

SC-CAMLR-XII

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

**REPORT OF THE TWELFTH MEETING
OF THE SCIENTIFIC COMMITTEE**

**HOBART, AUSTRALIA
25 - 29 OCTOBER, 1993**

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Abstract

This document presents the adopted record of the Twelfth Meeting of the Scientific Committee for the Conservation of Antarctic Marine Living Resources held in Hobart, Australia, from 25 to 29 October 1993. 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, United Nations Conference on straddling stocks and highly migratory species and publication of scientific papers. Reports of meetings and intersessional activities of subsidiary bodies of the Scientific Committee, including the Working Groups on Krill, on Fish Stock Assessment and for the CCAMLR Ecosystem Monitoring Program, are appended.

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**REPORT OF THE TWELFTH MEETING
OF THE SCIENTIFIC COMMITTEE**
(Hobart, Australia, 25 to 29 October 1993)

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 25 to 29 October 1993 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, Germany, 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 observers from Bulgaria, Greece, the Netherlands, Ukraine, the Antarctic and Southern Ocean Coalition (ASOC), the Food and Agriculture Organisation of the United Nations (FAO), the Intergovernmental Oceanographic Commission (IOC), the World Conservation Union (IUCN), the International Whaling Commission (IWC) and the Scientific Committee on Antarctic Research (SCAR) to the meeting and encouraged them to participate in the meeting as appropriate.

1.4 The observer from ASOC had been invited to attend the proceedings of the Scientific Committee by the Executive Secretary in accordance with rules of procedure for the attendance of observers to meetings of the Scientific Committee. The Delegation of Japan stated that it understood that the observer was attending under the conditions laid out in SC-CAMLR-X, paragraph 1.9. Amendments to the Rules of Procedure of the Scientific Committee were endorsed by the Commission at its 1991 meeting and are given in Annex 4 of SC-CAMLR-X.

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

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

- Dr V. Marín (Chile), Krill Resources;
- Dr M. Basson (UK), Fish Resources;

- Mr D. Miller (South Africa), Krill and Crab Resources;
- Dr B. Fernholm (Sweden), Scientific Research Exemption and New and Exploratory Fisheries;
- Dr J. Croxall (UK), Ecosystem Monitoring and Management;
- Dr W. de la Mare (Australia), Marine Mammal and Bird Populations and Assessment of Incidental Mortality;
- Drs D. Agnew and E. Sabourenkov (Secretariat), all other matters.

ADOPTION OF THE AGENDA

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

1.8 No items were proposed by Members for discussion under Item 19 “Other Business”.

REPORT OF THE CHAIRMAN

1.9 During the intersessional period Members had participated in a number of meetings. The Chairman expressed his thanks to Japan, the Republic of Korea and USA for hosting these meetings, and to Conveners, Members, Rapporteurs and the Secretariat for ensuring their success.

1.10 A Workshop on the Management of the Antarctic Crab Fishery was held in La Jolla, California, USA from 26 to 28 April 1993 and was chaired by the Convener, Dr R. Holt (USA).

1.11 The Working Group on Krill (WG-Krill) met from 4 to 12 August 1993 in Tokyo, Japan and was chaired by the Convener, Mr Miller. The Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP) met in Seoul, Republic of Korea from 16 to 23 August 1993, and was chaired by the Convener, Dr J. Bengtson (USA).

1.12 The Working Group on Fish Stock Assessment (WG-FSA) met in Hobart, Australia, from 12 to 19 October 1993, chaired by the Convener, Dr I. Everson (UK).

1.13 The report of WG-Krill is attached as Annex 4, that of WG-FSA as Annex 5, and that of WG-CEMP as Annex 6. The report of the Workshop on the Management of the Antarctic Crab Fishery is appended to the report of WG-FSA as Appendix E.

1.14 The Scientific Committee had been represented as an observer at a number of international meetings during the intersessional period. As appointed at last year's meeting (SC-CAMLR-XI, paragraph 10.24), Dr Agnew had been an observer for the Scientific Committee at the 81st Statutory Meeting of ICES, Dr de la Mare at the meeting of the IWC Scientific Committee and Dr Bengtson at the SCAR Planning Workshop for the Antarctic Pack-ice Seals Program (APIS). The APIS Program Workshop was co-sponsored by CCAMLR.

1.15 The Korea Ocean Research and Development Institute held the Third International Symposium on Antarctic Science on 24 and 25 August 1993 in Ansan, Republic of Korea. Dr Sabourenkov presented a paper at the Symposium entitled "The Role, Objectives and Activities of CCAMLR in the Antarctic Biological Sciences".

1.16 The first observation under the Scheme of International Scientific Observation had been conducted in the 1992/93 season through an agreement between Chile and the UK. In accordance with this agreement, a Scientific Observer nominated by the UK together with an observer nominated by Chile undertook scientific observations on board the Chilean longliner, *Frio Sur V*, fishing for *Dissostichus eleginoides* in Subarea 48.4 (South Sandwich Islands).

