that it was likely that APIS would make a strong contribution to the work of CCAMLR. The Draft Implementation Plan describes the continued development of this program, including additional details on logistical and scheduling aspects. WG-CEMP noted that the program will address several research topics of direct relevance to WG-CEMP and that it has an interest in crabeater seals.

10.3 The Working Group drew the attention of the Scientific Committee to the continued development of the APIS Program, and agreed that efforts to ensure close coordination and effective communication between CEMP and APIS should be maintained.

## SO-GLOBEC

10.4 Dr R. Holt (USA) reported on the SO-GLOBEC meeting that was held in Bremerhaven, Germany, in June 1994. It was noted that elements of SO-GLOBEC, especially for top trophic level predators and prey, were potentially of great interest to CCAMLR. WG-CEMP is eager to form a close liaison with the SO-GLOBEC Program as it continues to develop and be implemented to ensure coordination of the research programs of interest to both GLOBEC and CCAMLR. To facilitate improved awareness of such developments, it was hoped that reports from the SO-GLOBEC meetings be speedily produced and circulated.

## Ecology of the Antarctic Sea-Ice Zone (EASIZ)

10.5 Dr Croxall drew the attention of WG-CEMP to the development of SCAR's Coastal Zone EASIZ (Ecology of the Antarctic Sea-Ice Zone) Program, which addresses topics largely complementary to SO-GLOBEC and focuses on ecological interactions in the coastal zone. The proposed program is being tabled for formal adoption as the main marine ecological program within SCAR's IGBP initiative at the SCAR meeting in September. The first scheduled cruise within the Coastal Zone EASIZ Program is planned to be a European coordinated cruise on the *Polarstern* of the Alfred Wegener Institute, probably in 1996/97. This cruise may offer good opportunities for research programs of interest to CCAMLR to be undertaken.

## Consultation with the ATCM Concerning Protection of Sites

10.6 Dr Penhale reported on the intersessional activity of the *Ad Hoc* Subgroup on the Protection of Sites. The subgroup had been charged with three tasks: (i) to provide comments on the joint proposal by Brazil and Poland to the ATCM for an Antarctic Specially Managed Area (ASMA), Admiralty Bay, King George Island; (ii) to consider appropriate procedures to deal with such draft management plans received from the contracting parties to the Antarctic Treaty; and (iii) to consider to what extent to revise the provisions of Conservation Measure 18/IX so that they correspond to the provisions of Annex V to the Protocol on the Antarctic Environment. The subgroup's report is included as Appendix E.

10.7 With regard to the joint proposal by Brazil and Poland, only general remarks were provided because the draft available to the subgroup was not the latest version that had been reviewed by SCAR/Group of Specialists on Environmental Affairs and Conservation (GOSEAC).

The Working Group agreed that such proposals should:

- (i) indicate the extent to which other interested parties have been consulted in the process of producing proposals;
- (ii) be received by the Executive Secretary of CCAMLR for distribution to Members three months prior to the WG-CEMP meeting; and
- (iii) include high-quality topographic and bathymetric maps and charts, and note the exact location of seabird and marine mammal colonies as well as any available information on foraging areas and ranges.

10.8 It was noted that, due to the complexities of the two protected area systems under the Antarctic Treaty and CCAMLR, additional time is required to review and prepare recommendations to revise Conservation Measure 18/IX.

10.9 The implementation of Annex V to the Environmental Protocol to the Antarctic Treaty will involve the redrafting of current management plans for existing protected areas. Thus, CCAMLR is likely to receive several such plans for review and approval in the near future.

10.10 Improved coordination of CEMP site protection within the Antarctic Treaty System is likely to require further communication between the ATCM and CCAMLR, and their relevant subsidiary bodies.

## SUMMARY OF RECOMMENDATIONS AND ADVICE

11.1 The Working Group made the following recommendations to the Scientific Committee:

- (i) that Members not yet active in CEMP and/or not represented by their scientists at CEMP meetings be strongly encouraged to facilitate the participation of their scientists in the work of CEMP (paragraph 3.7);
- (ii) that the Secretariat be asked to print and circulate a set of revisions to the CEMP Standard Methods (paragraph 4.14);
- (iii) that a workshop on the at-sea behaviour of marine mammals and birds be held during the intersessional period following the 1995 meeting of the Commission (paragraph 4.22); and
- (iv) that a concerted effort be initiated to investigate the contrasting characteristics of the biological and physical marine environment in relation to predator performance in Subareas 48.1, 48.2 and 48.3 in 1993/94 (paragraph 7.24).

## ADOPTION OF THE REPORT AND CLOSE OF THE MEETING

12.1 The report of the meeting was adopted.

12.2 In closing the meeting the Convener thanked participants, rapporteurs, subgroups and the Secretariat for their work and assistance during the meeting. Special thanks were extended to the Government of South Africa and the Sea Fisheries Research Institute for hosting the meeting. The pleasant venue and excellent meeting arrangements had enabled the Working Group to progress through its work most efficiently.

12.3 The Convener expressed his view that the work of CEMP was increasingly being recognised as being at the forefront of approaches to managing marine living resources. He congratulated the scientists who had contributed to the development of CEMP over the past 10 years, and he stated his hope that as CEMP enters a new phase of its implementation, it would continue to advance the innovative ecosystem perspective being pioneered within CCAMLR.



12.4 Dr Bengtson informed the Working Group of his wish to step down as Convener of WG-CEMP following the conclusion of the Scientific Committee's 1994 meeting. He noted that the period of five years in which he had served in this capacity was longer than he had expected when originally encouraged to accept this role, and that he felt it was appropriate now for someone else to assume this responsibility.

12.5 The Working Group thanked Dr Bengtson for his great service to WG-CEMP over the last decade and in particular for his outstanding leadership, wise guidance and hard work over the years of his Convenership.

Table 1: Data submission for the 1993/94 season.

Site	Parameter/Species																										
	A1		A2	A3				A5		A6				A7				A8				A9			B1,2	C1	C2
	EUC	PYD	PYD	EUC	PYD	PYN	PYP	PYD	PYN	EUC	PYD	PYN	PYP	EUC	PYD	PYN	PYP	EUC	PYD	PYN	PYP	EUC	PYD	PYN	DIM	SEA	SEA
Anvers Is				USA				USA		USA				USA				USA									
Béchervaise Is		AUS	AUS	AUS						AUS				AUS				USA									
Bird Is	GBR			GBR			GBR			GBR			GBR	GBR				GBR			GBR				GBR	GBR	GBR
Cape Shirreff																											
Magnetic Is			AUS	AUS						AUS				AUS													
Seal Is								USA		USA		USA				USA				USA						USA	USA
Signy Is				GBR	GBR	GBR				GBR	GBR	GBR															
Terra Nova				ITA																							

Species code:

EUC macaroni penguin  
 PYD Adélie penguin  
 PYN chinstrap penguin  
 PYP gentoo penguin  
 DIM black-browed albatross  
 SEA fur seal

Country code:

AUS Australia  
 CHL Chile  
 ITA Italy  
 GBR UK  
 USA USA

Table 2: Assessment of predator and prey studies, 1988 to 1994. Predator parameters were obtained from WG-CEMP-94/16 unless otherwise referenced in the tables. Data are given qualitative rankings High, Medium, Low, Very Low (H, M, L, VL). The symbols +, 0, - indicate changes in parameters between successive years. Foraging duration is expressed as relative length of foraging trips to sea (S = short, M = medium, L = long, VL = very long). Information within the boxes relates to assessments based on the data actually submitted to the CEMP database.

2.1 Site: Anvers Is, Subarea 48.1

Year	Adélie				Krill			Environment			
	Breeding Population Size/Change (A3)	Breeding Success (A6)	Fledging Mass (A7)	Foraging Trip (A5)	Catch		CPUE	Biomass	Snow	Sea-ice	Ocean
					100 km radius	Subarea					
1988		-									
1989		-									
1990		L	L	M							
1991		L	M	L							
1992	H (First census)	H	H	L							
1993	L --	H	H	S							
1994	L - or 0	H	L	M							

2.2 Site: Cape Shirreff, Livingston Is, Subarea 48.1

Year	Antarctic Fur Seal <sup>1</sup>		Chinstrap <sup>2</sup>		Krill			Environment				
	Breeding Population Size/Change		Breeding Success	Breeding Population Size/Change (A3)	Breeding Success (A6)	Catch		CPUE	Biomass	Snow	Sea-ice	Ocean
						100 km radius	Subarea					
1988	L		M									
1989												
1990			L									
1991	M	+	H	?					H			
1992	H	+	H	0					M	+Brash		
1993	H	+	H	0					L	iceberg		
1994	H	+	H	-					L	-		

<sup>1</sup> WG-CEMP-92/53  
WG-CEMP-94/28

<sup>2</sup> *Boletín Antártico Chileno*, Vol. 11 (1): 12-14.  
Unpublished data.

2.3 Site: Admiralty Bay, King George Is, Subarea 48.1

Year	Gentoo		Adélie		Chinstrap		Krill			Environment			
	Breeding Population Size/Change (A3)	Breeding Success (A6)	Breeding Population Size/Change (A3)	Breeding Success (A6)	Breeding Population Size/Change (A3)	Breeding Success (A6)	Catch		CPUE	Biomass	Snow	Sea-ice	Ocean
							100 km radius	Subarea					
1988	M -	M	H +	M	L -	M							
1989	M +	H	H +	H	M +	H							
1990	M -	M	M -	M	M -	L							
1991	L --	M	L --	L	L --	L							
1992	H ++	H	L +	H	M +	H							
1993	H +	H	L -	M	M +	M							
1994	H - or 0	M	L +	H	M +	M							

(This summary table was constructed without reviewing the actual data and may contain source errors)

2.4 Site: Ardley Island and Stranger Point combined, King George Island, Subarea 48.1. Esperanza data used for 1991 for Stranger Point.

Year	Adélie <sup>1</sup> - Ardley		Chinstrap <sup>2</sup> - Ardley		Adélie <sup>3</sup> - Stranger		Krill			Environment			
	Breeding Population Size/Change (A3)	Breeding Success (A6)	Breeding Population Size/Change (A3)	Breeding Success (A6)	Breeding Population Size/Change (A3)	Breeding Success (A6)	Catch		CPUE	Biomass	Snow	Sea-ice	Ocean
							100 km radius	Subarea					
1988	H	H	M	M	L -	H							
1989	H	M	M	H	L -	H							
1990	M	L	H	L	M -	M							
1991	L	M	L	M	M -	L							
1992	M	?	L	M	? +	?							
1993	M	L	L	M									
1994	H +	M	L +	M									

<sup>1</sup> WG-Krill-92/21; WG-CEMP-92/54; Valencia, unpublished data

<sup>2</sup> WG-CEMP-92/54; Valencia, unpublished data

<sup>3</sup> WG-CEMP-92/6; WG-CEMP-92/45

Note 1991 data from Esperanza

2.5 Site: Seal Island, Elephant Island, Subarea 48.1

Year	Chinstrap <sup>1</sup>				Antarctic Fur Seal <sup>2</sup>				Krill <sup>3</sup>			Environment			
	Breeding Population Size/Change (A3)	Breeding Success (A6)	Fledging Mass (A7)	Foraging Trip (A5)	Pups Born Number/Change	Foraging Trip	Pup Growth Rate (C2)	Weight at Age	Catch		CPUE	Biomass g/m <sup>2</sup>	Snow	Sea-ice	Ocean
									100 km radius	Subarea					
1988	M ?	M	H	S	M +	M	M	H							
1989	L -	L	H	L	VL -	?	H	L							
1990	H +	H	M	L	M +	M	L	L				58.6			
1991	M -	L	L	M	L -	L	H	L				26.3			
1992	H +	M	M	M	M +	M	M	H				45.4			
1993	H -	M	M	S	M 0	L	M	M				111.4 <sup>4</sup>			
1994		M	L	M	M 0	M	M	H				8.8			

<sup>1</sup> Data are from the CCAMLR Data Centre and documents WG-CEMP-90/21, 91/11, 91/33, 92/17 and 93/27

<sup>2</sup> Data are from the CCAMLR Data Centre and documents WG-CEMP-89/21, 90/34, 90/41, 91/11, 92/17 and 93/27

<sup>3</sup> Data from document WG-Joint-94/9; <sup>4</sup> Value may be artificially high due to difficulty differentiating between echo signals from salps and krill

2.6 Site: Signy Is, South Orkneys, Subarea 48.2

Year	Adélie		Chinstrap		Gentoo		Krill			Environment			
	Breeding Population Size/Change (A3)	Breeding Success (A6)	Breeding Population Size/Change (A3)	Breeding Success (A6)	Breeding Population Size/Change (A3)	Breeding Success (A6)	Catch		CPUE	Biomass	Snow	Sea-ice <sup>1</sup>	Ocean
							100 km radius	Subarea					
1988	H +	M	L -	H	H ++	H						H	
1989	H 0	L-M	L 0	H	H +	H						H	
1990	M -	L-M	M +	L	H +	L						L	
1991	L --	M	L -	H	M -	H						M	
1992	M +	M-H	L-M +	H	M -	H						H	
1993	M 0	H	M 0	H	H +	M						?	
1994	M +	L	M +	L	H +	L						?	

<sup>1</sup> Murphy *et al.*, unpublished data

2.7 Site: Bird Island, South Georgia, Subarea 48.3

Year	Gentoo					Macaroni						Black-browed Albatross			
	Breeding Population Size/Change (A3)	Breeding Success (A6)	Krill in Diet (A8)	Meal Size (A8)	Fledging Mass (A5)	Breeding Population Size/Change (A3)	Breeding Success (A6)	Krill in Diet (A8)	Meal Size (A8)	Arrival Mass (A1)	Fledging Mass (A5)	Breeding Population Size/Change (B1)	Breeding Success (B2)	Adult Survival (B3)	Growth Rate <sup>1</sup>
1988	M -	M	M	H		M -	L	-	-			L ---	VL	M	-
1989	H ++	M	H	M-H	M	H +	H	M	M	M	H	M ++	M	L	H
1990	H -	L-M	M	M	H	M -	H	M	M	H	M	M 0	M	VL	L
1991	L --	VL	L	L	L	M -	H	L	L	L	M	L-M -	VL	?	M
1992	M +	H	M	M	H	M 0	M	H	H	M	H	L -	M	?	H
1993	M 0	H	H	M-L	M	M 0	M-H	H	M	M	M	L +	H	?	H
1994	L-M -	VL	VL	VL	L	L-M -	M	VL	L	M	L	L -	VL	?	?

Krill				Environment		
Catch		CPUE	Biomass	Snow <sup>2</sup>	Sea-ice <sup>3</sup>	Ocean
100 km radius	Subarea					
				H	H	
				M	M	
				M	L	
				M	L	
				H	M-H	
				M	L-M	
				M	?	

<sup>1</sup> P.A. Prince, unpublished data

<sup>2</sup> Black-browed albatross only

<sup>3</sup> Lunn *et al.* (WG-CEMP-93/10)

2.8 Site: Bird Island, South Georgia, Subarea 48.3

Year	Antarctic Fur Seal <sup>1</sup>								Krill			Environment		
	Pups Born Number/ Change <sup>1</sup>	Birth Mass <sup>2</sup>	Perinatal Period <sup>2</sup>	Foraging Trip (C1)	Pup Growth Rate (C2)	Wean Mass <sup>2</sup>	Breeding Success <sup>3</sup>	Catch		CPUE	Biomass	Snow	Sea-ice <sup>1</sup>	Ocean
								100 km radius	Subarea					
1988	H	0	H	M	S	M	M						H	
1989	H	-	H	M	M	H	M						M	
1990	H	+	H	M	S	L-M	M						L	
1991	L	--	L	S	VL	M	M						L	
1992	M	+	M	M	M	M	M-H						M-L	
1993	H	+	M	M	M-L	M-H	M-H						M-L	
1994	M	-	M	?	VVL	M	L						?	

<sup>1</sup> Lunn *et al.*, in press (WG-CEMP-93/10) and BAS unpublished data

<sup>2</sup> Data from Lunn and Boyd, 1993 (WG-CEMP-92/41), Lunn *et al.*, 1993 (WG-CEMP-93/9), Boyd, unpublished data

<sup>3</sup> Boyd, unpublished data

2.9 Site: Béchervaise Island, Mawson, Division 58.4.2

Year	Adélie							Krill			Environment			
	Arrival Mass (A1)	Incubation Shift (A2)		Breeding Population Size/change (A3)	Breeding Success (A6)	Fledge Mass (A7)	Krill in Diet (A8)	Catch		CPUE	Biomass <sup>1</sup>	Snow	Sea-Ice	Ocean
		1st	2nd					100 km radius	Subarea					
1991		Start		Start	Start		Start					L	M	
1992	Start	0	0	+2	0	Start	0					L	M	
1993	0	-	-	-	0	-	0					Ma	M	
1994		-	-	+	0	+	0					L	L	

<sup>1</sup> WG-Krill-92/23

<sup>2</sup> *Proc. Nat. Inst. Polar Res.*, 6 (1993)

0 = no change

Snow: L = little snow or none; Ma = medium snow during pre-egg stage; Mb = medium snow during chick fledging; H = snow in colony for most of the season

Ice: H = fast ice continuous to horizon late January; M = open water to horizon mid-January; L = late December



**AGENDA**

Working Group for the CCAMLR Ecosystem Monitoring Program  
(Cape Town, South Africa, 25 July to 3 August 1994)

1. Opening of the Meeting
2. Adoption of the Agenda
3. Review of Members' Activities
4. Monitoring Procedures
  - (i) Predator Monitoring
    - (a) Sites and Species
    - (b) Field Research and Data Collection Procedures
    - (c) Data Analysis and Submission Procedures
  - (ii) **Prey Monitoring Data Collection Procedures [joint meeting with WG-Krill]**
  - (iii) Environmental Monitoring
    - (a) Land-based Observations
    - (b) Remote Sensing
5. Review of Monitoring Results
  - (i) Predator Data
    - (a) Status of Data Submissions
    - (b) Report on Indices and Trends
  - (ii) **Review of Available Prey Data [joint meeting with WG-Krill]**
  - (iii) Environmental Data
    - (a) Sea-ice Patterns
    - (b) Other Environmental Events or Trends
6. **Ecosystem Interactions [joint meeting with WG-Krill]**

7. Ecosystem Assessment
  - (i) **[Items from the joint meeting with WG-Krill]**
  - (ii) Updating Ecosystem Assessment Summaries
  - (iii) Advice to the Scientific Committee
8. CCAMLR Policy on Data Access and Use
9. Organisation of Future Work
  - (i) Desirability of Expanding the Scope of CEMP
  - (ii) Future Priorities and Needs of CEMP
  - (iii) **[Items from the joint meeting with WG-Krill]**
10. Other Business
  - (i) IUCN Assessment of Marine Protected Areas
  - (ii) SCAR APIS Program
  - (iii) SO-GLOBEC
  - (iv) Coordination of CEMP Sites Protection within the Antarctic Treaty System
11. Summary of Recommendations and Advice
12. Adoption of the Report
13. Close of the Meeting.

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(Cape Town, South Africa, 25 July to 3 August 1994)

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**REPORTS OF MEMBERS' ACTIVITIES RELATING TO CEMP**

This appendix summarises reports of Members' activities in relation to CEMP that were submitted to this meeting by participants (Argentina, Australia, Chile, Italy, Japan, Republic of Korea, Norway, South Africa, Sweden, UK and USA).

2. During the 1993/94 summer season, Argentina continued developing its ecosystem monitoring program at Stranger Point, King George Island, at Hope Bay in the Antarctic Peninsula and at Mossman Peninsula, South Orkney Islands. The project is under the direction of Lic. Daniel Vergani and is mainly focused on population trends and breeding success of Adélie penguins.

3. During February and March 1994 a cruise mainly focused on demersal fish was conducted around South Georgia Island and the South Orkney Islands. Preliminary information was sent to WG-Krill describing those points that may be of interest for the Working Group.

4. Argentinian studies continued in relation to the use of the blue-eyed shag, *Phalacrocorax atriceps bransfieldensis*, as indicator of changes in coastal fish populations at Duthoit Point, Nelson Island; Low Rocks, King George Island; at Half Moon Island and at Pirie Peninsula, South Orkney Islands. For the next season it is planned to extend the sampling area to Marguerite Bay in the Antarctic Peninsula.

5. Routine monitoring of Adélie penguins was continued by Australia at Béchervaise Island near Mawson. Data on all parameters were gathered manually and by an automatic penguin monitoring system (APMS). Additional studies on the foraging ecology during the breeding season were undertaken using satellite tracking and time depth recorders (TDRs). An additional monitoring site was established on nearby Verner Island. Here human interaction with the birds is being kept to an absolute minimum and monitoring will be conducted using the automated monitoring system. These monitoring and research studies will be continued in 1994/95 and additional studies undertaken on disease and winter foraging of fledglings and adults. Related monitoring studies were conducted at Magnetic Island using an APMS.

6. In 1993/94 a team from the Instituto Antártico Chileno carried out censuses on fur seals at Cape Shirreff and San Telmo Island, which included weighing pups. The counts of animals at Cape Shirreff and San Telmo have been 50 (1966), 1 745 (1973), 8 929 (1987), 10 768 (1992), 13 242 (1993) and 15 139 (1994). Pups were weighed twice during the season (15 December 1993 and 22 January 1994), using CEMP Standard Method C2. On each occasion 48 individuals of each sex

were measured. Average weight for males was 7.20 kg (December) and 10.62 (January). For females it was 6.70 kg (December) and 9.73 kg (January). In addition, environmental parameters were recorded and censuses were carried out on other species of seals (Weddell seals 75, the same number as in 1993; one specimen of both leopard and crabeater seal; and the post-breeding colonies of elephant seals were 526 (1993), and 1 375 (1994) animals). A total of 280 kg of plastic marine debris was collected and sent to Santiago for further studies. Three peripheral males of *Arctocephalus gazella* were seen wearing neck collars. As a support to our field research the Servicio Hidrografico y Oceanografico de la Armada de Chile (SHOA) produced in July 1994 the first draft of a bathymetric chart of waters around the SSSI No. 32 and CEMP site (SHOA Chart No. 14 301, to a scale of 1:15 000).

7. In 1993/94 population studies of seabirds were carried out at Ardley Island; this will be continued during 1994/95. Each October and January the breeding activities of pygoscelids are studied. The numbers of penguin nests at Ardley Island during the 1993/94 season were: gentoo 5 746 (5 336 in 1992/93); Adélie 1 516 (1 120) and chinstrap 58 (38). The total number of nests recorded was 7 320 (6 494 in 1992/93). A map of Ardley Island to a scale of 1:4 000 is being prepared, showing the distribution of all penguin colonies present there. These studies have been conducted by Dr José Valencia, Universidad de Chile, supported by the Instituto Antártico Chileno.

8. Italy is planning to contribute to CEMP through the establishment of a monitoring program on Adélie penguins. This work will be undertaken at Edmonson Point (74°21'S, 165°05'E). A site was chosen for the program in November 1993 and a count of the penguins made according to the CEMP Method A3. A field camp will be established in October 1994. It is planned to obtain data on CEMP parameters A1 to A3 and A5 to A9 according to the standard methods, and in some instances using an APMS. Additionally, studies will be undertaken on foraging ecology (using satellite tracking and TDRs) and on the toxicology of pollutants.

9. Japan continues to monitor the annual trends in breeding population size of Adélie penguins near Syowa Station. In the future, studies on Adélie penguins with emphasis on prey-predator interaction using new techniques will be conducted in the Indian Ocean sector in cooperation with Australia.

10. The timing of hatching and chick growth of gentoo and chinstrap penguins was observed and banding was continued during early December 1993 to late January 1994 near King Sejong Station, King George Island, by the Republic of Korea.

11. TDRs were used for describing the diving behaviour of chinstrap penguins. Dive duration was between 20 and 120 seconds and diving effort was concentrated around midnight with a slight peak around noon. Dive depth averaged 20 to 30 m around midnight and 40 to 50 m around noon.

12. With logistic support from Sweden and South Africa, Norwegian studies of Antarctic petrels were continued in the 1993/94 season at Svarthamaren, Queen Maud Land, by the Norwegian Institute of Nature Research, Trondheim. Counts confirmed that the number of chicks shows great variation between years, increasing again from a minimum in the 1992/93 season. Preliminary results from study plots indicate a recapture probability of 0.90 and a survival probability of 0.95 for adult petrels between the seasons of 1991/92 and 1992/93. The median hatching dates were found to be 12 to 13 January as in previous years. The studies also included collection of stomach content samples and recording of data on adult weights, egg size, hatching success and duration of incubation shifts. Satellite tracking of three breeding birds indicated extremely long distances of travel. Experimental studies of parental investment were continued.

13. Results from satellite tracking and TDR studies of crabeater seals in the Weddell Sea pack-ice in 1993 by the Department of Arctic Biology, University of Tromsø, are now being published.

14. The funding agency for the Norwegian Antarctic Research Program, the Norwegian Research Council, has now been committed to allocate funds for longterm CEMP-related monitoring and research. Plans for a monitoring site for fur seals and chinstrap and macaroni penguins on Bouvet Island, directed studies of crabeater seals in the Weddell Sea and a monitoring site for Antarctic petrels at Svarthamaren, will be developed by the Norwegian Polar Institute during the forthcoming year.

15. Sweden has no CEMP-related monitoring activity. Basic research on king penguins and elephant seals is undertaken in cooperation with BAS (UK); research on crabeater seals is in cooperation with the USA.

16. South Africa commenced monitoring of macaroni penguins and gentoo penguins at Marion Island (Prince Edward Islands) in May 1994 as a contribution to CEMP. In the first year of monitoring, attempts will be made to apply many CEMP Standard Methods for penguins to both species. However, banding of gentoo penguins will not be undertaken, and if certain procedures result in high disturbance of gentoo penguins those methods will be discontinued for that species. Attempts will be made to quantify disturbance to both species of penguin during monitoring in 1994/95.

17. Limited monitoring of rockhopper penguins and imperial cormorants will be undertaken. Ongoing research on albatrosses and southern elephant seals will be continued.

18. United Kingdom land-based research in support of CEMP is conducted at Signy Island, South Orkney Islands and Bird Island, South Georgia. Parameters measured in 1994 were identical

to those recorded in 1992 and 1993 (SC-CAMLR-XI, Annex 7, Appendix D, paragraph 20) and are listed in Table 1.

19. In addition, the detailed demographic studies on grey-headed and black-browed albatrosses and on Antarctic fur seals were continued, and these now provide annual data on population size, adult survival, juvenile survival (recruitment), breeding frequency and breeding success for albatrosses and age-specific fecundity rate, maternal mass, pup birth mass and breeding success for fur seals.

20. Additional directed research (summarised in Table 2) is being carried out on:

- (a) chick growth, foraging trip duration, meal size and at-sea activity budgets of albatrosses, especially black-browed albatross;
- (b) aspects of diving performance and at-sea activity budgets in Antarctic fur seals; and
- (c) activity-specific energy budgets using implanted recorders to measure heart rate and other parameters in gentoo penguins, black-browed albatrosses and Antarctic fur seals.

21. In 1994 substantial additional research, especially on the distribution and foraging of albatrosses and penguins, was carried out in conjunction with the predator-prey cruise of the *James Clark Ross* (see below). Some of the shipboard research involved collaboration with US scientists and the shore-based research benefited from the continuing collaboration with Swedish scientists on research of king penguins.

22. Of papers tabled in 1992, WG-CEMP-92/41 (*Symp. Zool. Soc. Lond.* (1993) 66: 115-129) is now published. Of papers tabled last year WG-CEMP-93/6 (*Ibis* (1994) 136:50-71), 93/7 (*Ornis Scand.*) (1993) 24: 243-245), 93/9 (*J. Mammal.* (1993) 74: 908-919), 93/11 (*J. Zool.* (1993) 229: 177-190), 93/12 (*Mar. Ecol. Prog. Ser.* (1992) 86:15-30), 93/13 (*J. Anim. Ecol.* (1993) 62: 551-564) and 93/14 (*Mar. Mamm. Sci.* (1993) 9: 424-430) are all published. WG-CEMP-93/8 (*Penguin Biology Symposium*) and 10 (*J. Anim. Ecol.*) are still in press.

23. Six papers concerning predators are tabled this year. WG-CEMP-94/12, describing the identification of different types of foraging activity of Antarctic fur seals and interannual variation in these, has already been widely circulated as part of the review of data for TDR-based studies. WG-CEMP-94/11 shows that Antarctic fur seal foraging trip duration is negatively correlated with the rate of milk energy production at sea, but positively correlated with subsequent milk energy production

on land. WG-CEMP-94/13 describes progress towards using heart rate as an activity-specific index of energy costs, using data for black-browed albatrosses. WG-CEMP-94/14 reports on the diet of white-chinned petrels at South Georgia showing that this combines krill, myctophid fish and squid (particularly *Martialia*). Studies of white-chinned petrels, therefore, may have considerable potential for integrating with CCAMLR research on currently and potentially exploited resources. WG-CEMP-94/15 reviews interannual variation in the diet of Antarctic prions, suggesting that this closely reflects variation in the relative abundance of krill, amphipods and copepods. Again, studies of this species have significant potential for enhancing CEMP research. WG-CEMP-94/10 paper presents model analyses of the interaction of predators with a prey resource being advected by ocean currents past a central colony.

24. During January and February 1994 a series of research projects was undertaken on board RRS *James Clark Ross* (Scientist in Charge: Martin White) in the vicinity of South Georgia. Larger-scale studies were conducted during transects between South Georgia, South Orkneys and Falkland Islands and across the Polar Front. Shipborne observations were made by scientists from BAS in conjunction with others from USA, Spain and Germany. Part of the cruise was undertaken with the South African research vessel *Africana* (Scientist in Charge: Denzil Miller). This work was part of a major cruise undertaken by the Pelagic Ecosystem Studies group at BAS. Areas of interest were identified by linking data from satellite-tracked predators with information on large-scale bathymetry and remotely-sensed surface data. The large-scale studies undertaken during the cruise were part on an ongoing study of large-scale variability of the Southern Ocean ecosystem.

25. Studies on the pelagic trophic interactions in a system dominated by ommastrephid squid at the Antarctic Polar Frontal Zone were undertaken along with concurrent observations on feeding aggregations of seabirds. Throughout the cruise krill were found to be scarce, providing valuable opportunities for observing predator-prey interactions in a 'poor' krill year and for setting this in the context of the large-scale studies. Observations were made of foraging aggregations of seabirds and mammals associated with krill aggregations.

26. United States activities in 1993/94 directly related to CEMP consisted of:

- (i) land-based predator studies at Seal Island, near Elephant Island, and at Palmer Station, Anvers Island;
- (ii) repeated surveys of hydrographic conditions, phytoplankton production, and krill abundance and distribution in the waters surrounding Elephant Island; and
- (iii) analyses of data on crabeater seal demographics, and ecology.

Preliminary reports on activities (i) and (ii) are provided in the AMLR field season report, WG-CEMP-94/37.

27. At Seal Island, monitoring according to CEMP Standard Methods and directed research in support of CEMP objectives were conducted on populations of Antarctic fur seals, chinstrap penguins, macaroni penguins and cape petrels. Field procedures were conducted for Standard Methods A4, A5, A6 (procedures A and C), A7, A8, A9, C1 and C2. In addition, directed research was conducted on foraging ecology and at-sea behaviour of fur seals and penguins, penguin breeding population size and penguin chick growth. An automated, land-based system for tracking seals and penguins to determine foraging locations was further developed and tested.

28. Two 30-day cruises were conducted aboard the NOAA ship *Surveyor* from mid-January to mid-March 1994 in the vicinity of the Seal Island CEMP site near Elephant Island. Chlorophyll *a* concentrations, primary production rates, organic carbon concentrations, phytoplankton species compositions, nutrient concentrations, and solar irradiance were measure and mapped. In addition, the distribution and abundance of krill were measured using sampling nets and hydroacoustic instrumentation.

29. Analyses and manuscripts were completed for studies of interannual variability in cohort strengths of crabeater seals and of the distribution and movements of crabeater seals relative to sea-ice and the continental shelf/slope break.

30. In support of the NSF's LTER Program, two oceanographic cruises were conducted by the NSF ship *Polar Duke* in August 1993 and January 1994. Primary production rates, chlorophyll *a* concentrations, organic carbon concentrations, microbial production rates, nutrient concentrations and irradiance were investigated in an area from Palmer Station to Rothera Station. Krill distributions were measured using nets and acoustic instrumentation. Seabird surveys were conducted and Adélie penguin diet samples were collected in the Palmer Station area.

31. Anticipated CEMP-related field work in 1994/95 will include continued penguin and fur seal monitoring and directed research at Seal Island and penguin monitoring at Palmer Station. A collaborative cruise with Japanese scientists aboard the RV *Kaiyo Maru* will be conducted near Elephant Island to investigate predator/prey interactions among Antarctic krill and its marine mammal and bird predators. Shipboard surveys of hydrographic conditions, phytoplankton production, krill distribution, abundance and demography will be conducted around Elephant Island. In addition, the LTER Program will continue to conduct research similar to that conducted this year.

**REPORT OF THE WG-CEMP *AD HOC* SUBGROUP ON  
THE DESIGNATION AND PROTECTION OF SITES**

The *Ad Hoc* Subgroup on the Designation and Protection of Sites, consisting of Drs K. Kerry (Australia), P. Penhale (USA) and D. Torres (Chile), was charged with three tasks during the intersessional period: (i) to provide comments on the joint proposal by Brazil and Poland to the ATCM for an Antarctic Specially Managed Area (ASMA), Admiralty Bay, King George Island; (ii) to consider appropriate procedures to deal with draft management plans received from the Contracting Parties to the Antarctic Treaty; and (iii) to consider to what extent to revise the provisions of Conservation Measure 18/IX so that they correspond to the provisions of Annex V to the Protocol on environmental protection to the Antarctic Treaty.

(i) Comments on the Admiralty Bay ASMA Proposal

2. At its last meeting the Commission asked the Scientific Committee and its Working Groups to review the draft management plan for Admiralty Bay. This plan had been prepared by the Delegations of Brazil and Poland as CCAMLR-XII/BG/13 (CCAMLR-XII, paragraph 10.9) as an ASMA in accordance with Annex V to the Protocol. It was submitted to the Commission for its consideration as would be required under Article 6 (2) of Annex V to the Protocol once the Protocol came into force.

3. It was noted by the *ad hoc* subgroup that the joint proposal had been referred to the SCAR Group of Specialists on Environmental Affairs and Conservation (GOSEAC) for consideration and subsequent review and re-drafting by SCAR. Given also that the Protocol is not yet in force, the proposal must be considered as preliminary and likely to be subject to change.

4. Many nations are known to be working in the region detailed in the proposal, yet it is not clear from the document what degree of consultation has taken place among those parties and whether or not their interests have been taken into account.

5. It was noted that the protection of seabird and mammal colonies and the known foraging areas of the various species in the area are of particular interest to CCAMLR. To this end, more detailed, annotated maps and marine bathymetric charts, where available, would have improved the document.



(ii) Procedures to Deal with Draft ATCP Management Plans

6. With regard to procedures to deal with such management plans, it was recommended that the draft Antarctic Specially Protected Areas (ASPAs) and ASMAs which include marine areas should be received by the Executive Secretary for transmission to all Members of the Commission at least three months prior to consideration by WG-CEMP (similar to procedures in Conservation Measure 18/IX).

7. It was noted that the review by the *ad hoc* subgroup and by WG-CEMP would be facilitated by the receipt of any guidance that has been provided by ATCM bodies to the originators of the proposal and is available prior to the meeting of WG-CEMP.

8. The provision of the following information *inter alia* is considered to be important to CCAMLR in its assessment of any ASMA or ASPAs.

- (i) Locations of all colonies of birds and seals, including points of entry into and departure from the sea.
- (ii) The areas in which vertebrate species, associated with or breeding in the proposed management area, are known to forage.
- (iii) The location of sites where monitoring studies are being undertaken in support of CEMP. This should be irrespective of whether or not the site has been formally declared a CEMP site under Conservation Measure 18/IX.

9. It was noted that in order to review the proposals fully, the inclusion of high quality topographic maps and bathymetric charts is critical. The exact location of seabird and marine mammal colonies, as well as any available information on foraging areas and ranges, is an important element for consideration.

(iii) Possible Revisions to Conservation Measure 18/IX

10. The extent to which it might be appropriate to revise the provisions of Conservation Measure 18/IX was considered. In order to facilitate a comparison of the management plans for CEMP sites and ASPAs, the Science Officer had prepared a comparative table of management plan elements (WG-CEMP-94/9).

11. The *ad hoc* subgroup noted the usefulness of this table, and provided additional annotations and revisions to the table for future reference. A number of similarities and differences were noted in the comparison between elements of both management plan systems.

12. In order to improve consistency, several revisions to Conservation Measure 18/IX, Annex A, may be appropriate.

13. A general area of inconsistency of detail concerns restrictions on material and organisms which may be brought into an area and the collection or removal of anything not brought into an area by a permit holder or visitor.

14. Another example of inconsistency is that the Antarctic Treaty System management plan system includes provisions for site inspections and reports thereof, while the CEMP management plan does not. Additional examples may be found.

15. It was considered that due to the complexities of the two protected area systems, additional time was required for the review and the preparation of recommendations for revision of Conservation Measure 18/IX.

(iv) General Comments

16. It was observed that the implementation of Annex V to the Protocol involves the re-drafting into the ASPA and ASMA format of current management plans for existing protected areas under the agreed measures for the conservation of Antarctic fauna and flora. Thus, CCAMLR may expect to receive several such management plans for review and approval in the near future.

17. It was also noted that concern was raised during ATCM XVIII regarding the possible use of mandatory prohibitions within the management plans for ASMAs. It was noted (ATCM XVIII, paragraphs 110 and 111) that clarification of this point would be necessary before designating any ASMAs under Article 6 of Annex V of the Protocol.

18. Improvement of coordination of CEMP site protection within the Antarctic Treaty System is likely to require further communication between the ATCM and CCAMLR and their scientific advisory bodies.

**REPORT OF THE JOINT MEETING OF THE  
WORKING GROUP ON KRILL AND THE WORKING GROUP  
FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM**

(Cape Town, South Africa, 27 July to 2 August 1994)

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INTRODUCTION

1.1 The second Joint Meeting of the Working Group on Krill (WG-Krill) and the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP) was held at the Breakwater Lodge, Cape Town, South Africa, between 27 July and 2 August 1994, and was chaired by the Chairman of the Scientific Committee, Dr K.-H. Kock.

MEETING OBJECTIVES

2.1 The Chairman outlined the meeting objectives:

The Joint Meeting has as its primary objective the facilitation of interaction between WG-Krill and WG-CEMP on matters of common concern. This should be primarily directed at the development of an ecosystem approach to management (SC-CAMLR-XII, paragraph 15.4). Specific items identified by the Scientific Committee for consideration include:

- the development of appropriate proposals for models to evaluate the statistical performance and cost-effectiveness of possible experimental harvesting regimes designed to distinguish between natural variation in predator performance and effects due to fishing (SC-CAMLR-XI, paragraph 6.10);
- the review of the scope of CEMP monitoring with respect to species (both predators and prey) being monitored (SC-CAMLR-XII, paragraphs 8.13 and 8.14);
- the presentation of (i) fine-scale data from fisheries within 50 and 100 km of CEMP sites, (ii) indices of krill availability to the fishery, product quality and catch length composition, and (iii) indices of krill cohort strength and recruitment derived from length frequency data (SC-CAMLR-XII, Annex 6, paragraphs 5.33 and 5.34) in such a way as to indicate the extent to which reliable indices are actually, or potentially, available (SC-CAMLR-XII, paragraph 8.22);

- making progress on linking predator-derived indices to conventional management approaches being applied to the krill fishery (SC-CAMLR-XII, paragraph 8.29); and
- discussion of the implications of existing and projected analyses of models addressing functional relationships between krill, predators and fishery (SC-CAMLR-XII, paragraph 8.41).

2.2 The Agenda was discussed and proposals were made for amendments. Sub-item 2(iii), dealing with fisheries activities, was included. A presentation by the Convener of CEMP was included as sub-item 3(ii). With these amendments the Agenda was adopted.

2.3 The Agenda is included in this report as Appendix A, the List of Participants as Appendix B and the List of Documents submitted to the meeting as Appendix C.

2.4 The report was prepared by Drs D. Agnew (Secretariat), I. Boyd (UK), Prof. D. Butterworth (South Africa), Drs J. Croxall (UK), R. Holt (USA), T. Ichii (Japan), V. Marín (Chile), S. Nicol (Australia), E. Sabourenkov (Secretariat) and V. Siegel (Germany).

2.5 Fisheries activities were summarised by the Chairman. The total krill catch in the season 1993/94 was 82 600 tonnes and was concentrated in Statistical Area 48. The fishing pattern had been similar to previous seasons; a winter fishery took place in Subarea 48.3 and moved to Subareas 48.1 and 48.2 in summer. The fishery in Subarea 48.1 took place later in the summer, with highest catches taken in March/April. Only about 1 000 tonnes were taken in the Indian Ocean (Division 58.4.1), all by Japan.

## PREY MONITORING

### Data Collection Procedures

3.1 Prey monitoring undertaken using acoustics and net sampling was reviewed.

3.2 Considerable progress has been made in recent years with the development and validation of acoustic techniques. Individual or groups of targets can now be discriminated on a fine scale, and estimates of target strength have been refined. The latter may be obtained from (i) dense aggregations by echo integration followed by trawl haul to determine density, or (ii) dispersed aggregations by direct *in situ* measurement using dual- or split-beam echo sounders. In both cases net sampling is necessary for precise target identification and measurement of length distribution.

Behavioural effects associated with net sampling, e.g., avoidance, must be considered. Another problem still to be resolved is the acoustic estimation of krill near the surface.

3.3 Acoustic differentiation of krill and salps is possible in some cases by measurement at two distinct frequencies. The most commonly used single frequency is 120 kHz and this is often supplemented by measurement at 38 or 200 kHz.

3.4 Much work has been undertaken on the design of acoustic surveys. The appropriate design depends on a survey's purpose. A number of example designs have been set out in the Report of the Subgroup on Survey Design (SC-CAMLR-X, Annex 5, Appendix D). In addition, the matter has been investigated intersessionally by WG-Krill in accordance with SC-CAMLR-XII, paragraph 2.41. A major discussion topic is the relative merits of spacing transects uniformly, which maximises spatial information, as opposed to random spacing which is required for the calculation of the variance of a biomass estimate using classical statistics.

3.5 A review of world-wide studies relevant to the topic of birds as indicators of change in marine prey stocks was tabled as WG-Joint-94/13. Many aspects of this review are relevant to CCAMLR, and especially CEMP, approaches to this subject.

3.6 Results of studies by French scientists around the Kerguelen Islands (Division 58.5.1) showed good correspondence between the abundance and certain characteristics of zooplankton (mainly *Euphausia vallentini* and *Themisto gaudichaudii*) in gentoo penguin diet and in simultaneous net hauls (WG-Joint-94/11).

3.7 It was pointed out that none of the above techniques addressed the problem of collecting data on krill distribution and abundance in ice-covered areas.

## Review of Available Data

### Krill Biomass Estimates in the Integrated Study Regions (ISRs)

3.8 The latest information concerning the biomass estimates of krill from within ISRs is contained in the WG-Krill report (Annex 5, paragraphs 4.45 to 4.50).

3.9 In considering the availability of krill biomass estimates within ISRs, the meeting noted that boundaries for each of the three ISRs enclosed a large area. The boundaries of each ISR were originally drawn to indicate the regional areas of importance to CEMP. They were chosen *inter alia*

as regions where the harvest of krill had taken place, krill surveys had been undertaken, and which were presumed to encompass important foraging areas of the predators to be monitored (see SC-CAMLR-V, Annex 6, paragraphs 11 and 12).

3.10 The meeting accepted that these boundaries were useful in the above context, but in doing so emphasised that it may not be necessary to conduct krill surveys over the whole of these regions.

3.11 The meeting noted that the application of new technology, e.g., satellite tracking and the use of time/depth recorders, has and will provide a better understanding of the foraging ranges and patterns of krill predators. This in turn should allow better definition of areas where krill surveys are required in the future, based upon the foraging areas of predators.

#### Fine-scale Catch Data

3.12 Fine-scale catch data for the 1992/93 season were presented in WG-Krill-94/6. The pattern of winter fishing at South Georgia followed by late summer fishing around the Peninsula was similar to that observed in previous years. It was noted that catches had been taken outside the Convention Area (in Division 41.3.2) and that these had initially been reported on STATLANT forms as having been taken in Subarea 48.1.

3.13 It was pointed out that there was a fairly consistent increase in the percentage of the krill catch taken after March in Subarea 48.1 over a 10-year period. This was caused by fishing vessels starting later and staying longer in the area. Both Chile and Japan indicated that the late start was due to operational reasons.

#### Fine-scale Surveys

3.14 It was noted that carefully integrated studies of krill surveys and predator foraging were being undertaken annually by the USA (WG-CEMP-94/37) near Seal Island (Antarctic Peninsula ISR) and by the UK within the South Georgia ISR.

3.15 Additional krill biomass data from ISRs in Prydz Bay (WG-Krill-94/21 and 34) and the South Shetlands (WG-Joint-94/9) were presented. In neither of these areas did the surveys cover the whole ISR. The group warned of the problems of comparing biomass estimates from different-sized areas; krill density was deemed to be more appropriate for such comparisons.



3.16 In Prydz Bay, bias in acoustic estimates of biomass and distribution of *Euphausia superba* could arise from the co-occurrence of *E. crystallophias*. However, it is likely that the two euphausiid species can be differentiated by spatial separation, samples from net hauls and different acoustic signatures on the echo-trace. Complete differentiation between these species may not be necessary for some purposes because some predators tend to eat both species.

3.17 Paper WG-Joint-94/9 reported that the mean density of krill around Elephant Island had not changed markedly over four surveys in 1993/94, but that the distribution of krill around the island showed great variation. More importantly, the average density of krill was five times lower than the densities in the preceding four years. It was concluded that methodological variation was not responsible for the annual changes in density. In addition to low densities, a skewed age structure with a lack of young krill was observed.

3.18 In addition to the results presented in WG-Joint-94/9, it was known that surveys had been carried out by the UK around South Georgia and the South Orkneys, by South Africa around South Georgia, and by Argentina around South Georgia. Analyses of the results of these cruises were still being undertaken. The group hoped that these analyses would be presented at the next meeting.

#### PREDATOR MONITORING

3.19 The Convener of WG-CEMP provided a brief overview of predator monitoring being undertaken within CEMP. The main function of predator monitoring is to provide the Scientific Committee with information on dependent species within the ecosystem. To achieve this, predators, prey and environmental conditions are being studied. In particular, changes in predator performance are to be considered in light of prey and environmental changes.

3.20 Two types of work are carried out under CEMP. Firstly, directed research produces data on, for instance, predator behaviour at sea, foraging behaviour and bio-energetics. Secondly, monitoring of a number of variables, such as reproductive performance and environmental conditions produces comparable longterm data sets from different sites for a suite of predators consuming krill, *Pleuragramma antarcticum* and *E. crystallophias*. Four sites in three ISRs have been the source of data over a period of five years.

3.21 Protocols for the collection and submission of CEMP data have been set up and predator indices are calculated annually by the Secretariat. Special attention is being given to the potential impact of local fisheries and functional relationships between krill availability and predator performance.

3.22 It was noted that investigating the location and timing of likely predator/prey interactions was important. Predator indices operating over restricted time and space scales, such as foraging duration, provide valuable information about sensitivity of predators to prey availability and environmental conditions. In addition, there is an important link between vertical distribution of krill and diving depths of predators.

3.23 Within CEMP certain types of environmental data, relating to weather conditions at monitoring sites and to the location of ice at sea near these sites, are collected using standard methods. No proposals have yet been made for the collection of any other physical or biological environmental data (e.g., that may relate to the distribution, abundance and availability of prey).

## ECOSYSTEM INTERACTIONS

### Distribution of Krill Fishing and Predators

4.1 Paper WG-Joint-94/17 presented a revised assessment of the impact of the krill fishery on penguins in Subarea 48.1 (WG-Krill-93/7) based on Japanese 'finer scale' catch data (10 x 10 n miles). The paper took into account the detailed spatial distribution of the fishery, likely foraging areas and foraging depths of predators and available information on krill biomass, current fields and sea-ice distribution in the South Shetland region. The authors concluded that the present fishery is unlikely to have an adverse impact on the penguin populations for the following reasons:

- (i) the spatial overlap between the main fishing and foraging areas is low;
- (ii) the overlap between trawling depth and foraging dive depth of penguins was also not substantial;
- (iii) a difference between size distribution of krill caught by trawlers and penguins was observed; and
- (iv) the current catch by the krill fishery is very low compared with the local krill biomass.

4.2 The group welcomed this analysis which represented the most detailed attempt so far to investigate interactions between penguins, fisheries and krill at this particularly appropriate scale.

4.3 However, a number of reservations were expressed concerning aspects of the approach and interpretation in WG-Joint-94/17:

- (i) any analysis of spatial and temporal overlap between predators, krill and fisheries that does not incorporate the known or potential effects of krill flux cannot resolve the true nature of the impact of krill fisheries on predators. In this context, it was noted that extensive empirical data on currents, additional to those used in WG-Joint-94/17, exist for the Bransfield Strait/South Shetland Islands area;
- (ii) it had already been noted that the data on penguin diving depths used in WG-Joint-94/17 were not necessarily spatially concurrent with the krill data (SC-CAMLR-XII, Annex 6, paragraphs 6.11 and 6.12). In any case, any assessment of vertical differences between foraging strata of penguins and trawler fishing depth needs to recognise that diel vertical movements of krill may result in penguins and fisheries simply exploiting the same swarm of krill, even if at different depths and times; and
- (iii) the feeding studies presented suggested that the trawl fishery was capable of taking all size classes of krill eaten by penguins. The topic of size, sex and maturity stage selectivity of krill taken by penguins and fisheries was an important one for further investigation.

4.4 The group agreed that pursuing the question of the interaction of predators and the fishery was of great importance to CCAMLR. This question can be considered at many different scales, from whole subarea population interactions to individual foraging interactions, and it was agreed that research at all scales would be important.

4.5 However, it was agreed that it was equally important that collection of any data should be accompanied by theoretical work establishing how such data could be used in management. In particular, given that interpretations of present data (e.g., arising from WG-Joint-94/17) in regard to the impact of the fishery on predators are ambiguous, it was essential that future recommendations by the group for data collection should be evaluated to determine what additional observations are required to resolve the ambiguities.

4.6 At larger scales, the group encouraged continuation of modelling studies such as WG-CEMP-94/10 and 30 which examined the combined effects of fishing and krill flux on krill density in predator foraging areas (see paragraphs 4.37 to 4.39 for further discussion). It was noted that further breakdown of flux calculations at finer scales more relevant for predators may be required.

4.7 In considering this, the group acknowledged that there was considerable work still to be done in refining the estimates of krill flux at the scales currently being used, and in acquiring new data

sets (Annex 5, paragraph 4.13). It was agreed that in the course of this work it was likely that a number of data sets applicable to calculation of krill flux at finer scales would become available, and, as appropriate, fine-scale investigation of flux could be made.

4.8 At smaller scales, it was suggested that studies of predator foraging should be continued to investigate detailed behavioural interactions between krill predators and their prey. In this context it was noted that three-dimensional descriptions of the prey field as presented in WG-Joint-94/12 were an innovative method of assessing krill availability to penguins.

4.9 Such studies within CEMP may contribute to the development of quantitative expressions of predator/prey interactions (see e.g., WG-CEMP-94/12) through refinement of appropriate models of functional relationships and through the development of indices of predator performance. In order for such studies to be most useful, observations of predator foraging and prey distribution should be obtained at the same place and time.

4.10 The Data Manager reminded the meeting that for the last few years the Secretariat has been asked to report the catches of krill within a 'critical foraging period-distance', defined as being within 100 km of predator colonies over the period December to March. Following the discussions at the 1993 meetings of WG-CEMP and WG-Krill, the Secretariat has taken this work forward to develop a calculation of a generalised index of predator - fishery overlap (WG-Joint-94/8). This work is in a preliminary stage, but is formulated such that predator demand in any defined area can be calculated, given species-specific foraging characteristics and energetic demands, and used together with catch data to calculate an index of the overlap between predators and the fishery taking account of the functional interaction between the two rather than the arbitrary calculations which are currently performed.

4.11 The group welcomed this initiative. It was considered, however, that the work on interaction between predators and the fisheries, as investigated in both WG-Joint-94/8 and 17, had been taken as far as possible for the moment. Further work on updating these analyses was encouraged but not considered to be a priority at this time.

4.12 In the light of these discussions, the Secretariat was requested to continue to calculate the catch of krill taken in the critical period-distance rather than provide further refinements to the model described in WG-Joint-94/8.

4.13 Given the importance that the group attached to this topic, and the comments and ongoing work outlined in paragraphs 4.3 to 4.9, it was recommended that a discussion on the full implications of these studies be held at a future meeting.

## Potential Effect of Precautionary Measures

4.14 In 1992 the Scientific Committee requested the Data Manager to develop a model which would examine the effects of various management strategies on the krill fishery in Subarea 48.1. This model was presented last year as WG-Krill-93/14. As a result of comments by both WG-Krill and WG-CEMP in 1993 the model had been further developed to increase model realism and was presented to this meeting as WG-Joint-94/4.

4.15 The model now uses catch and effort data from both the Chilean and Japanese fleets to estimate the probability of encountering a fishable swarm. This probability is applied to data on fishing duration, fleet size and CPUE to calculate an estimated total catch in each of a number of fine-scale squares. The estimated numbers of penguins foraging in each of these squares is used to calculate a 'disturbance index'. The success of management scenarios is assessed according to their ability to minimise the disturbance index whilst maximising catch. The most successful scenario studied was found to be one which restricted fishing within 75 km of breeding penguins during January and February. This resulted in a 90% reduction in overlap with foraging predators and a 15 to 20% reduction in catch.

4.16 These developments in the model were welcomed by the group. Although a number of parameters are probably poorly estimated (for instance the form of the encounter probability), and the criteria for assessing performance are difficult to define, the overall structure of the model appears appropriate for estimating the impact of management measures on an established fishery. However, there were some concerns about the relationship of the model to the operational requirements of fishing.

4.17 The group recommended that further development of the model by the Secretariat was unnecessary at this stage, but encouraged interested parties to proceed with validation of the model and come forward with proposals for parameter re-definitions. For instance, the incorporation of fisheries independent information to refine some of the parameters was suggested. Development of alternative models was also encouraged.

## Krill/Predator Functional Relationships

4.18 The Chairman drew the attention of the meeting to paragraphs 5.12 to 5.21 of the 1993 report of WG-Krill (SC-CAMLR-XII, Annex 4), paragraphs 7.11 to 7.39 of the 1993 report of WG-CEMP (SC-CAMLR-XII, Annex 6) and paragraphs 2.54 to 2.57 of the 1993 report of the Scientific Committee (SC-CAMLR-XII). These referred to the need for more information about the effects of

krill fishing on predator populations. Attention was drawn to papers WG-Krill-94/24 and 93/43 which describe ongoing developments of a modelling approach to address this question.

4.19 Dr Butterworth explained the fundamental features of the model described in WG-Krill-94/24, emphasising the general and preliminary nature of the approach and that it would not be in the interests of the progressive development of the model to introduce too much complexity at this early stage. He reminded the meeting that an important finding of WG-Krill-93/43, reported last year, was that natural fluctuations in krill biomass make predator populations less resilient to krill fishing than deterministic evaluations would suggest.

4.20 WG-Krill-94/24 extended this work by attempting to estimate the parameters of functional relationships by using mean, variance and skewness of the observed distributions of predator survival rates and by incorporation of a term to relate these rates to the availability of krill rather than their abundance over a large area. The statistic developed to indicate the impact of krill fishing on the predator population under the model was expressed as the intensity of krill fishing which was required in order to halve the average predator population present in the absence of a krill harvest. Intensity of krill fishing was expressed as the fraction of a biomass estimate which could be set for harvest. The results suggested a surprising sensitivity of the predator populations to the harvesting of krill.

4.21 It was clear that the model had not produced realistic results in some cases (e.g., it was indicated that some species were unable to sustain themselves even in the absence of a krill fishery). Contributors of the predator data noted that this was possibly partly due to the values which had been used for juvenile survival in fitting the model. They suggested that better account should be taken of the age-dependence of survival rates where this could be estimated from data. One of the weaknesses of the approach was that the distributions of predator survival rates are not well known; even the most extensive data set, for black-browed albatrosses, contains only 15 values (one for each year), although it was acknowledged that a very substantial and sustained effort has been necessary to collect such a time series. However, it was also acknowledged that the distribution of krill biomass is even less well defined, being based upon model predictions rather than direct observations.

4.22 Even so, there remains a case for concentrating attention, by means of this modelling approach, on the predators which seem likely to show the greatest sensitivity to krill harvesting. The group noted that one of the purposes of the modelling exercise was to focus attention on the specific data needed to refine functional relationships between predator populations and their prey.

4.23 There was some discussion of the mathematical form assumed for the functional relationship between predator survival and krill biomass. There were questions as to how, with the small estimate predicted for interannual variability in krill biomass by the krill dynamics model, it was possible to derive reliable estimates of functional relationships outside this range. It was noted that many different mathematical functions could provide a reasonable representation of the survival rate data over this biomass range, but would nevertheless have very different implications for assessments of predator resilience which depended on extrapolation beyond this range. However, this extrapolation process was somewhat assisted by making further plausible assumptions: for example, that survival rates would tend to be zero for low krill biomass for a predator dependent almost entirely on krill, and would show asymptotic behaviour in the case of large krill biomass. In addition, based purely on broad ecological principles involving predators exploiting patchily-distributed prey, one would expect functional relationships of the type illustrated in WG-Krill-94/24.

4.24 The possibility of examining the functional relationship between predator survival and krill biomass directly, rather than attempting to use distributions predicted from models, was addressed. Unfortunately, although there are sufficient years (up to 20) of predator data to contribute to such an analysis, the available time series of estimates of krill biomass are much shorter (about three years, depending on location), which precludes such a direct approach.

4.25 Further discussion of the problems and technical details of the model was referred to a subgroup. This group examined four key questions: (i) whether survival data for predators had been interpreted correctly; (ii) whether the shapes assumed for the functional relationships were realistic; (iii) whether the method of modelling errors was realistic; and (iv) whether the simple empirical way in which density-dependence was introduced in the model for the predator dynamics was appropriate. The results of these discussions, which were subsequently reported to the Joint Meeting, are set out below.

4.26 It was explained that the first year survival rate values used had been derived from the fledging rates and the pup mortality rates for black-browed albatrosses and Antarctic fur seals respectively. Thereafter, in the absence of anything better, the average adult survival rate had been used even for the juvenile year classes. There are problems when applying this approach to Antarctic fur seals and black-browed albatrosses and this probably explains some of the unrealistic results of the model. Potential solutions to the problem were discussed and it was agreed that further bilateral discussions between the relevant parties would take place intersessionally on this subject.

4.27 There were some concerns regarding the functional relationship between the juvenile survival rate of predators<sup>1</sup> and krill biomass (e.g., WG-Krill-94/24, Figures 2i and 2ii). Dr Butterworth explained that juvenile survival rate would be expected to be a still-increasing function of krill biomass in the region of median krill biomass in the absence of exploitation. As harvesting depletes krill biomass, it is the behaviour of the relationship below rather than above this median value which is important.

4.28 There was further discussion of the shape of the functional relationship. It was agreed that a logistic model for the functional relationship would be most appropriate because it could accommodate a variety of shapes and, in particular, could represent a sharp drop in predator survival with declining krill biomass. Attention was drawn to the need to test robustness of results to a variety of slopes, which could have different implications for estimates of predator resilience to krill fishing.

4.29 The question of modelling errors was discussed briefly. Dr Butterworth outlined the necessity for dealing with errors within the structure of the model, which arises because whenever a model is fitted there will not be exact agreement with the observed data. The group considered that the estimation procedures of WG-Krill-94/24 are probably reasonably sound, and that the greatest variability ('error') would arise in the relationship between krill availability and krill biomass. It was emphasised that having only 15 years or fewer of data for some of the predator species would necessarily result in relatively imprecise estimates and, further, that some of the estimates of predator survival rate had fairly wide confidence intervals. It would be necessary to find some way of incorporating this information into the procedure for estimating the resilience of the predator populations to krill harvesting.

4.30 Finally, the equations used for modelling density-dependence (WG-Krill-94/43, equation 3) were considered. Overall, the meeting believed that this was probably the most appropriate approach as it followed conventional population dynamics models in its broad structure. There was some discussion about the appropriateness of assuming the density-dependent component to be linear. There may be value in examining the robustness of results to both concave and convex forms for this function.

4.31 The problem of the necessary levels of escapement from a krill harvest from a predator perspective was considered (WG-Krill-94/11 and WG-Krill-93/43). It was emphasised that 'escapement' did not mean the biomass of krill available after krill harvest (for possible consumption

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<sup>1</sup> 'Juvenile survival rate' in this model reflects all processes relating mature females to the number of their female offspring which survive to the end of their first year of life, i.e. pregnancy or laying rate, the fraction of births that are female, and survival over the first 12 months of life.



by predators), but rather the level to which krill would be reduced, under a steady harvest, as a fraction of its average pre-exploitation level.

4.32 The group noted that placing nominal bounds on the acceptable levels of escapement had proved to be useful in developing precautionary measures within fisheries management in the past. Usually this level is taken to be about 0.5 in a single-species fishery context, which ignores dependent and related species in contrast to the dictates of Article II. At the other extreme, the best situation for the predators is clearly provided by a value of 1.0 (i.e., no krill fishing). It was suggested that, as a starting point in the absence of more quantitative assessments of predator responses to different levels of escapement, it may be appropriate to specify a target escapement level of 0.75, being intermediate between the 0.5 and 1.0 'extremes'.

4.33 The group recognised that it was very difficult to determine the levels of escapement required to sustain predator populations without knowledge of the krill biomass available to predators. However, there was no fundamental objection to using an escapement target of 0.75 as a point from which to start making management recommendations; this target value could be revised in future in the light of new information both from the models currently being developed and from predator data.

4.34 The possible effects of prey selectivity by predators on age-dependent natural mortality of krill have been highlighted by WG-Krill (Annex 5, paragraph 4.56). Results in WG-Krill-94/23 suggest that the krill yield estimation model may be particularly sensitive to krill age-dependent mortality (the present model assumes krill natural mortality to be constant with age). Information on prey size selectivity by predators is sought from WG-CEMP.

4.35 This matter was referred to a subgroup for further discussion. This group concluded that, because many of the more important seabird and seal predators of krill chiefly consumed substantial amounts of 2+ year classes of krill, the matter warranted further investigation. As an initial step, some broadly representative krill length frequency data derived from predators would be sent to Drs Butterworth and Thomson (for comparison with the krill dynamics model predictions) by Drs Ichii, Boyd, Croxall, Bengtson, Marín, Trivelpiece and Kerry.

4.36 The meeting then considered other models concerning predator/prey interactions and, in particular, those involving spatial and flux components described in WG-CEMP-94/10 and 30.

4.37 Introducing WG-CEMP-94/30, Dr Holt described the objectives of the preliminary form of this model. The aim is to model the predator-prey system around Elephant Island. The four steps in the development of this model were: (i) to simulate the krill distribution around Elephant Island; (ii) to superimpose foraging of predators from the known foci of predators in the area; (iii) to further

superimpose the impact by the krill fishery; and (iv) to simulate the effects of the fishery on predator behaviour. The model will also attempt to incorporate the flux of krill through the area and variability of the location of the ice-edge.

4.38 The group suggested that the interannual variation in krill arising from recruitment variability should be incorporated in the model to provide comparability with outputs from the krill yield model.

4.39 Regarding WG-CEMP-94/10, Dr E. Murphy (Invited Expert) explained that the origins of his model predated the deliberations of WG-Krill about modelling. The model describes a single through-flow system with flux of krill past a predator breeding colony. Distance-impact relationships are derived using variable krill transport rates into the area and retention times within the area. The model also investigates the dynamics of predator-prey interactions by addressing the effect of flux within disturbed systems. An important conclusion of the model is that coastal effects produce aggregation of krill swarms and this results in greater spatial and temporal variability within the system. Relatively small variability in oceanic krill stocks can build up to large levels locally in inshore regions.

4.40 The group commented that this was a good example of a model which incorporates prey flux and interactions with predator populations.

## ECOSYSTEM ASSESSMENT

5.1 The Convener of WG-CEMP introduced this item by noting that WG-CEMP's tasks under the ecosystem assessment agenda item as directed by the Commission (CCAMLR-IX, paragraph 4.34) and Scientific Committee (SC-CAMLR-XI, paragraphs 5.4, 5.39 and 8.6) are:

- to determine annually the magnitude, direction and significance of trends in each of the predator populations being monitored;
- to evaluate annually these data by species, site and region;
- to consider conclusions in the light of relevant information on prey and the environment;  
and
- to formulate appropriate advice to the Scientific Committee.

5.2 Since 1992 WG-CEMP has been considering ways to undertake this assessment by:

- (i) reviewing background information available to the Working Group in submitted papers; and
- (ii) reviewing together predator, prey, environment and fishery data, and especially those data in the CEMP database.

5.3 The assessments made in 1992 (SC-CAMLR-XI, Annex 7, Table 5) were chiefly qualitative in nature, although many parts of the assessment of predator data were based on quantitative data from the CEMP database.

5.4 In 1993 WG-CEMP had repeated this process (SC-CAMLR-XII, Annex 6, Table 5) noting, however, the limitations of continuing to make somewhat subjective assessments for predators and an inability reliably to make even subjective assessments for all prey and most environmental data. WG-CEMP had therefore requested that WG-Krill consider the best potential indices for assessing prey data and that the whole issue also be discussed at the Joint Meeting (SC-CAMLR-XII, Annex 6, paragraph 6.40). To facilitate this process, some specific questions had been formulated (SC-CAMLR-XII, Annex 6, paragraph 5.33).

5.5 In 1993 the Scientific Committee:

- (i) endorsed the view that WG-CEMP should, at least for the predator data, move to objective assessments based on analysis of the quantitative data available within the CEMP database;
- (ii) noted the continuing lack of data on krill biomass within ISRs and especially in the vicinity of CEMP sites, which was hampering interannual comparisons, including those with the predator data; and
- (iii) re-emphasised the need to make progress with linking the predator-derived indices to the more conventional management approaches being applied to the krill fishery. It requested that this should receive further consideration at the present Joint Meeting.

5.6 WG-CEMP in 1993 noted that it had developed a set of annual indices of predator parameters with which to monitor different aspects of predator performance. In order to combine and evaluate information from predators, prey and environmental conditions, it felt that increased attention needed to be focused on developing a series of prey indices (SC-CAMLR-XII, Annex 6, paragraph 5.30). In

addition to relevant prey data from fishery-independent surveys, the annual provision of fine-scale data from the fishery, such as catch locations, CPUE and krill length frequency within ISRs, and especially in the vicinity of CEMP sites, could be very valuable in assisting these evaluations (SC-CAMLR-XII, Annex 6, paragraphs 5.31 and 5.32).

#### Development of Prey, Fishery and Environmental Indices

5.7 In addressing the questions posed by WG-CEMP in SC-CAMLR-XII, Annex 6, paragraph 5.33, the Joint Meeting responded as noted below.

5.8 Fine-scale fishery catch data within ISRs and/or in the vicinity of CEMP sites are summarised this year in WG-Krill-94/6. For Subarea 48.1, all data are available back to 1988 and Japan has recently submitted all its catch data for this subarea since 1980. Fine-scale effort data on all catches, except those made by Japan, are contained in the CCAMLR database.

5.9 Fine-scale catch and effort data are still needed for Subareas 48.2 and 48.3; the latter is a particular priority as it contains a CEMP ISR. Data from the fisheries of the former Soviet Union would be especially valuable in this respect and the group noted the procedure endorsed by the Scientific Committee to obtain such data (SC-CAMLR-XII, paragraph 2.87).

5.10 The derivation of reliable information on krill availability to the fishery and on krill product quality was still under active discussion within WG-Krill (SC-CAMLR-XII, Annex 6, paragraph 5.33(ii)).

5.11 The CCAMLR database has few krill length frequency data; some of these are summarised in WG-Krill-94/4.

5.12 Information on the between-year variability of krill year class strength and recruitment between 1975 and 1994, based on data from German expeditions and US AMLR cruises in the Elephant Island area, has been developed and validated (WG-Krill-94/22). The recruitment index described in WG-Krill-94/22 is based on the relative abundance of 1+ year classes. The indices derived are likely to be applicable throughout Subareas 48.1 and 48.2 but their validity for application to Subarea 48.3 needs investigation.

5.13 The group noted that reliable krill recruitment indices can be obtained from fishery-independent surveys only. Assessment of the proportional recruitment of 2+ year classes

(perhaps the category of greatest relevance to most seabird and seal predators) on an ordinal scale might be feasible from fishery data.

5.14 As far as potential environmental indices were concerned, beyond those for sea-ice currently being developed by the Secretariat in conjunction with WG-CEMP, the meeting was unable to make additional specific suggestions (see paragraph 3.23). It noted, however, that data of considerable potential relevance might be forthcoming from future satellite remote sensing activities. Nevertheless, many of these data would probably require considerable validation and careful evaluation before they could provide useful indices for CEMP purposes.

5.15 In respect of the requirements for fishery-derived indices as indicated by WG-CEMP in SC-CAMLR-XII, Annex 6, paragraph 5.34, it was felt that in general there were few possibilities for deriving useful indices, beyond those from catch statistics. Although it was feasible to provide various CPUE indices, with confidence limits, it was unlikely that such values would accurately reflect changes in krill abundance/availability. It was possible, however, that some expressions of CPUE, such as catch-per-towing-time, may be useful to provide information about local concentrations/distributions of krill (e.g., WG-Krill-94/14). Nevertheless, it was felt that it is not possible to use CPUE calculated from the data currently collected as one of the indices for assessment of prey abundance/availability in the context of comparisons with the predator indices derived from CEMP.

5.16 The above assessments of the status and utility of prey indices derived from the fishery mean that, at least in the near future, the provision of prey indices relevant to the CEMP Program will depend extensively on fishery-independent information.

5.17 At present, therefore, data on prey in the vicinity of CEMP sites and/or within ISRs relevant to the types of prey indices outlined at the early meetings of CEMP (SC-CAMLR-VI, Annex 4, Table 5) are still of limited availability.

5.18 It was recalled that, although it was never expected that detailed prey data would be available for all CEMP sites, obtaining such data near at least some sites in the ISRs had been viewed as essential for understanding how predator parameters in general might respond to changes in prey availability and environmental conditions.

5.19 The need to consider the relative value of several annual surveys in restricted areas versus less frequent coordinated surveys of large areas was discussed. It was noted, however, that each of these types of survey was designed to produce very different data, although both were of great relevance to CCAMLR management objectives.

5.20 As far as the CEMP prey monitoring surveys were concerned, a minimum current requirement was for annual surveys of at least one area within each ISR.

5.21 Within ISRs and/or in the vicinity of the main sites providing data to CEMP, a series of relevant annual data is currently only available from the Elephant Island area (vicinity of Seal Island CEMP site). Although some relevant data are available for the South Georgia ISR (including the vicinity of Bird Island CEMP site) and the Prydz Bay ISR, the data are more difficult to relate directly to CEMP activities.

5.22 This suggests that there may be greater difficulties than originally envisaged in trying to integrate data for predator, prey and environment in order to evaluate changes in predators in relation to changes in prey and environment.

5.23 The group therefore felt that it was necessary to review this whole topic at its next meeting. In particular, it would be necessary to address questions of whether it is best to proceed in future by:

- (i) trying to increase the number and frequency of prey surveys in ISRs and to facilitate the acquisition of complementary environmental data;
- (ii) defining and developing more appropriate prey indices;
- (iii) developing a suite of different approaches to management measures involving predator/prey interactions, which do not necessarily require the close linkage of data from predators, prey and environment in the same way as hitherto attempted; or
- (iv) some combination of the three approaches above.

5.24 In order to improve the development of an ecosystem-based management approach, the Joint Meeting agreed that it is necessary to improve current understanding of both the structure and dynamic functioning, including temporal and spatial variability, of the Antarctic marine ecosystem.

5.25 Therefore, Members were urged to submit proposals aimed at identifying variables most likely to indicate trends in important ecosystem components, especially for prey, hydrography and weather, at various spatial (e.g., areas/subareas, ISRs, fishing grounds) and temporal (e.g., interannual, intraseasonal) scales.

5.26 The Joint Meeting noted WG-CEMP's past progress in addressing this issue specifically for predators (SC-CAMLR-VI, Annex 4, Table 5; SC-CAMLR-XII, Annex 6, paragraphs 5.33, 5.34 and Table 5) and agreed that this offered some useful examples from which to proceed.

#### Integrating Predator, Prey, Environmental and Fishery Indices into Ecosystem Assessments

5.27 In addition to the initiatives set in train in paragraphs 5.10 to 5.25, progress on this topic was reported by WG-CEMP (Annex 6, section 7) and WG-Krill (Annex 5, paragraphs 3.21 to 3.28).

#### CEMP Experimental Approaches (Experimental Fishing Regimes)

5.28 The suggestion of a need to establish an experimental fishing regime to investigate cause/effect relationships between potential fisheries impact and predator performance was formulated most recently and explicitly at the Joint Meeting in 1992 (SC-CAMLR-XI, Annex 8, paragraph 9).

5.29 Desirable though such activities might be, it was noted that they could not proceed without formalising the precise objectives of the experiment and evaluating its feasibility thoroughly. Members had been requested to undertake such tasks, but no proposals or evaluations had been forthcoming.

5.30 It was noted that continuing to measure and evaluate annual variations in predator, prey and environmental parameters would strengthen the possibility of formulating well defined hypotheses for possible future experimental perturbations. In the meantime, sharp fluctuations in the natural variability of these parameters (e.g., local krill availability) could be considered a form of natural experiment that would help to develop hypotheses for future work.

#### Incorporating Ecosystem Assessments into Management Advice

5.31 Given the difficulties which have become apparent in developing assessments using some combination of predator, prey and environmental data based on those submitted to the CEMP database, and the unlikelihood of the situation improving markedly in the near future, it was suggested that greater priority should be given to considering how the assessments of predator population status, trends, reproductive performance, diet and demography could on their own contribute to the formulation of management recommendations for the krill fishery.

5.32 One viewpoint was that such information should form the basis for triggering management measures to restrict krill fishing in certain circumstances. It was noted that use of information from both predators and krill was implicit in the decision rule for the selection of levels of  $\gamma$  in the yield model developed by WG-Krill (see Annex 5, paragraph 4.98). Formulation of operational criteria to objectively assess ecosystem variability in terms of distinguishing between potential harvest-induced impacts and natural variability could be viewed in a similar way.

5.33 This raised questions as to what methods could be used to determine the appropriate triggering criteria. One view was that this simply restated the need to estimate functional relationships and the associated implications for predators when krill fishing occurs. Another view was that there existed other approaches, complementary to this one, which needed to be investigated.

5.34 It was recollected that some papers outlining suggestions of appropriate procedures had been tabled at past CCAMLR meetings and Members were encouraged to bring these and other suggestions forward to the next meetings of appropriate Working Groups.

#### ORGANISATION OF FUTURE WORK

##### Advice on the Re-organisation of the Scientific Committee's Working Groups

6.1 The scope and complexity of the Scientific Committee's work have increased considerably in recent years. The work conducted by its Working Groups has become more interrelated as progress has been made in implementing an ecosystem approach to study and manage Antarctic marine living resources. At its Twelfth Meeting in 1993, the Scientific Committee recognised that there are areas of common interest in some Working Groups, in particular WG-Krill and WG-CEMP. The Joint Working Group considered these matters under the assumption that the Scientific Committee would continue to delegate the consideration of technical matters currently addressed by WG-Krill and WG-CEMP to one or more specialist Working Groups.

6.2 In order to avoid unnecessary duplication of work and to carry out work more efficiently, the Scientific Committee requested that during the 1993/94 intersessional period the Working Groups should:

- (i) review their terms of reference;



- (ii) identify elements of work currently being undertaken by Working Groups that are being addressed well and those elements which could be improved; and
- (iii) suggest ways in which priority work can be accomplished most efficiently (SC-CAMLR-XII, paragraph 15.16).

6.3 Based on this review, the Scientific Committee will at its meeting in 1994 provide advice to the Commission on the appropriate structure to best accomplish its work.

6.4 Taking particular account of the specific issues being addressed by the various groups, it was further assumed that the structure of the Working Groups will be kept under review in the future. However, at present, given the greater degree of commonality of issues considered by WG-CEMP and WG-Krill, it would be preferable to initiate re-organisation between these two groups first. At this time, it would be premature to combine their work or elements of their work with that conducted by WG-FSA. However, the group reiterated that there are fields of common interest, such as the by-catch of fish in the krill fishery, which require close liaison among WG-FSA, WG-Krill and WG-CEMP or their successor(s), as has been the practise in the past.

6.5 To accomplish the work of WG-Krill and WG-CEMP more efficiently, the Joint Meeting considered two alternatives, namely to:

- keep the current structure of the two Working Groups but conduct joint sessions of the two groups to cover questions of common interest with emphasis on extending these joint sessions over the next few years as the work of the two groups becomes more integrated; or
- combine the two Working Groups into one group under one convenership. All items would be discussed within this group but the group may, as is the current practice, establish subgroups which would provide advice on specialised issues.

6.6 The group endorsed the second option. It was recognised that this option would more fully integrate the common work of the two Working Groups and still allow specialised tasks to be conducted by experts.

6.7 In recent years it has been the practice of the Working Groups that highly focused or technical topics are dealt with in subgroups. The group felt that these topics should continue to be

addressed in this way. The group recalled the most recent subgroups which had addressed such topics:

- (i) *ad hoc* groups on data collection methods for predator monitoring under the CCAMLR Ecosystem Monitoring Program;
- (ii) *ad hoc* group on statistical methods for the analysis of predator parameters under the CCAMLR Ecosystem Monitoring Program;
- (iii) *ad hoc* group for reviewing proposals for the protection of CEMP monitoring sites;
- (iv) *ad hoc* subgroup on the estimation of krill biomass;
- (v) workshop on acoustic survey design (Yalta, 1991);
- (vi) workshop on krill flux (Cape Town, 1994); and
- (vii) *ad hoc* subgroups for the evaluation of parameters used in models of krill yield and predator-krill functional interactions.

6.8 The group agreed that, as has been the practice in the past, *ad hoc* subgroups with specific tasks could be created by the new joint group, either by forming groups during the meeting or by establishing groups with intersessional tasks. The tasks identified by WG-CEMP and WG-Krill for the 1994/95 intersessional period, which will require *ad hoc* groups were:

- (i) evaluation of proposals for new CEMP methods;
- (ii) evaluation of new statistics and methods of analysis of CEMP data;
- (iii) evaluation of any new proposals for CEMP site protection;
- (iv) development of standard methods for foraging performance of predators;
- (v) continuation of the analysis of krill flux;
- (vi) estimation of krill biomass and evaluation of acoustic methods; and
- (vii) continuation of work on yield and functional relationship models.

6.9 The group noted that in order to undertake effectively the many specialist tasks required under the proposed new Working Group structure, it would need increased participation from specialist scientists.

## List of Priority Activities

6.10 In addition to the tasks referred to in paragraph 6.8, the group identified the following as priorities for future work:

- further work on the determination of krill flux in Statistical Area 48, especially in relation to predators (paragraph 4.7) and with consideration of temporal as well as spatial variation;
- investigation of options for decision rules (in addition to those implicit in the bullet following) for the calculation of appropriate levels, distribution and timing of krill harvesting (paragraph 4.33);
- further work on the functional relationship between predators and prey, especially involving further determination of the parameters for and formulation of the Butterworth/Thomson model (paragraphs 4.25 to 4.30);
- further evaluation of the significance of localised interactions between krill harvesting and krill-dependent predators and identification of suitable approaches for further research initiatives and management measures; and
- review of the links between prey, predator and environmental data within the scope of the CEMP Program (paragraphs 5.22 to 5.25).

6.11 It was agreed that further work on the Secretariat's modelling of the effect of management measures on the krill fishery in Subarea 48.1 was of low priority, and should not be continued by the Secretariat at this time.

## Terms of Reference of a New Working Group on Ecosystem Monitoring and Management (WG-EMM)

6.12 Members of the Joint Meeting reviewed the present terms of reference for WG-CEMP and WG-Krill and the present status of their work and recommended that the Scientific Committee consider the following terms of reference for the new Working Group.

- (i) Formulate advice to the Scientific Committee on the management of krill fisheries, taking into account the effects of fishing on both krill and predators.

- (ii) Consider other forms of predator-prey-fisheries interactions, as appropriate.
- (iii) Plan, recommend and coordinate research taking into account the dynamic functioning of the Antarctic marine ecosystem, the influence of the physical environment and harvesting activities.
- (iv) Gather, review and evaluate information on environmental features which may affect the distribution and abundance of predators and prey (particularly krill).
- (v) Gather, review and evaluate information concerning the status and performance of predators with respect to prey (particularly krill) and environmental features.
- (vi) Develop further, coordinate the implementation of and ensure continuity within the CCAMLR Ecosystem Monitoring Program.
- (vii) Evaluate the impact on krill stocks, krill predators and krill fisheries of current and possible future patterns of harvesting, including specification of the data required for this evaluation.

#### OTHER BUSINESS

7.1 Dr Marín presented a paper (WG-Joint-94/16) describing an Environmental Information Modelling System (EIMS). The main goal of EIMS is to assess strategies for sustainable development and the monitoring of fragile ecosystems. One of the ecosystems chosen is the Antarctic marine ecosystem. The University of Chile plans to implement the system in the next three years.

#### Future Cooperative Research

7.2 Since the last CCAMLR meeting in Hobart, a group of scientists from several Member countries has discussed cooperative research in the Antarctic Peninsula area during the 1994/95 austral summer. Dr S. Kim (Republic of Korea) coordinated the exchange of research plans and distributed a summary table (Table 1) which describes the period, area, research vessel and major objectives of national programs.

7.3 During the present meeting, the representatives of a number of countries (Germany, Japan, Korea and USA) confirmed their oceanographic research activities. Some other participants expressed their countries' intention to conduct research in this area, but could not give details of their plans at this moment.

7.4 Four nations plan to conduct oceanographic observations near the South Shetland Islands from late November 1994 to early March 1995. It was realised that the Elephant Island area would be covered six times at roughly two-three week intervals. Therefore, the above four nations agreed to conduct multinational cooperative research activities as follows:

- (i) based on bilateral agreements, each national program leader would encourage the exchange of scientists from one ship to another, if circumstances allowed;
- (ii) as a common activity at least one transect line (60°S, 55°W to 61°45'S, 55°W) with five to eight environmental sampling stations at 15 n mile intervals will be completed. CTD casts should cover the vertical range from the surface down to at least 750 m. Net sampling should be carried out from the surface down to 200 m with a mesh size between 300 to 500 µm. The group noted that for the calculation of krill (or zooplankton) density, it is necessary to determine the volume of water filtered by the net. Krill length measurements should be given as 'total length' (tip of rostrum to tip of telson). Ship speed should be standardised to 10 knots between stations when hydroacoustic measurements are conducted;
- (iii) additional data from upstream areas and possibly from the Chilean commercial krill fishery will be included in the analysis;
- (iv) Members also agreed to hold a workshop on 'temporal changes in marine environments in the Antarctic Peninsula area during the 1994/95 austral summer' before the next WG-Krill meeting. There was consensus that Hamburg (Germany) would be the appropriate place for this workshop.

7.5 It was noted that several nations have active programs of research at land-based sites. Many of these activities are summarised in Table 1. A number of nations are collaborating in these efforts (e.g., Korea/Germany, Argentina/Germany/Netherlands, United Kingdom/ Sweden). It was recalled that cooperative research efforts are the subject of ongoing discussions within SCAR as well as CCAMLR.

## ADOPTION OF THE REPORT

8.1 The report of the Joint Meeting was adopted.

## CLOSE OF THE MEETING

9.1 In closing the meeting, the Chairman thanked all participants, rapporteurs, the Secretariat and especially the South African hosts for a successful and very valuable meeting. He noted that although the work of the group had been enhanced by the participation of colleagues from 13 Member countries, a number of colleagues had not felt able to take a very active part in discussions. He strongly encouraged these colleagues to take a more active role in the discussions of the group in the future.

Table 1a: Summary table of research activities (ocean survey) in the Antarctic Peninsula area during the 1994/95 austral summer.

BA Bacteria, P Phytoplankton, Z Zooplankton, PP Primary Production, K Krill, S Salps  
 B Benthos, F Fish, BD Birds, MM Marine Mammals, O Oceanography, C Chemical Survey, OP Optical Survey  
 R Rosette, BO Bongo net, M MOCNESS, T Trawl, OT Otter Trawl  
 G Grab sampler, AC Acoustic, ADCP Acoustic Doppler Current Profiles, RMT Rectangular Midwater Trawl

Country (Organisation)	Ocean Survey					
	Date	Area	Ship	Major Objectives (and Instruments)	Availability to Foreign Scientists	Contact
Brazil ( )	Dec 1994 - Mar 1995	Around South Shetland Is	New oceanographic vessel	F larvae, BA, P, Z, PP, K, B, F, O (instruments not yet defined)	Unknown	Edith Fanta UFDR, Biologia Celular CXP 19031 815 31-970 Curitiba, PR, Brazil Fax: +55-41-2662042
Germany (SFRI)	29 Nov - 5 Jan 1994/95	Elephant Island	<i>Polarstern</i>	All macrozooplankton (RMT) Larvae	Probably	Volker Siegel Tel: (49) 4038905221 Fax: (49) 4038905129
Japan <sup>1</sup> (NRIFSF)	early Dec 1994 - early Feb 1995	Around South Shetland Is	<i>Kaiyo-Maru</i>	P, Z, PP, K, S, F, BD, MM, O, C, OP (R, AG, M, OT, ADCP)	4-5 people	Mikio Naganobu Tel: 81-543-34-0715 Fax: 81-543-35-9642 Email: naganobu@ss.enyo.affrc.go.jp
Korea (KORDI)	Early to mid Jan 1995 (possibly early to mid Dec 1994)	Bransfield Strait north of South Shetland Is	maybe <i>Yuzhmorgeologiya</i>	BA, P(R) Z(BO, MOCNESS) PP K B(G) O	Probably 1-2 people	Suam Kim KORDI, Seoul, Korea Tel: 82-345-400-6420 Fax: 82-345-408-5825 Email: suamkim@sari.kordi.re.kr

Table 1a (continued)

Country (Organisation)	Ocean Survey					
	Date	Area	Ship	Major Objectives (and Instruments)	Availability to Foreign Scientists	Contact
Spain (PNA)	early Nov - late Mar 1995 (two stages)	Bransfield Strait South Shetland Is	<i>Hesperides</i>	P, Z, PP, B  (R, BI, G, OT)	Unknown	Eduardo Balguerías Tel: 34-22-549439 Fax: 34-22-549554 Email: EBG @CA.IEO.ES  Marta Estrada Tel: 34-4-2216450 Fax: 34-3-2217340
USA AMLR Program (SWFC)	7 Jan - mid Mar 1995 (two stages)	Elephant Island	<i>Surveyor</i>	P, Z, PP, K, S, BD, MM, O  (R, BO, AC, OT)	Probably 1-2 people	Rennie Holt Tel: 1-619-546-5601 Fax: 1-619-546-7003 Email: OMNET R. Holt
LTER Program (NSF)	9 Jan - early Feb 1995	Around Palmer Station (200 x 400 km)	<i>Polar Duke</i>	BA, P, Z, PP, K, F, BD, C, OP  (R, T, AC)		Polly Penhale Tel: 1-703-306-1033 Fax: 1-703-306-0139 Email: OMNET P. PENHALE

<sup>1</sup> *Hokuho-Maru* will conduct a survey along 140°E



Table 1b: Summary table of research activities (land-based) in the Antarctic Peninsula area during the 1994/95 austral summer.

Country (Organisation)	Land-based Research			
	Location (and/or Station Name)	Period	Major Objectives	Contact
Argentina ( )	Jubany St, King George I Camara St, Moon Bay Brown St, Admiralty Bay	year-round 1994 summer 1993/94 summer 1994/94	Fish, birds, mammals, plankton Plankton, birds Biochemistry	Esteban Barrera-Oro Instituto Antártico Argentino Fax: 54-1-812-2039
Brazil ( )	King George I (Comandante Ferraz St)	year-round: biological research mainly from Dec - Mar	Fish, krill, birds and other groups: biology, physiology, biochemistry, predator/prey interactions	Edith Fanta UFDR, Biologia Celular CXP 19031 815 31-970 Curitiba, PR, Brazil Fax: +55-41-2662042
Chile ( )	Cape Shirreff Ardley Island	Dec 1993 - Jan 1994	Fur seal and beach debris survey Penguins	Jefe Depto. Científico Instituto Antártico Chileno Casilla 16521 Correo 9 Santiago Chile Fax: 56-2-2320440
	Greenwich I (Prat St)	unknown year	Oceanography	
	South Bay (Dummer I)	Jan 1994	Fish ecophysiology	
Germany (AWI)	Jubany (Dallman)	Oct 1994 - May 1995	Benthic community ecology	Heinz Kloser Alfred Wegener Institute Tel: 49-471-4831-309 Fax: 49-471-4831-149
Japan (NRIFS)	Seal Island (Elephant Island)	late Dec - late Jan	Predator/prey interaction studies	Mikio Naganobu Tel: 81-543-34-0715 Fax: 81-543-35-9642 Email: naganobu@ss.enyo.affrc.go.jp
Korea (KORDI)	King George I (King Sejong St)	year-round	Fish	Suam Kim KORDI, Seoul, Korea Tel: 82-345-400-6420 Fax: 82-345-408-5825 Email: suamkim@sari.kordi.re.kr
		Nov - Feb	Penguins	
		Jan 1995	Benthic organisms	

Table 1b (continued)

Country (Organisation)	Land-based Research			
	Location (and/or Station Name)	Period	Major Objectives	Contact
Spain (PNA)	Livingston Island (BAE Juan Carlos I)	Nov - Mar tentative dates	Penguin	Eduardo Balguerías Instituto Español de Oceanografía, Centro Oceanográfico de Canarias Apartado de Correos 1373 Santa Cruz de Tenerife España
UK (BAS)	Bird Island	year-round	Seal biology and populations Bird biology and populations	John Croxall BAS, Cambridge, UK Tel: 44-223-251000 Fax: 44-223-62616
	Signy Island	until Mar 1995	Benthic biology Water column studies	Andrew Clarke BAS, Cambridge, UK Tel: 44-223-251000 Fax: 44-223-62616
USA AMLR Program (SWFC)	Seal Island (Elephant Island)	early Dec - mid Mar	Predator/prey interaction studies Adélie penguins (CEMP protocols)	John Bengtson Seattle, Wa. USA Tel: 1-206-526-4016 Fax: 1-206-526-6615 Email: bengtson@afsc.noaa.gov
	Anvers Island (Palmer St)	1 Oct - 31 Mar		
LTER Program (NSF)	Palmer I (Palmer St) Admiralty Bay	1 Oct - 31 Mar	Seabirds, broad-based studies on eight species	Polly Penhale Tel: 1-703-306-1033 Fax: 1-703-306-0139 Email: OMNET P. PENHALE

**AGENDA**

Joint Meeting of WG-Krill and WG-CEMP  
(Cape Town, South Africa, 27 July to 2 August 1994)

1. Welcome
2. Introduction
  - (i) Review of Meeting Objectives
  - (ii) Adoption of Agenda
  - (iii) Fisheries Activities
3.
  - (i) Prey Monitoring
    - (a) Data Collection Procedures
    - (b) Review of Available Data
      - (i) Krill Biomass Estimates in the ISRs
      - (ii) Fine-scale Catch Data
      - (iii) Fishery-independent Fine-scale Surveys
  - (ii) Predator Monitoring
4. Ecosystem Interactions
  - (i) Potential Impacts of Localised Krill Catches
  - (ii) Krill/Predator Functional Relationships
5. Ecosystem Assessment
  - (i) Development of Prey, Fishery and Environmental Indices
  - (ii) Integrating Predator, Prey, Environmental and Fishery Indices into Ecosystem Assessments
  - (iii) CEMP Experimental Approach
  - (iv) Incorporating Ecosystem Assessments into Management Advice
6. Organisation of Future Work
  - (i) Review Current Working Groups' Organisation and Effectiveness
  - (ii) Identification of Priority Tasks Best Addressed by Working Groups
  - (iii) Working Groups' Terms of Reference and Organisation

7. Other Business
8. Adoption of Report
9. Close of Meeting.

## LIST OF PARTICIPANTS

Joint Meeting of WG-Krill and WG-CEMP  
(Cape Town, South Africa, 27 July to 2 August 1994)

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## LIST OF DOCUMENTS

Joint Meeting of WG-Krill and WG-CEMP  
(Cape Town, South Africa, 27 July to 2 August 1994)

WG-Joint-94/1	AGENDA
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WG-Joint-94/3	LIST OF DOCUMENTS
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WG-Joint-94/5	MODELLING FUNCTIONAL RELATIONSHIPS BETWEEN PREDATORS AND PREY J.P. Croxall, I.L. Boyd and P.A. Prince (United Kingdom)
WG-Joint-94/6	MODELLING FUNCTIONAL RELATIONSHIPS BETWEEN PREDATORS AND PREY Wayne Z. Trivelpiece and Susan G. Trivelpiece (USA)
WG-Joint-94/7	DIAGNOSTIC MODEL OF FUNCTIONING OF ANTARCTIC KRILL POPULATION IN THE COOPERATION SEA V. Belyaev and M. Khudoshina (Ukraine)
WG-Joint-94/8	DEVELOPMENT OF A FINE-SCALE MODEL OF LAND-BASED PREDATOR FORAGING DEMANDS IN THE ANTARCTIC D.J. Agnew and G. Phegan (Secretariat)
WG-Joint-94/9	DISTRIBUTION AND ABUNDANCE OF ANTARCTIC KRILL IN THE VICINITY OF ELEPHANT ISLAND DURING THE 1994 AUSTRAL SUMMER Roger P. Hewitt and David A. Demer (USA)
WG-Joint-94/10	ANTARCTIC NERITIC KRILL <i>EUPHAUSIA CHRYSALLOROPHIAS</i> : SPATIO-TEMPORAL DISTRIBUTION, GROWTH AND GRAZING RATES E.A. Pakhomov (Ukraine) and R. Perissinotto (South Africa)
WG-Joint-94/11	GENTOO PENGUIN <i>PYGOSCELIS PAPUA</i> DIET AS AN INDICATOR OF PLANKTONIC AVAILABILITY IN THE KERGUELEN ISLANDS C.A. Bost, P. Koubbi, F. Genevois, L. Ruchon and V. Ridoux (France)

- WG-Joint-94/12           ACOUSTIC VISUALIZATION OF THE THREE-DIMENSIONAL PREY FIELD OF FORAGING CHINSTRAP PENGUINS  
Jeannette E. Zamon, Charles H. Greene, Eli Meir, David A. Demer, Roger P. Hewitt and Stephanie Sexton (USA)
- WG-Joint-94/13           BIRDS AS INDICATORS OF CHANGE IN MARINE PREY STOCKS  
W.A. Montevecchi (Canada)
- WG-Joint-94/14           DRAFT REPORT OF THE STUDY GROUP ON SEABIRD/FISH INTERACTIONS  
Copenhagen, 6-10 September 1993
- WG-Joint-94/15           ESTIMATED FOOD CONSUMPTION BY PENGUINS AT THE PRINCE EDWARD ISLANDS  
N.J. Adams, C. Moloney and R. Navarro (South Africa)
- WG-Joint-94/16           AN ENVIRONMENTAL INFORMATION AND MODELLING SYSTEM (EIMS) FOR SUSTAINABLE DEVELOPMENT: FROM THE ARID SUBTROPICAL TO ANTARCTICA  
Victor H. Marín (Chile)
- WG-Joint-94/17           A REVISED ASSESSMENT OF THE IMPACT OF THE KRILL FISHERY ON PENGUINS IN THE SOUTH SHETLANDS  
T. Ichii, M. Naganobu and T. Ogishima (Japan)

**REPORT OF THE *AD HOC* WORKING GROUP ON INCIDENTAL  
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(Hobart, Australia, 21 and 22 October 1994)

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# **REPORT OF THE *AD HOC* WORKING GROUP ON INCIDENTAL MORTALITY ARISING FROM LONGLINE FISHING**

(Hobart, Australia, 21 and 22 October 1994)

## INTRODUCTION

1.1 The meeting of the *Ad Hoc* Working Group on Incidental Mortality Arising from Longline Fishing (WG-IMALF) was held in Hobart, Australia, on 21 and 22 October 1994. The Convener, Dr C. Moreno (Chile), chaired the meeting.

## ORGANISATION OF THE MEETING AND ADOPTION OF THE AGENDA

2.1 The Convener welcomed participants to the meeting and introduced the Provisional Agenda which had been circulated prior to the meeting. The Provisional Agenda was adopted.

2.2 The Agenda is included in this report as Appendix A, the List of Participants as Appendix B and the List of Documents presented to the meeting as Appendix C.

2.3 The report was prepared by Mr N. Brothers (Australia), Dr J. Croxall (UK), Ms J. Dalziell (Australia), Drs M. Imber (New Zealand), W. de la Mare (Australia), T. Polacheck (Australia), Lic. E. Marschoff (Argentina), Mr D. Miller (South Africa) and Dr E. Sabourenkov (Secretariat).

## LEVEL OF INCIDENTAL MORTALITY ARISING FROM LONGLINE FISHING AND ITS SIGNIFICANCE TO MARINE ANIMALS FOUND WITHIN THE CONVENTION AREA

### Incidental Mortality Associated with Longline Fishing in the Convention Area

3.1 Longline fishing for Patagonian toothfish (*Dissostichus eleginoides*) was started in the South Georgia area (Subarea 48.3) by the Soviet Union in 1988/89 and around Kerguelen (Division 58.5.1) by Ukraine in 1990/91.

## Subarea 48.3 (South Georgia)

3.2 In the South Georgia area no reports of incidental mortality were received from 1986/87 to 1989/90. In 1990/91 Dalziell and De Poorter (WG-IMALF-94/5) observed the hauling of three lines (set at night) and recorded six dead birds (four white-chinned petrels, two albatrosses - one a black-browed albatross), a rate of 0.66 birds/1 000 hooks. Extrapolating to the whole longline fishery at South Georgia in this year (581 vessel-days) gave a total estimated mortality of 2 300 white-chinned petrels and 1 150 albatrosses. Although the sample size is small, the estimate is possibly conservative because bird catch rates for daytime sets would probably be higher (especially of albatrosses) than night time ones. WG-IMALF-94/5 also contains a report of observations by a Soviet fisheries inspector that catches of four to eight seabirds per line were typical in the 1989/90 season.

3.3 The only data on levels of incidental mortality received by CCAMLR for 1991/92 and 1992/93 concerned five cases of incidental mortality of seabirds reported by commercial fishing vessels operating in Subarea 48.3 in 1991/92; data were on form C2. However, reports on measures taken to avoid incidental mortality were made by Russia for 1991/92 (CCAMLR-XI/BG/17). According to these reports mortality of birds normally occurred during daylight and deterrents, including use of streamer lines, were being investigated. A similar report for 1992/93 (SC-CAMLR-XII/BG/18) indicated that setting lines before dawn and stopping offal discard 30 minutes before setting were 5 to 10% effective at reducing seabird mortality. The use of a towed streamer line (as illustrated in SC-CAMLR-XII/BG/18, Figure 1), however, was 60 to 80% effective. In addition, Ashford *et al.* (1994)<sup>1</sup> reported that up to six seabirds (principally black-browed albatrosses) were caught per set during Chilean fishing operations in 1992/93 in Subarea 48.3 (see also SC-CAMLR-XII, paragraph 10.2).

3.4 From the fishery in 1993/94, when scientific observers were present (under the provisions of Conservation Measure 69/XII) on all four of the vessels authorised to fish in the area, detailed reports on incidental mortality were available to the meeting from the vessels *Friosur V* (WG-IMALF-94/15 and 16), *Ihn Sung 66* (WG-IMALF-94/14) and *Makshevo* (SC-CAMLR-XIII/BG/9 Rev. 1).

3.5 On the *Friosur V*, using the 'traditional' method<sup>2</sup>, observations of 20 of the 27 lines set recorded 98 seabird mortalities (all during setting, none during hauling) at an average rate of 0.47 birds/1 000 hooks (WG-IMALF-94/15). However, the four daylight sets resulted in 85% of the total mortality (mainly giant petrels, grey-headed and black-browed albatrosses), whereas the 16 night

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<sup>1</sup> Ashford, J.R., J.P. Croxall, P.S. Rubilar and C.A. Moreno. 1994. Seabird interactions with longlining operations for *Dissostichus eleginoides* at the South Sandwich Islands and South Georgia. *CCAMLR Science*, Vol. 1: 143-153.

<sup>2</sup> In the 'traditional' method of rigging the longline, a single line is laid from which branchlines containing hooks are strung (see Ashford *et al.*, 1994).

time sets only contributed 15% of the mortality (exclusively of white-chinned petrels). There were some technical difficulties with rigging a streamer line<sup>3</sup> to CCAMLR specifications, but when used it reduced seabird mortality under most conditions, being least effective in calm weather and when birds were feeding intensively. Avoidance of potential interactions during hauling would be improved by discarding offal over the side of the ship opposite to the side where hauling takes place. There was some evidence that smaller fishing hooks were more readily ingested by petrels than larger ones.

3.6 For the first time in longline fisheries in the Convention Area, significant interactions involving cetaceans (sperm and killer whales) were reported (WG-IMALF-94/16). These occurred in respect of 25 of the 27 lines observed and were restricted to the hauling operation (whether at day or at night). No mortality was observed although sperm whales were twice entangled, before breaking free. There was considerable circumstantial evidence that the whales removed fish from the lines, often in substantial numbers. The losses in terms of fish and fishing time (delaying sets and/or changing sites to avoid killer whales) are costly to the fishery and the report suggests it would be prudent to investigate developing measures to reduce interactions in order to assist the fishery and to minimise the likelihood of future action potentially harmful to cetaceans.

3.7 On the *Ihn Sung 66*, using the ‘Spanish’ method<sup>4</sup>, 30 sets, deploying 250 400 hooks, were made (WG-IMALF-94/14). A total of 21 seabirds were reported killed (15 black-browed albatrosses, 1 light-mantled sooty albatross, 5 giant petrels), giving a rate of 0.08 birds/1 000 hooks. However, for the 25 860 hooks monitored by the scientific observer, five black-browed albatrosses were caught, a rate of 0.19 birds/1 000 hooks. This represents a total mortality of 55 albatrosses over the fishing period. Eight birds (3 black-browed albatrosses, 5 giant petrels) were observed to be snagged during hauling (they eventually freed themselves, although hooks were still embedded in them), giving an estimated total of 29 black-browed albatrosses and 48 giant petrels over the fishing period. From the evidence available, setting lines only at night would have prevented all the observed seabird mortality on this vessel. No streamer line was in use for 16 of the sets. Once a line was rigged, seabird mortality was reduced by some 79%. Suggestions for a streamer line design, suitable for longliners using the ‘Spanish’ method, are provided in WG-IMALF-94/14, Figures 2 and 3. The paper notes that offal was being discarded continuously during hauling operations. This clearly increased the potential for seabird mortalities; discharging the offal only on the side of the ship opposite to the side where hauling operations took place would have improved the situation considerably.

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<sup>3</sup> A streamer line is defined in Conservation Measure 29/XII. The term is also used to include such bird deterring devices as ‘tori’ pole and bird line and pole.

<sup>4</sup> In the ‘Spanish’ method of rigging, two lines are laid, one the fishing line holding the branchlines and hooks, and the other joined to the fishing line which is used for hauling.

3.8 From the same fishing operation, SC-CAMLR-XIII/BG/14 reports interactions with killer whales similar to those discussed in paragraph 3.6 above. An adult female elephant seal was killed after becoming entangled in the hauling and fishing lines.

3.9 On the *Makshevo* 82 longlines, deploying 239 200 hooks, were set using a Mustad autoliner (SC-CAMLR-XIII/BG/9 Rev. 1). Seventy-five seabirds were caught, comprising 41 sooty shearwaters (probably white-chinned petrels), 27 giant petrels, 6 black-browed and 1 wandering albatross, at an overall rate of 0.31 birds/1 000 hooks. A streamer line of the 'Russian' design (see paragraph 3.3 above and SC-CAMLR-XII-BG/18) was in regular use. On the one day when this line broke, 21 birds (17 giant petrels, 4 black-browed albatrosses), comprising 28% of the overall mortality, were entangled during the set.

3.10 Interactions with sperm and killer whales were also frequent and several observations were made of them feeding on *D. eleginoides* from the longline; the presence of whales usually forced the vessel to search for a new fishing area. One sperm whale became entangled in the longline which it broke on diving.

3.11 In discussing these reports of the longline fishery in Subarea 48.3, the following points were made:

- (i) the use of scientific observers had provided CCAMLR with the first adequate sets of quantitative data on incidental mortality of seabirds in the Convention Area and the first evidence of any kind of interactions involving cetaceans;
- (ii) the observers had produced excellent results, often under very difficult conditions, and had also managed to achieve and maintain good relations with the fishing masters and crew without which such useful data could not have been collected;
- (iii) catch rates of seabirds were broadly similar to those reported for longline fisheries elsewhere (see Table 2 and paragraph 3.41). Current annual mortality of seabirds from longline fishing in Subarea 48.3 is likely to be in the order of a few hundred birds (over half of these would be albatrosses). The levels of mortality, at least in some previous years with greater fishing effort and little or no use of mitigating measures, could easily have been five or more times higher. Even current levels of mortality are likely to be having detrimental effects on some local albatross populations;
- (iv) setting lines only at night would reduce very significantly the catch of albatrosses. It would probably, however, result in larger numbers of white-chinned petrels being

killed; further work on measures to prevent incidental mortality of petrels will be required;

- (v) streamer lines were shown to be highly effective in reducing seabird mortality. Some modification of the existing CCAMLR specification, to cater for the different types of longline fishing in the Convention Area, would be appropriate;
- (vi) discharge of offal during setting should continue to be prohibited; discharge during line hauling should be conducted on the opposite side of the vessel to hauling operations; and
- (vii) attention should be given to the problem of cetacean interactions.

3.12 The meeting noted that a report from the Russian scientific observer on the Bulgarian longliner *RK-1* should be available for the meeting of the Scientific Committee and the relevant data it contains will need evaluating at that time.

#### Subarea 48.4 (South Sandwich Islands)

3.13 Detailed observations of seven sets were made by a scientific observer during an exploratory fishing cruise during 1992/93 (SC-CAMLR-XII/BG/8 Rev. 1) and reported to CCAMLR last year (SC-CAMLR-XII, paragraphs 10.1 and 10.2). No incidental mortality was seen and only one bird was hooked during hauling. However, aggregations of potentially vulnerable seabirds (especially black-browed albatrosses and white-chinned petrels) were observed close to the fishing vessel.

#### Division 58.5.1 (Kerguelen)

3.14 In longline fishing around Kerguelen in 1990/91, seabird mortality rates averaged 0.5 birds per set (over 163 sets), approximately 0.2 birds/1 000 hooks. These birds were principally black-browed albatrosses, giant petrels and white-chinned petrels (SC-CAMLR-X/BG/14). However, this rate was observed largely in the absence of mitigating measures.

3.15 A detailed 13-day study of seabird/longline interactions was undertaken at Kerguelen in February 1994 (WG-IMALF-94/12). The current longline fishery takes *D. eleginoides* at relatively shallow depths (450 to 590 m), compared to the fishery around South Georgia (800 to 1 600 m), and uses Mustad autoliners. Seabirds attempting to take bait from hooks were principally white-

chinned petrels, giant petrels and albatrosses; white-chinned petrels comprised 87% of the birds following ships. From 72 sets, 38 birds (36 white-chinned petrels, 2 grey-headed albatrosses) were recorded killed, giving a rate of 0.22 birds/1 000 hooks. However, rates were significantly higher for daytime sets (1.00) than night-time ones (0.38) and, at night, higher when deck lights were on (0.59) than when off (0.15). Most important, however, the discharge of offal at the start of setting, on the opposite side of the vessel to that used for setting, reduced seabird mortality to very low levels (five white-chinned petrels in 44 sets and only one in the 41 sets when the timing and positioning of the offal discharge was most advantageous). This success is only possible because the setting operation takes only 10 to 15 minutes and almost all birds in the vicinity can be attracted to the offal, rather than to the baited hooks, throughout the setting period.

3.16 The report from Ukraine (CCAMLR-XIII/BG/14) indicates that streamer lines and appropriate offal discharge practice were in use on all three vessels operating in this fishery in 1993/94. An average of one to two birds is reported to be killed during each longline setting.

3.17 Further data on the potential for interactions between seabirds and *D. eleginoides* longlining in Division 58.5.1 are provided in WG-IMALF-94/11. A substantial proportion of wandering albatrosses breeding at Crozet Island have a foraging range including the western part of the Kerguelen shelf - the area to which longline operations are restricted; wandering albatrosses associate with longline vessels in substantial numbers. Wandering albatrosses breeding at Kerguelen are probably at even greater risk. Black-browed albatrosses from study colonies to the southeast of Kerguelen forage over the eastern shelf and do not appear to overlap with the longline fishery. Birds from northwest Kerguelen forage over the western shelf and are likely to be at risk. Northern giant petrels are also significantly at risk. However, provided that the *D. eleginoides* fishery on the Kerguelen shelf is maintained at its current level and the enforcement of measures to reduce incidental mortality is maintained, there should be very limited impact from this source on local seabird populations.

#### Indirect Information on Seabird/Longline Interactions

3.18 Information from South Georgia presented to CCAMLR last year (SC-CAMLR-XII/BG/7) suggested that in 1992/93 there had been an increase in the incidence of fishing debris, including longline hooks, associated with wandering and black-browed albatrosses at their breeding colonies.

3.19 Similar data for 1993/94 (SC-CAMLR-XIII/BG/4) indicate a six-fold increase in the incidence of such material. Hooks regurgitated by and attached to birds were all from longline fisheries and of a variety of types, including those characteristic of Korean, Chilean and Russian fisheries. The

incidence of hooks in pellets regurgitated by wandering albatross chicks suggested that some 20% of the population could be affected. This also raises the concern that in addition to the observed mortality associated with longliners, there may also be additional mortality of birds that have escaped with hooks in or attached to them.

3.20 Concern was also expressed that the number of birds ingesting hooks was difficult to reconcile with the data reported by the observers on the longline vessels. It was suggested that the existence of other fishing for *D. eleginoides* in Subarea 48.3 and waters adjacent to the CCAMLR Convention Area might be contributing to the problem.

3.21 Recent significant declines in adult survival rates of black-browed albatrosses (SC-CAMLR-XII/BG/21) are believed to be associated with the onset of the *D. eleginoides* fishery in the South Georgia area (see also SC-CAMLR-XII, paragraph 10.8).

#### Information from Outside the Convention Area

3.22 Papers describing incidental mortality in longline fisheries outside the Convention Area were tabled: one describing the tuna fishery off Southern Brazil (WG-IMALF-94/4); one on the tuna fishery off Uruguay (WG-IMALF-94/17); one on the Japanese southern bluefin tuna longline fishery in the Southern Ocean (WG-IMALF-94/6); and five discussing the tuna fishery in New Zealand waters (WG-IMALF-94/10, 21, 22 and 23). Catch rates of birds described in these papers are presented in Table 2. In addition, four papers were tabled that discussed the observed effects of longline fishing on seabird populations (WG-IMALF-94/7, 8, 11 and 18).

3.23 The Working Group stressed that the data discussed were obtained solely from observers on fishing vessels, not from data provided by fishing vessels without observers on board.

#### Southern Brazil

3.24 Substantial seabird mortality in the tuna longline fishery off southern Brazil was described in WG-IMALF-94/4. A total of 71 birds killed on the longlines was observed during 52 days of fishing. Of these birds, 64 were white-chinned petrels (*Procellaria aequinoctialis*), four were wandering albatrosses (*Diomedea exulans*), and two were black-browed albatrosses (*Diomedea melanophris*). Higher mortality occurs when seas are stormy, and during full and first quarter moon.

## Uruguay

3.25 Paper WG-IMALF-94/17 described seabird mortality during sword fish and tuna longlining off the coast of Uruguay. Birds were caught during both setting and hauling. Two types of line design were used: the Florida type and the Spanish type (WG-IMALF-94/17). The mean mortality was 10.5 birds per thousand hooks for the Florida gear type, and 0.2 birds per thousand hooks for the Spanish type. Black-browed albatross was the species most frequently caught. All five bird bands retrieved during this study had been attached on South Georgia.

3.26 The Working Group noted that the average catch rate of 6.6 birds per thousand hooks in this fishery was higher than that presented in other papers. This may be due to the lack of mitigation measures in this fishery.

## Australia

3.27 Paper WG-IMALF-94/6 described albatross mortality in the Japanese tuna longline fishery in the Southern Ocean. The paper compared catch rates between albatross species, concluding that the more aggressive species tend to be caught more frequently. It was noted that subsequent work on this fishery supports the findings of this paper.

3.28 New data (supplied by Mr Brothers) on the origin of 67 bands retrieved from albatrosses and giant petrels incidentally caught in the southern bluefin tuna fishery were presented and are set out in Table 1. These data show that birds taken on longlines come from most of the sub-Antarctic islands, both within and outside the Convention Area.

## New Zealand

3.29 Two papers relating to the tuna longline fishery in the New Zealand region were presented by New Zealand. Paper WG-IMALF-94/10 reports the incidental mortality resulting from eight days of fishing by a New Zealand longliner to the east of the northern tip of New Zealand. Although a streamer line was deployed, a total of 134 hooked baits were taken, resulting in six seabirds, all albatrosses, being hooked. Bait takes occurred in daylight. It was noted that the relatively high rate of survival in hooking incidents was due to the lighter gear and short soak time (approximately six hours). Only approximately 4.5% of bait takes resulted in a bird being hooked.



3.30 Paper WG-IMALF-94/22 reports that night-time setting reduces considerably the by-catch of seabirds, although this may be counteracted when the moon is out. The streamer lines reduced mortality, but birds may become used to them. Their design is therefore important. Two additional papers note population trends and vulnerability of albatrosses and petrels (WG-IMALF 94/10 and 21) to tuna longline fishing. It is notable that both the larger albatrosses and the smaller petrels are vulnerable, and while the albatrosses may be deterred by streamer lines from taking the baits, the smaller petrels are not.

#### *D. eleginoides* Fisheries Outside the Convention Area

3.31 Extensive fisheries are operating in waters off southern Chile, over the Patagonian shelf and all oceanic banks adjacent to the Convention Area, and have recently commenced around the Falkland/Malvinas Islands. No data on incidental mortality of seabirds are currently available for any of these fisheries. However, black-browed and wandering albatrosses from South Georgia forage widely over the Patagonian shelf and have been reported caught in fishing gear around the Falklands and as far west as the west coast of southern Chile. There is, therefore, the potential for significant mortality of albatrosses from South Georgia, and indeed from other sites within the CCAMLR Convention Area, in these longline fisheries.

3.32 Any efforts that CCAMLR can make to influence these fisheries to adopt the fishing practices, including mitigating measures, in operation within CCAMLR would be highly beneficial.

3.33 The fisheries around the Falklands/Malvinas and on the Patagonian shelf are believed to use scientific observers, requested to report incidental mortality, on all vessels. CCAMLR should consider requesting access to these reports, in order to assess the magnitude of the by-catch of birds from the Convention Area, as a matter of priority.

#### Other Areas

3.34 The Working Group noted that while no data were available from the eastern Pacific or the Indian Ocean and waters around South Africa, there were known to be extensive longline fisheries, both pelagic and demersal, in these areas, some of which have extensive bird by-catch. Some of these fisheries are prosecuted by nations who are not Members of CCAMLR. The Working Group therefore concluded that the problem of incidental mortality of seabirds from the Convention Area clearly occurs in all three oceans bordering the Convention Area.

## Evidence of Effects of Longline Fishing Outside the Convention Area on Seabird Populations of Sub-Antarctic Islands

3.35 The declines in wandering albatross populations, especially at Crozet and South Georgia Islands, in the 1980s are widely regarded as resulting from the rapid expansion of tuna longline fisheries (see e.g., CCAMLR-VIII/BG/6, SC-CAMLR-X/BG/8). More recently, declines in grey-headed albatross populations and reductions in recruitment and survival rates of grey-headed and black-browed albatrosses at South Georgia have been attributed, at least in part, to tuna longline fisheries (SC-CAMLR-XII/BG/21).

### Crozet and Kerguelen Islands

3.36 Paper WG-IMALF-94/11 presented information on changes in the population size of large Procellariiformes breeding in the French sub-Antarctic islands. Studies carried out over the past three decades in the French austral territories indicate that most albatross and giant petrel populations have markedly declined. Demographic studies indicate that these declines are mainly the result of increased adult mortality. This high rate of mortality has been suspected to be the result of mortality incurred in longline fisheries. Satellite tracking studies of breeding birds and band recoveries of non-breeding birds indicate that during and outside the breeding season these populations are in contact with longline fisheries, mainly the pelagic Japanese tuna fishery.

### Marion and Gough Islands

3.37 Paper WG-IMALF-94/18 reported the recovery of two tuna longline hooks from wandering albatross nests at Marion Island in the 1990s. The paper also reported that a total of 26 birds of three species banded at Marion and Gough Islands have been recovered at sea in the period 1951 to 1993.

3.38 An age-structured model of a wandering albatross population, developed to simulate population trends over time, was presented in WG-IMALF-94/8. The paper assumes that fishing operations affect juveniles more than adults, and that there is therefore a time-lag of 5 to 10 years before further decreases in population numbers are reflected in the breeding population. In addition, population growth rates will take approximately 30 to 50 years to stabilise after a perturbation. The authors concluded that caution should be exercised when interpreting population trends because short-term estimates may not provide good indications of longterm trends.

## Macquarie Island

3.39 An analysis of the dynamics of the wandering albatross population on Macquarie Island was presented in WG-IMALF-94/7. The estimated breeding population of this species has declined since 1966 at an average rate of 8.1% per year, and this decline is correlated with the onset of a large-scale tuna longline fishery in the southern hemisphere.

## Species Involved

3.40 Several papers reported that the species caught on tuna longlines tend to be the larger, more aggressive species (WG-IMALF-94/4 and 10). Smaller birds can dive up to 10 m (SC-CAMLR-XII/BG/14) and bring baits to the surface. These birds may get hooked but larger birds often take baits from smaller birds as they bring them to the surface, and it is these birds that can ultimately become hooked.

## Summary of Interactions between Seabirds and Longline Fisheries

3.41 Table 2 gives a summary of estimated catch rates of seabirds by longline fisheries, both inside and outside the CCAMLR Convention Area, contained in the papers presented to the Working Group. The estimated catch rates were calculated from direct observations, collected by scientific observers, of seabirds captured on longlines. As such, they usually represent only a small proportion of the total number of hooks set in the fisheries represented, and therefore, the implied total mortalities are extrapolations subject to uncertainty. Large variations of seabird incidental catch data among areas, years and fisheries are to be expected. In addition, no data are available from a number of longline fisheries and areas. Therefore, an accurate estimate of total seabird mortality is not possible. Nevertheless, in the case of tuna fisheries, the total annual effort in the southern hemisphere has exceeded 100 million hooks. Therefore, although the catch rates are uncertain, they imply that substantial numbers of seabirds are captured each year. Apart from the example from the South Atlantic tuna fisheries off southern Brazil and Uruguay, the catch rates are similar across fisheries, despite the considerable differences in the near-surface longline gear employed in fisheries for tuna and the bottom lines used in the fishery for *D. eleginoides*.

3.42 The results from the Japanese tuna fishery in New Zealand waters with and without mitigation methods show that substantial reductions in catch rates may be achieved by setting longlines at night and by using bird-scaring streamer lines.

3.43 The results in the table show that the greater part of seabird incidental mortality relating to birds breeding within the Convention Area arises from fisheries outside the Convention Area. However, catch rates of seabirds in the longline fisheries within the Convention Area are comparable with those outside. Accordingly, future growth in these fisheries has the potential to lead to substantial incidental mortality unless mitigation measures are continued and improved.

3.44 Table 3 summaries the species composition of birds killed in longline fisheries, taken from the studies of incidental mortality of seabirds presented to the Working Group. This table shows clearly the prevalence of albatrosses, particularly black-browed and wandering albatrosses, of giant petrels and of white-chinned petrels as victims of longline fishing, especially in the Convention Area.

3.45 The Working Group noted that the data presented showed that many of the populations of seabirds that breed in the Convention Area were subject to incidental mortality on longlines outside the Convention area. However, as the species affected are from the Convention Area, CCAMLR has a responsibility under Article II of the Convention to address the problem in a proactive manner.

#### DATA ON INCIDENTAL MORTALITY ASSOCIATED WITH LONGLINE FISHING

4.1 Two forms are currently in use in CCAMLR for reporting information on incidental by-catch of seabirds and marine mammals during longline fishery:

- CCAMLR standard fine-scale catch and effort data form for longline fishery (Form C2, version 4); and
- form for reporting observations on incidental mortality of birds and mammals (Format 7, *Scientific Observers Manual*).

4.2 The Working Group reviewed the data provided by Members during the last two seasons. Only five cases of incidental mortality of seabirds were reported on form C2 by commercial fishing vessels. These five reports came from two longline vessels which carried out fishing for *D. eleginoides* in Subarea 48.3 (South Georgia) during the 1991/92 season. No reports on form C2

were received for the 1993/94 season, except a report of an incidental catch of one petrel, although completed C2 forms were received from all vessels authorised to take part in the fishery.

4.3 In view of the discrepancies between reports on C2 formats received from the commercial fishery and those made by observers (see paragraphs 3.5, 3.7 and 3.9), the Working Group agreed that there is a need to improve the collection of information on incidental mortality. Experience from the 1993/94 season had demonstrated that the only practical method of obtaining reliable data was from scientific observers. It was noted that the small number of vessels involved in the fishery and the high variability in rates of incidental mortality meant that observers are required for every vessel to achieve accurate and unbiased estimates of mortality. It was further noted that vessels without observers are likely to behave differently, which makes extrapolations of results from observed vessels to unobserved vessels questionable.

#### Advice to the Scientific Committee

4.4 The meeting identified some important requirements for improving the quality of seabird data. In particular, the meeting noted the need for improved observer coverage and the priority tasks for observers with respect to the collection of data for quantifying interactions between seabirds and longline fisheries. A number of aspects relevant to observer tasks need further detailed consultation with WG-FSA.

- (i) Whenever logistically possible (e.g., berth availability), two scientific observers should be present on each vessel.

Justification: To obtain adequate data on fish, fishery and seabird mortality from this fishery requires full observer coverage. One observer per vessel cannot undertake all tasks currently being specified. Ideally, one observer would record the seabird data and another the relevant data from the fish and fishery.

- (ii) For seabirds it is essential that all dead specimens are retained whole, appropriately labelled and returned to port for the necessary processing.

Justification: In order to overcome difficulties in accurately identifying seabird species, carcasses need to be retained for subsequent checking by a specialist ornithologist. Information on age and sex, which can only be obtained from specialist investigation of carcasses, is vital for species conservation purposes. Correct identification of seabirds caught in longline fishing is vital if the impact of such fishing is to be properly assessed.

- (iii) If it is not possible to retain the whole specimen, a minimum requirement would be retention of bird head, legs and bands and samples suitable for DNA analysis.

Justification: Retention of heads and legs at least will ensure accurate specific identification and perhaps ageing of each bird caught. The recovery of bands from seabirds will contribute to demographic studies and to determining the provenance of birds caught.

- (iv) Observers should be given training to a level where they can at least distinguish reliably the differences between ALBATROSS, SHEARWATER, PETREL (suggested minimum identification categories). Data sheets used to record the catch will then include provision for recording seabird identification by observers.

Justification: This would provide some minimum desirable data if the specimens retained were somehow lost.

- (v) A responsibility of each Member shall be to ensure that appropriate genetic material from each seabird specimen is retained for submission to a central storage/processing institute.

Justification: Determination, using molecular genetic techniques, of the provenance of birds caught by a fishery is a high priority if we are to understand the relationship between seabird by-catch in fisheries and seabird populations.

- (vi) Documentation of fishing equipment, techniques, vessel configuration and details of mitigation measures are essential. This will involve recording information on line setting as well as line hauling.

Justification: Accurate documentation of the nature and use of fishery equipment is essential to evaluate catch rates of seabirds, particularly in relation to the use of mitigating measures.

4.5 The Working Group agreed that the priorities for observations on commercial vessels in the longline fishery, as laid out in the pilot edition of the *Scientific Observers Manual*, should be updated. The following research priorities were identified which could be addressed by the collection of information by scientific observers:

- monitoring of total incidental bird mortality by species, sex and age;
- bird mortality per unit of fishing effort and relative vulnerability of different species;
- collection of bird bands and notification of other study markers;
- efficacy of mitigation measures;
- investigation of the practicalities of the implementation of different mitigation methods.

4.6 It is recommended that observers be equipped with the relevant documentation in order to assist with the education and dissemination of information to fishermen on the problem of incidental mortality and potential solutions.

4.7 The Working Group recommended the following:

- (i) reporting data on incidental mortality on form C2 to be continued; and
- (ii) the Secretariat to create data sheets in book format, based on information set out in Appendix D, for reporting observations conducted on board longline vessels by scientific observers designated under the CCAMLR Scheme of International Scientific Observation.

4.8 These data formats will need to be considered at the meeting of the Scientific Committee in 1995. The Working Group recognised that these formats would not be prepared in time for the 1994/95 fishing season. It was therefore suggested to circulate to Members the list of information required (Appendix D) in order to standardise the collection of information by scientific observers in the 1994/95 season.

4.9 An additional appendix to the *Scientific Observers Manual* should be prepared by the Secretariat to provide guidance for observers placed on longline vessels for the purposes of recording information relating to incidental mortality.

#### MEASURES FOR REDUCING AND/OR ELIMINATING INCIDENTAL MORTALITY ASSOCIATED WITH LONGLINE FISHING

##### Reports of Members' Work in the Convention Area

5.1 Paper WG-IMALF-94/12 described the dumping overboard of minced offal a few minutes before and during the setting of longline. This method, it was pointed out in discussion, is applicable only to short (10 to 15 minutes) settings in certain *D. eleginoides* fisheries, but would be of little use

in longer settings or in the tuna fishery (six-hour settings). Reduced seabird mortality with night setting and, further, at night with deck lights off, was shown.

5.2 The data in WG-IMALF-94/14 demonstrated increased mortality during daylight setting; the streamer line caused reduction of this by 79%. The authors pointed out problems with the CCAMLR-designed weight at the end of the streamer line and suggested its replacement by floats to maintain tension of the bird line. It was suggested that disposal of offal during hauling should be on the opposite side of the ship to where hauling occurred.

5.3 Paper SC-CAMLR-XII/BG/18 emphasised setting in pre-dawn hours (0300 to 0400) in Subarea 48.3, a time when least birds follow the ship. No offal was discharged from 30 minutes before setting. It also contained an illustration of a streamer line that had been useful (40 to 50 m, streamers at 1 m intervals).

#### Experience from Research and Fishing Operations Outside the Convention Area

5.4 Paper WG-IMALF-94/9 described a streamer line with 12 swivelled streamers which reduced seabird hooking significantly.

5.5 Paper SC-CAMLR-XII/BG/13 drew attention to three problems: the terminal weight or buoy on the streamer line tangling with the mainline; the streamers becoming wrapped around the streamer line during operation; and the first streamer tangling with baited hooks during setting. Modifications were proposed, including 100 m of rope with streamers at the end of the line to provide drag, instead of the weight.

5.6 Paper WG-IMALF-94/17 emphasised night setting to avoid mortality of seabirds, and the use of a weighted swivel (80 g) on the snoods (hook branch line) to aid the sinking of baited hooks. The reduction of deck-lighting at night reduced by-catch.

5.7 Paper WG-IMALF-94/23 stressed the importance of night setting to avoid incidental catch; the greatest risk of by-catch was during setting between 1200 to 1800 hours. Thawed baits caught fewer birds. Moon phase affected incidental catch, with highest mortality three nights either side of full moon.

5.8 Paper WG-IMALF-94/24 stressed the need for baits used in longline to be well-thawed so that they sink; intact fish need to have the swim bladder deflated.



## Use and Effectiveness of Various Mitigation Methods Outside the Convention Area

### Light Conditions

5.9 Three studies showed that setting longlines at night significantly reduced the incidental catch of seabirds (WG-IMALF-94/10, 23 and SC-CAMLR-XII/BG/14). However, these papers also noted that a full moon increases the activity of birds and hence the number that are caught. Anecdotal evidence described in WG-IMALF-94/4 supported these findings.

5.10 Papers WG-IMALF-94/10 and 22 suggested that the greatest seabird catches were taken on lines set during the afternoon.

### Streamer Lines

5.11 Paper WG-IMALF-94/6 described streamer lines developed and used in Japanese longline vessels in tuna fisheries north of the Convention Area. This work formed the basis and original impetus for CCAMLR's adoption of Conservation Measure 29/XII. Subsequent investigations have shown that the deployment of such streamers has reduced considerably the incidental catch of seabirds in these fisheries.

5.12 Experience of streamer lines in other fisheries was also presented (WG-IMALF-94/9).

5.13 The principles of operation of the streamer lines are provided in WG-IMALF-94/19. It is important to note that their effectiveness depends principally on the scaring effect produced by the independent and unpredictable movement of the lines.

5.14 Some papers (e.g., WG-IMALF-94/10) stated that birds had become accustomed to the streamer lines, and that this had reduced the effectiveness of those lines. The Working Group agreed, however, that this indicated that the lines used were inadequately constructed or deployed.

5.15 WG-IMALF-94/10 and 22 concluded that two streamer lines might be more effective than one.

## Offal Dumping

5.16 Several studies reported on the effect of throwing offal into the water at the time of setting and hauling to distract birds (WG-IMALF-94/4, 12 and 17; see also paragraph 3.15).

## Weights

5.17 Bird catch was reduced by attaching an 80 g leaded swivel to the branch line, 3.6 m from the hook (WG-IMALF-94/17). The Working Group noted that this may have been even more effective had it been placed closer to the hook.

5.18 Paper SC-CAMLR-XII/BG/14, which discussed incidental mortality of seabirds in the Japanese tuna longline fishery in New Zealand waters, also recommended the use of 70 g swivels on branch lines, as close as possible to the hooks.

## Bait Throwers

5.19 The Working Group noted that bait-casting machines had been developed in the Australian tuna fishery. These machines reduced incidental mortality and were also advantageous to the fisheries.

## Bait Quality

5.20 WG-IMALF-94/24 identifies bait quality as an important factor in the rate at which baits sink so that they are less likely to be located by birds. Bait that is thawed, and has had the air in its swim bladder expelled, will sink. The paper also discussed the sink rates for various species of bait fish commonly used in the Japanese tuna longline fishery.

## Advice to the Scientific Committee

5.21 The Working Group agreed that much of its discussion and review of information was directly relevant to the provisions set out in Conservation Measure 29/XII. These provisions aim to minimise incidental mortality of seabirds during longlining in the Convention Area.

5.22 In this context, the Working Group drew SC-CAMLR's attention to:

- the need to review Conservation Measure 29/XII as a matter of urgency;
- a major amendment to the above measure should ensure that scientific observers are placed on all longline vessels fishing in the Convention Area. Such placement necessitates both the collection and reporting of data by observers in a format specified by the Scientific Committee. This must be achieved in such a way that the observers' scientific impartiality is not compromised by a perception that they need to enforce compliance or report violations of conservation measures in force;
- the need to ensure that the setting of all longlines only takes place at night (i.e., between the times for nautical twilight) and only the minimum lights necessary for ship safety are used. This measure aims to minimise incidental mortality of albatrosses, although it increases the impact on petrels; this will require further research to develop appropriate mitigating measures;
- dumping of trash and/or offal during longline operations must be avoided if possible, but should it occur, it must be done as far away as possible from the area of the vessel where the longlines are being set or hauled. This will serve to reduce potential interactions between seabird foraging for offal and longline operations;
- the requirement that only thawed bait be used during longline operations;
- the continued need to ensure that longline fishing is conducted so that baited hooks sink as soon as possible after being put into the water;
- the need to deploy streamer lines at all times during the setting of longlines. The appendix to Conservation Measure 29/XII should be revised to allow an option to use weights, floats or other methods to maintain suitable tension of the streamer line;
- every effort should be made to ensure that birds captured during longlining are released alive and that wherever possible hooks are removed without jeopardising the life of the bird concerned.

5.23 The Working Group agreed on the need to investigate the effectiveness of any alternative streamer line configurations prior to recommendation. Principles to be considered are described in detail in WG-IMALF-94/19.

5.24 The Working Group further agreed that future development of mitigation of incidental mortality of longline fishing would require an experimental approach. Data arising from such an approach would augment that being collected by observers aboard commercial vessels.

5.25 Recognising the potential for interactions between cetaceans and longline fisheries in the Convention Area, the Working Group recommended that the Scientific Committee investigate how research on mitigating such interactions might be undertaken practically.

5.26 The Working Group agreed that CCAMLR should exchange information on the state of Antarctic seabird populations affected by longline fisheries, incidental catches in these fisheries, and relevant data on fishing effort with appropriate fisheries management authorities and international organisations.

5.27 It was noted that while it may not always be possible to transfer mitigation techniques used in one fishery into another fishery, experience in formulating and implementing conservation measures to mitigate incidental mortality in longline fisheries should be shared around various organisations (see Appendix E).

#### REQUIREMENTS FOR FUTURE WORK

6.1 The Working Group has identified areas where further work is needed:

- assessment of incidental mortality in the Convention Area;
- education of fishermen and involvement of the industry;
- development and evaluation of mitigation measures; and
- monitoring of bird populations in the Convention Area likely to be affected by longline activities.

6.2 Consequently, several actions were proposed:

- to maintain or increase monitoring of the bird populations involved;
- liaison with national and international fisheries agencies in adjacent waters concerning incidental mortality of seabirds from the Convention Area;

- to put in place a mechanism facilitating the identification and further processing of specimens collected by scientific observers;
- to develop data collection forms to be used by observers on board fishing vessels. These forms should be prepared in close liaison with WG-FSA;
- to produce a brochure relevant to CCAMLR fisheries and have it translated into the languages of the fishing nations. This task would be carried out by the Secretariat in contact with appropriate experts during the intersessional period addressing, *inter alia*, the conservation and economic advantages of reducing incidental mortality;
- to design and implement an experimental program using commercial longline and research vessels, aimed at improving bird-scaring devices. The program should also address vessel configuration, gear design and methods of its deployment.

ADOPTION OF THE REPORT  
AND CLOSE OF THE MEETING

7.1 The report of the meeting was adopted.

7.2 In closing the meeting, the Convener thanked the participants, rapporteurs and the Secretariat for their hard work and cooperation during the meeting.

7.3 The meeting was closed at 0020 hours on 23 October 1994.

Table 1: Place of banding of a sample of albatrosses and giant petrels caught in the southern bluefin tuna longline fishery.

Location:	Number of Birds
Islands within the Convention Area:	
South Shetland Islands	2
Bird Island, South Georgia	21
Crozet Island	11
Kerguelen Island	6
Marion Island	6
Islands outside the Convention Area	
Gough Island	1
Amsterdam Island	1
Macquarie Island	1
Albatross Island, Tasmania	2
Mewstone Island, Tasmania	3
Auckland Island	1
Campbell Island	12

Table 2: Catch rates of seabirds in various longline fisheries from data collected by observers both inside and outside the CCAMLR Convention Area. Rough estimates of total mortality are extrapolated from estimates of total effort. These estimates may involve substantial extrapolation, and hence may be subject to considerable uncertainty.

Region	Fishery	Season	Number of Hooks Observed	Number of Birds Caught (Observed)	Incidental Catch Rate of Seabirds (No. per 1 000 hooks)	Total Effort in Fishery (Millions of hooks)	Annual Implied Total Seabird Mortality	Reference
South Atlantic off Brazil	Tuna	1990	18597	71	3.82	-	2650 <sup>1</sup>	WG-IMALF-94/4
South Atlantic off Brazil and Uruguay	Tuna	1994	55624	280	5.03	-	-	WG-IMALF-94/17
Australia, SW of Tasmania	Tuna (Japanese)	1987	108662	45	0.41	107.9 <sup>5</sup>	44000	WG-IMALF-94/6
New Zealand (north)	Tuna (domestic)	1994	11200	6	0.27	-	-	WG-IMALF-94/10
New Zealand (w/o mitigation)	Tuna (Japanese)	1988-91	1269000	304	0.24	10.4	2500	SC-CAMLR-XII-BG/14
New Zealand (streamer lines + night-setting)	Tuna (Japanese)	1992	1032000	16	0.016	9.0	144 <sup>2</sup>	SC-CAMLR-XII-BG/14
Fisheries in CCAMLR Convention Area								
South Georgia (Subarea 48.3)	<i>D. eleginoides</i>	1991	9000	6	0.67	5.2 <sup>3</sup>	3000	WG-IMALF-94/5
“ (single vessel)	“	1994	239200	75	0.31	0.2392	75	SC-CAMLR-XIII-BG/9 Rev 1.
“	“	1994	25860	5	0.19	0.2504	55	WG-IMALF-94/14
“	“	1994	206720	98	0.47	0.2914 <sup>4</sup>	138	WG-IMALF-94/15
Kerguelen (Division 58.5.1)	“	1994	174000	38	0.22	-	-	WG-IMALF-94/12

<sup>1</sup> Estimate calculated as birds per fishing day. Number of fishing days is an estimate only.

<sup>2</sup> Reported to be higher in 1993

<sup>3</sup> Estimated

<sup>4</sup> C. Moreno, pers. comm.

<sup>5</sup> All hooks south of 30°S

Table 3: Summary of the species composition of birds killed in longline fisheries.

Region	Fishery	Season	No. of Killed Birds Identified	Composition by Species <sup>a</sup> (%)									Reference
				WA	BBA	GHA	YNA	SA	LMA	GP	WCP	Other	
South Atlantic off Brazil	Tuna	1990	71	6	3	-	-	-	-	-	90	1 <sup>b</sup>	WG-IMALF-94/4
South Atlantic off Brazil and Uruguay	Tuna	1994	45	13	82	-	2	-	-	-	2	-	WG-IMALF-94/17
Australia, SW of Tasmania	Tuna (Japanese)	1987	33	21	42	3	-	21	9	3	-	-	WG-IMALF-94/6
New Zealand (North)	Tuna (domestic)	1994	6	82	18	-	-	-	-	-	-	-	WG-IMALF-94/10
New Zealand (w/o mitigation)	Tuna (Japanese)	1988-91	135	19	19	4	-	-	-	1	-	57 <sup>e</sup>	SC-CAMLR-XII-BG/14
New Zealand (streamer lines + night-setting)	Tuna (Japanese)	1992											
Fisheries in the CCAMLR Convention Area													
South Georgia (Subarea 48.3)	<i>D. eleginoides</i>	1991	6	-	16	-	-	-	-	-	67	16 <sup>c</sup>	WG-IMALF-94/5
“ (single vessel)	“	1994	75	1	8	-	-	-	-	36	55	-	SC-CAMLR-XIII-BG/9 Rev 1.
“	“	1994	21	-	71	-	-	-	5	24	-	-	WG-IMALF-94/14
“	“	1994	98	-	21	27	-	-	-	15	15	12 <sup>d</sup>	WG-IMALF-94/15
Kerguelen (Division 58.5.1)	“	1994	38	-	-	5	-	-	-	-	95	-	WG-IMALF-94/12
Kerguelen	“	1991	8	-	50	-	-	-	-	13	37	-	SC-CAMLR-X/BG/14

<sup>a</sup> WA wandering albatross; BBA black-browed albatross; GHA grey-headed albatross; YNA yellownose albatross; SA shy albatross; LMA light-mantled albatross; GP giant petrel; WCP white-chinned petrel

<sup>b</sup> Antarctic fulmar

<sup>c</sup> Albatross sp.

<sup>d</sup> Cape petrel

<sup>e</sup> Grey petrel 35%, Bullers albatross 16%, white-capped albatross 4%; cape petrel 1%, westland petrel 1%



**AGENDA**

*Ad Hoc* Working Group on Incidental Mortality  
Arising from Longline Fishing  
(Hobart, Australia, 21 and 22 October 1994)

1. Opening of the Meeting
2. Adoption of the Agenda
3. Data on Incidental Mortality Associated with Longline Fishing
  - (i) Data Reported as Part of CCAMLR Conservation Measures
  - (ii) Other Data
  - (iii) Data Reporting Forms
  - (iv) Advice to the Scientific Committee
4. Level of Incidental Mortality Arising from Longline Fishing and its Significance to Marine Animals found within the Convention Area
  - (i) Review of Submitted Papers
  - (ii) Advice to the Scientific Committee
5. Measures for Reducing and/or Eliminating Incidental Mortality Associated with Longline Fishing
  - (i) Reports of Members' Work in the Convention Area
  - (ii) Experience from Research and Fishing Operations Outside the Convention Area
  - (iii) Advice to the Scientific Committee
6. Requirements for Future Work
7. Adoption of the Report.

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Arising from Longline Fishing  
(Hobart, Australia, 21 and 22 October 1994)

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## LIST OF DOCUMENTS

*Ad Hoc* Working Group on Incidental Mortality  
 Arising from Longline Fishing  
 (Hobart, Australia, 21 and 22 October 1994)

WG-IMALF-94/1	PROVISIONAL AGENDA
WG-IMALF-94/2	LIST OF PARTICIPANTS
WG-IMALF-94/3	LIST OF DOCUMENTS
WG-IMALF-94/4	SEABIRDS MORTALITY ON LONGLINE FISHING FOR TUNA IN SOUTHERN BRAZIL Vaske, T. 1991. <i>Ciencia e Cultura</i> , 43 (5): 388-390.
WG-IMALF-94/5	SEABIRD MORTALITY IN LONGLINE FISHERIES AROUND SOUTH GEORGIA Dalziell, J. and M. de Poorter. 1993. <i>Polar Record</i> , 29 (169): 143-145.
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WG-IMALF-94/7	POPULATION DYNAMICS OF THE WANDERING ALBATROSS ( <i>DIOMEDEA EXULANS</i> ) ON MACQUARIE ISLAND AND THE EFFECTS OF MORTALITY FROM LONGLINE FISHING William K. de la Mare and Knowles R. Kerry (Australia)
WG-IMALF-94/8	USE OF A POPULATION MODEL TO ASSESS THE IMPACT OF LONGLINE FISHING ON WANDERING ALBATROSS POPULATIONS Coleen L. Moloney, John Cooper, Peter G. Ryan and W. Roy Siegfried (South Africa)
WG-IMALF-94/9	REDUCED BAIT LOSS AND BYCATCH OF SEABIRDS IN LONGLINING BY USING A SEABIRD SCARER S. Løkkeborg and Å. Bjordal (Norway)
WG-IMALF-94/10	REPORT ON A TUNA LONG-LINING FISHING VOYAGE ABOARD <i>SOUTHERN VENTURE</i> TO OBSERVE SEABIRD BY-CATCH PROBLEMS M.J. Imber (New Zealand)

- WG-IMALF-94/11 CHANGES IN POPULATION SIZE OF LARGE PROCELLARIIFORMES BREEDING IN THE FRENCH SUB-ANTARCTIC ISLANDS: POTENTIAL INFLUENCE OF SOUTHERN FISHERIES AND PARTICULARLY LONG-LINING  
Henri Weimerskirch and Pierre Jouventin (France)
- WG-IMALF-94/12 INTERACTIONS BETWEEN LONGLINE VESSELS AND SEABIRDS IN KERGUELEN WATERS AND A METHOD TO REDUCE SEABIRD MORTALITY  
Yves Cherel, Henri Weimerskirch and Guy Duhamel (France)
- WG-IMALF-94/13 ENTANGLEMENTS AND INCIDENTAL MORTALITY OF BIRDS AND SEALS - SUMMARY OF REPORTS TO CCAMLR, 1985 TO 1993  
Secretariat
- WG-IMALF-94/14 REPORT ON INCIDENTAL BIRD MORTALITY AND EFFECTIVENESS OF MITIGATION MEASURES DURING DEMERSAL LONG LINING BY *IHN SUNG 66* IN SUBAREA 48.3 - DECEMBER 1993 TO FEBRUARY 1994  
Caradoc Jones and Graeme Parkes (UK)
- WG-IMALF-94/15 SEABIRD INTERACTION WITH LONG-LINING OPERATIONS FOR *DISSOSTICHUS ELEGINOIDES* AROUND SOUTH GEORGIA, APRIL AND MAY 1994  
J.R. Ashford, J.P. Croxall (UK), P.S. Rubilar and C.A. Moreno (Chile)
- WG-IMALF-94/16 INTERACTIONS BETWEEN CETACEANS AND LONG-LINING OPERATIONS FOR PATAGONIAN TOOTHFISH *DISSOSTICHUS ELEGINOIDES* AROUND SOUTH GEORGIA  
J.R. Ashford (UK) and P.S. Rubilar (Chile)
- WG-IMALF-94/17 MORTALITY OF ALBATROSSES AND OTHER SEABIRDS PRODUCED BY TUNA LONG-LINE FISHERIES IN URUGUAY  
L. Barea, I. Loinaz, Y. Marin, C. Ríos, A. Saralegui, A. Stagi, R. Vaz-Ferreira and N. Wilson (Uruguay)
- WG-IMALF-94/18 SEABIRD MORTALITY FROM LONGLINE FISHERIES: EVIDENCE FROM MARION AND GOUGH ISLANDS  
J. Cooper (South Africa)
- WG-IMALF-94/19 PRINCIPLES OF BIRDLINE CONSTRUCTION AND USE TO REDUCE BAIT LOSS AND BIRD DEATHS DURING LONGLINE SETTING  
Nigel Brothers (Australia)
- WG-IMALF-94/20 CATCHING FISH NOT BIRDS  
A GUIDE TO IMPROVING YOUR LONGLINE FISHING EFFICIENCY (ENGLISH VERSION)  
Nigel Brothers (Australia)



WG-IMALF-94/21	POPULATION TRENDS AND VULNERABILITY TO TUNA LONGLINING BYCATCH OF ALBATROSSES, MOLLYMAWKS AND <i>PROCELLARIA</i> PETRELS OF NEW ZEALAND SEAS M.J. Imber (New Zealand)
WG-IMALF-94/22	ASPECTS OF SEABIRD BYCATCH AND ITS MITIGATION IN THE NZ LONGLINE FISHERY FOR TUNA M.J. Imber (New Zealand)
WG-IMALF-94/23	COOPERATIVE ANALYSIS OF NEW ZEALAND SEABIRD BYCATCH DATA - INTERIM REPORT (New Zealand)
WG-IMALF-94/24	INFLUENCE OF BAIT QUALITY ON SEABIRD MORTALITY AND ECONOMIC LOSSES IN LONGLINE FISHING: AN EXPERIMENTAL APPROACH Nigel Brothers and Andrew Foster (Australia)
CCAMLR-VIII/BG/6	RECOVERIES OF WANDERING ALBATROSSES <i>DIOMEDEA EXULANS</i> RINGED AT SOUTH GEORGIA 1958 - 1986 Delegation of United Kingdom
SC-CAMLR-VIII/BG/54	DEVELOPMENT OF A LONGLINE DATA RECORDING SHEET Secretariat
CCAMLR-X/BG/18	INFORMATION OF INTEREST TO CCAMLR COLLECTED BY M.V. <i>GONDWANA</i> ON GREENPEACE'S 1990/91 EXPEDITION ASOC Observer
SC-CAMLR-X/BG/4	INCIDENTAL CATCH OF SEABIRDS IN TRAWL FISHERIES Delegation of New Zealand
SC-CAMLR-X/BG/8	REPRODUCTIVE PERFORMANCE, RECRUITMENT AND SURVIVAL OF WANDERING ALBATROSSES <i>DIOMEDEA EXULANS</i> AT BIRD ISLAND, SOUTH GEORGIA Delegation of United Kingdom
SC-CAMLR-X/BG/14	INCIDENTAL MORTALITY ARISING FROM FISHERIES ACTIVITIES AROUND KERGUELEN ISLAND (DIVISION 58.5.1) Delegation of France
CCAMLR-XI/BG/17	REPORT ON ASSESSMENT AND AVOIDANCE OF INCIDENTAL MORTALITY IN THE CONVENTION AREA 1991/92 Russian Federation
SC-CAMLR-XII/BG/7	RECORDS OF FISHING HOOKS ASSOCIATED WITH ALBATROSSES AT BIRD ISLAND, SOUTH GEORGIA, 1992/93 Delegation of United Kingdom

SC-CAMLR-XII/BG/8 Rev.1	SEABIRD INTERACTIONS WITH LONG-LINING OPERATIONS DURING AN EXPLORATORY FISHING CRUISE FOR <i>DISSOSTICHUS ELEGINOIDES</i> TO SOUTH SANDWICH ISLANDS, ANTARCTICA Delegations of United Kingdom and Chile
SC-CAMLR-XII/BG/13	OBSERVATIONS ON CCAMLR SPECIFICATIONS FOR STREAMER LINES TO REDUCE LONGLINE BY-CATCH OF SEABIRDS Delegation of New Zealand
SC-CAMLR-XII/BG/14	INCIDENTAL CAPTURE OF SEABIRDS BY JAPANESE SOUTHERN BLUEFIN TUNA LONGLINE VESSELS IN NEW ZEALAND WATERS 1988 - 1992 Delegation of New Zealand
SC-CAMLR-XII/BG/18	REPORT ON MEASURES ON BOARD RUSSIAN VESSELS IN 1992/93 TO AVOID INCIDENTAL MORTALITY OF SEABIRDS Delegation of Russia
SC-CAMLR-XII/BG/21	POPULATION DYNAMICS OF BLACK-BROWED AND GREY-HEADED ALBATROSSES <i>DIOMEDEA MELANOPHRIS</i> AND <i>D. CHRYSOSTOMA</i> AT BIRD ISLAND, SOUTH GEORGIA Delegation of United Kingdom
SC-CAMLR-XII/BG/22	CO-OPERATIVE MECHANISMS FOR THE CONSERVATION OF ALBATROSS Delegation of Australia
SC-CAMLR-XIII/BG/9 Rev. 1	CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION - PRELIMINARY REPORT OF THE SCIENTIFIC OBSERVER FV <i>MAKSHEEVO</i> , 7 FEBRUARY TO 18 APRIL 1994 Delegation of USA
SC-CAMLR-XIII/BG/14	SUMMARY REPORT OF THE UK NOMINATED SCIENTIFIC OBSERVERS ON FV <i>IHN SUNG 66</i> , 16 DECEMBER 1993 TO 7 FEBRUARY 1994 Delegation of United Kingdom
CCAMLR-XIII/BG/14	REPORT ON ASSESSMENT AND AVOIDANCE OF INCIDENTAL MORTALITY IN THE CONVENTION AREA 1993/94 Report of Observer (Ukraine)
CCAMLR-XIII/BG/15	REPORT ON ASSESSMENT AND AVOIDANCE OF INCIDENTAL MORTALITY IN THE CONVENTION AREA 1993/94 United States of America
SC-CAMLR-XIII/BG/4	FISHING GEAR, OIL AND MARINE DEBRIS ASSOCIATED WITH SEABIRDS AT BIRD ISLAND, SOUTH GEORGIA, 1993/94 Delegation of United Kingdom

**DATA TO BE COLLECTED AND REPORTED BY  
SCIENTIFIC OBSERVERS ON LONGLINE VESSELS**

**General items**

Cruise date (trip start/finish date)\*  
 Observer name\*  
 Designating CCAMLR Member\*  
 Vessel name\*  
 Vessel type (longliner, converted, etc.)\*  
 Nationality  
 Owner\*  
 Captain\*  
 Fishing master  
 Vessel radio call sign\*  
 Target species\*  
 Registered length  
 Gross weight (GRT)  
 Electronic equipment  
*Comments*

**Fishing Gear Description**

Start/end date of gear use  
 Longline type (e.g. traditional, Spanish, automatic line, etc.)\*  
 Diagram of configuration of the longline  
 Samples of fishing gear collected  
 Mainline material  
 Mainline diameter (mm)\*  
 Branch material  
 Branch length (m)\*  
 Hook size\*  
 Hook type\*  
 Hook make/model\*  
 Height of hook setting off the bottom\*  
 Method of baiting (manual/automatic)  
 Automatic baiting (random/precision)  
 Vessel equipped with streamer line (Y/N)  
 Floats  
 Weights  
*Comments*

**Environmental Conditions**

Wind speed/direction\*  
 Sea height/direction  
 Swell height/direction  
 Barometric pressure  
 Barometer (rising/falling/steady)  
 Cloud cover  
 External air temperature  
 Surface water temperature\*  
 Daylight period (dawn, dusk, day, night)  
 Moonlight (full moon, half moon, none)  
 Deck lights (On/Off)  
*Comments*

**Bait details**

Bait species\*  
 Bait size  
 Bait mix (proportion)  
 Bait thawing (full thawed, half frozen, frozen)  
*Comments*

**Offal dumping (Y/N)**

Time/date of observation  
 Side of vessel (longline set/opposite)  
 Start/stop time of dumping  
*Comments*

### **Streamer Line Description**

Diagram of the mitigation device  
Samples of mitigation device collected  
Bird pole length (m)  
Bird pole position  
Streamer line length (m)  
Streamer line material  
Streamer line diameter (mm)  
Streamers length (m)  
Streamers material  
Streamers diameter (mm)  
Streamers colour  
Streamers distance apart (m)  
Number of streamers  
Height of attachment above water  
Line over bait entry point ? (Y/N)  
Distance from bait entry point and bird line  
*Comments*

### **Set and Haul Details**

Time zone  
Start/end set time/date\*  
Start/end set latitude/longitude\*  
Start/end haul time/date\*  
Start/end haul latitude/longitude\*  
Setting speed/ship speed (knots)  
Mainline length (km)  
Number of hooks set  
Distance between branches  
Streamer line in use? (Y/N)  
*Comments*

### **Bird and marine mammals abundance during line setting**

Time/date of observation\*  
Estimated total no. of birds\*  
Estimated no. of albatrosses  
Estimated no. of petrels  
Estimated no. of penguins  
Estimated no. of seals  
Estimated no. of whales  
*Comments*

### **Seabird By-catch Data**

Time/Date of observation\*  
Species\*  
Time in on haul  
Alive or dead  
Cause of injury or death\*  
Sample retained (Y/N)  
Type of sample (whole bird/head only)  
Sample number  
Band (Y/N)  
Tag number  
Number of hooks observed  
*Comments*

### **Marine Mammals Interaction**

Time/date of observation\*  
Species\*  
Number\*  
Interaction description\*  
*Comments*

\* Data currently reported on the CCAMLR standard fine-scale catch and effort data form for the longline fishery (form C2, version 4) and the form for reporting observations on incidental mortality of birds and mammals (format 7, *Scientific Observers Manual*).

**INTERNATIONAL FISHERIES ORGANISATIONS WHOSE COMPETENCE  
COVERS WATERS ADJACENT TO THE CCAMLR CONVENTION AREA**

Organisation	Fisheries Managed	Areas Covered
International Commission for the Conservation of Atlantic Tunas (ICCAT)	Tuna and tuna-like species	Atlantic Ocean between 50°N and 50°S
Indian Ocean Tuna Commission	Tuna and tuna-like species except southern bluefin tuna	Indian Ocean (FAO Areas 51 and 57) Western Pacific (FAO Area 71)
Indian Ocean Fisheries Commission (IOFC)	Species other than tuna and tuna-like species	Indian Ocean (FAO Areas 51 and 57)
South Pacific Commission (SPC)	Tunas (mainly skip jack, yellow fin, big eye and albacore); no management responsibility, research only	Western and Central Pacific (southern boundary at 45°S) between 150°E and 140°W
South Pacific Forum Fisheries Agency (FFA)	All species of finfish and shellfish	200-mile EEZ of South Pacific Ocean states
Commission for the Conservation of the Southern Bluefin Tuna (CCSBT)	Southern bluefin tuna	All areas where this species occurs, mainly to the south of 30°S
Inter-American Tropical Tuna Commission (I-ATTC)	All species of tuna and billfish	Eastern Pacific within FAO Area 87

**SCIENTIFIC COMMITTEE BUDGET FOR 1995  
AND FORECAST BUDGET FOR 1996**

<u>1994</u>		<u>1995</u>	<u>1996</u>
	<b>Working Group activities:</b>		
17 200	WG-Krill meeting	0	0
16 700	WG-CEMP meeting	0	0
8 000	Joint Meeting on Functional Approaches	0	0
0	WG-EMM meeting	35 100	36 500
7 100	Sea-ice Monitoring	0	3 100
0	Standard Methods	4 000	0
27 200	WG-FSA meeting	29 000	29 100
0	WG-IMALF meeting	0	6 100
0	Publication of 1994 meeting report	1 000	0
0	Conservation in longline fisheries brochure	4 000	0
	<b>Workshops:</b>		
8 000	Krill Flux Analysis	0	0
0	<i>D. eleginoides</i> analysis methods	8 000	0
0	At-sea Monitoring Workshop	0	8 200
	<b>Secretariat Travel</b>		
27 600	Travel for Workshops and Working Groups	31 200	34 000
5 500	Representation at SCAR Symposium	0	0
4 000	Representation at SCAR/COMNAP Data Meeting	3 000	4 000
0	Representation at ICES and CWP	4 000	4 100
	<b>Other</b>		
0	APIS Program planning meeting	2 500	0
<u>5 900</u>	Contingency	<u>6 000</u>	<u>6 200</u>
A\$127 200	Total from Commission Budget	A\$127 800	A\$131 300

**ACCESS TO AND USE OF DATA WITHIN CCAML R**



## ACCESS TO AND USE OF DATA WITHIN CCAMLR

Over the past couple of years problems occasionally have arisen concerning the use of data provided for work requested by CCAMLR.

2. Article XX, paragraph (1) of the Convention states:

‘The Members of the Commission shall, to the greatest extent possible, provide annually to the Commission and to the Scientific Committee such statistical, biological and other data and information as the Commission and Scientific Committee may require in the exercise of their functions.’

This clearly indicates that the submission/utilisation of data is crucial to the Commission’s effective operation. Commensurate with the functions of the Scientific Committee implicit in Article XV, the analysis of data submitted to CCAMLR should also be directed in pursuance of the Convention’s objectives.

3. Together, these provisions imply that comprehensive, unhindered analyses and exchange of data are required, so necessitating extensive cooperation between researchers in different Member countries. Further, to make timely progress with such work prompt submission and circulation of data are essential.

4. The basic rights of data originators/providers are implicit in the above process. Consequently, the intellectual investment in and time/effort spent collecting specific data entitles the investigator(s) concerned to certain fundamental rights which need protecting. That is, the publication of descriptive, or interpretative, results derived immediately and directly from the data is the first privilege and responsibility of the scientists who collected them.

5. To ensure equitable and practical use of data submitted to the CCAMLR Data Centre, the Commission gave effect to these principles at its Eighth Meeting (CCAMLR-VIII, paragraph 64) by agreeing that:

- (a) All data submitted to the CCAMLR Data Centre should be freely available to Members for analysis and preparation of papers for use within the CCAMLR Commission, Scientific Committee and subsidiary bodies.

- (b) The originators/owners of the data should retain control over any use of their unpublished data outside of CCAMLR.
- (c) When Members request access to data for the purpose of undertaking analyses of or preparing papers to be considered by future meetings of CCAMLR bodies, the Secretariat should supply the data and inform the originators/owners of the data. When data are requested for other purposes, the Secretariat will, in response to a detailed request, supply the data only after permission has been given by originators/owners of the data.
- (d) Data contained in papers prepared for meetings of the Commission, Scientific Committee, and their subsidiary bodies should not be cited or used in the preparation of papers to be published outside of CCAMLR without the permission of the originators/owners of the data. Furthermore, because inclusion of papers in the *Selected Scientific Papers* (now read *CCAMLR Science*) series or any other of the Commission's or Scientific Committee's publications, constitutes formal publication, written permission to publish papers prepared for meetings of the Commission, Scientific Committee and Working Groups should be obtained from the originators/owners of the data and authors of papers.
- (c) The following statement should be placed on the cover page of all unpublished working papers and background documents tabled:

'This paper is presented for consideration by CCAMLR and may contain unpublished data, analyses, and/or conclusions subject to change. Data contained in this paper should not be cited or used for purposes other than the work of the CCAMLR Commission, Scientific Committee or their subsidiary bodies without the permission of the originators/owners of the data.'

6. This carries the clear implication that any scientist wishing to make use of data in the CCAMLR Database other than his own should communicate with the investigator(s) who acquired the data prior to commencing analysis; this consultation is mandatory if any form of publication of the results of analyses is envisaged. These rules and procedures should be applied to all data submitted to CCAMLR.

7. In cases where collaborative undertakings involving data are planned, it is essential to establish responsibilities (i.e., for data submission, analysis and authorship) at the outset.

8. In all cases, it is recommended that effective communication between data users and data owners/originators be established. Permission to publish the results of such usage, and agreements to authorship should be obtained before submission of any subsequent papers for publication.

Extract from SC-CAMLR-XIII/4

Access to and Use of Data within CCAMLR

5.27 The Convener outlined briefly the principles of access to data and use of data within CCAMLR (WG-Krill-94/19).

5.28 Some concern was expressed where collaborative analyses, to be carried out during the intersessional period, were sanctioned by the Working Group during its meeting.

5.29 The Working Group reiterated that:

- (i) analyses presented as Working Group documents are not considered to be public documents; and
- (ii) if the final aim of the analysis is formal publication then the onus is on the person(s) undertaking the analysis to obtain the necessary permission from the originators of the data at the outset of any collaborative undertaking.

5.30 The Working Group agreed that it is highly desirable that in cases outlined in paragraph 5.29 that this permission should be obtained during the relevant Working Group or subgroup meeting.

Extract from SC-CAMLR-XIII/3

CCAMLR Policy on Data Access and Use

8.1 WG-CEMP considered that WG-Krill-94/19 provided a very useful explanation of how the CCAMLR policy on data access and use actually operated and of the principles that should guide the interpretation of this policy.

8.2 WG-CEMP noted that following the procedures set out in WG-Krill-94/19 should prevent some of the difficulties that have arisen in the last couple of years concerning the status of data in documents not actually tabled at CCAMLR meetings but circulated intersessionally for analyses to be presented at subsequent CCAMLR meetings.