1.17 The first issue of the *CCAMLR Scientific Abstracts* and a new volume of the *Selected Scientific Papers* were published and distributed to Members in April and September 1993 respectively.

KRILL RESOURCES

FISHERY STATUS AND TRENDS

2.1 The krill catch for the 1992/93 season was 70% less than in 1991/92 and totalled 88 000 tonnes (Table 2.1).

Table 2.1: National krill landings (in tonnes) since 1984/85 based on STATLANT returns.

Member	Split-Year*								
	1985	1986	1987	1988	1989	1990	1991	1992	1993
Chile	2598	3264	4063	5938	5329	4501	3679	6066	3261
Germany	50	0	0	0	0	396	0	0	0
Japan	38274	61074	78360	73112	78928	62187	67582	74325	59272
Republic of Korea	0	0	1527	1525	1779	4040	1211	519	0
Poland	0	2065	1726	5215	6997	1275	9571	8607	15910
Spain	0	0	379	0	0	0	0	0	0
USSR**	150538	379270	290401	284873	301498	302376	275495	0	0
Russia								137310	2998
Ukraine								61719	6083
Total	191460	445673	376456	370663	394531	374775	357538	288546	87524

* 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, statistics are compiled here for Russia and Ukraine separately for the complete split-year, i.e. 1 July 1991 to 30 June 1992 for comparative purposes.

2.2 The total krill catch by subarea and country for 1991/92 and 1992/93 is given in Table 2.2.

Table 2.2: Total krill catch in 1992/93 by area and country. The catch for 1991/92 is indicated in brackets.

Subarea /Area	Chile	Japan	Republic of Korea	Poland	Russia	Ukraine
48.1	3261 (6066)	29665 (61598)	0 (519)	7294 (641)	0 (8975)	
48.2		10049 (272)		2621 (2742)	0 (80142)	0 (20333)
48.3		13763 (12405)		5995 (5224)	2948 (48163)	6083 (41386)
48.4						
48.6		33 (0)				
58.4.1		5762 (0)			50 (0)	
88		(50)				
Total	3261 (6066)	59272 (74325)	0 (519)	15910 (8607)	2998 (137310)	6083 (61719)

Subarea /Area	Total
48.1	40220 (77799)
48.2	12670 (103489)
48.3	28789 (107178)
48.4	
48.6	33 (30)
58.4.1	5812 (0)
88	(50)
Total	87524 (288546)

2.3 Table 2.2 shows that catches by Chile and Japan decreased and those of Poland increased in the 1992/93 season. The combined fleets of Russia and Ukraine have substantially reduced their catch levels since 1991/92.

2.4 Dr K. Shust (Russia) stated that it is not possible to forecast precisely the level of catches for 1993/94. He anticipated that four or five vessels may participate in the krill fishery and further supposed that some of this activity may have the form of joint-ventures.

2.5 Dr M. Naganobu (Japan) indicated that catches by Japanese vessels in 1993/94 will be about the same level as recent years.

2.6 Mr Z. Cielniaszek (Poland) stated that the increase in krill catches during last season is not going to continue in the future.

2.7 Dr V. Yakovlev (Ukraine) reported Ukrainian activities related to krill fishery. He stated that differences between STATLANT and fine-scale data submissions were the result of incomplete information provided by the vessels. Furthermore, he stated that fine-scale data from July to August 1992 had been prepared and submitted to this meeting. He anticipated that six Ukrainian vessels would participate in the krill fishery during 1994 and that observers would be deployed on some of these. A detailed report of Ukrainian activities was submitted as CCAMLR-XII/BG/15.

2.8 The Commission's attention is drawn to India's reported interest in participating in the krill fishery (Annex 4, paragraph 3.12).

2.9 As stated in the past, the Scientific Committee agreed that it would still be valuable if fishing Members could indicate the number of vessels planning to fish for krill in the forthcoming season, their catching capacities and proposed fishing grounds. While many Members again expressed their reservations as to the practicality of this, there was general agreement that the marked reductions in krill catches during the most recent season indicate that the fishery is in a particularly dynamic state and such information would be useful in anticipating substantial changes in catch levels in the future.

2.10 Lic. E. Marschoff (Argentina) asked about responsibilities for submitting data to CCAMLR in the cases of such joint ventures, particularly when a non-member country participated in the venture. Members also discussed the issue of responsibility for reporting data when two Members carry out a joint venture. The Scientific Committee agreed that this issue should be brought to the Commission's attention, especially regarding:

- (i) which country is responsible for submitting the data arising from joint ventures in the Convention Area to CCAMLR?
- (ii) how should responsibilities be delimited in cases where a member and a non-member nation start a joint fishing venture in the Convention Area?

2.11 The observer from FAO (Dr R. Shotton) stated that in the case of submission of fisheries data to FAO, the catches are attributed to the country of registration of the vessel concerned.

REPORT OF THE WORKING GROUP ON KRILL

2.12 The Fifth Meeting of the Working Group on Krill (WG-Krill) was held in Tokyo, Japan from 4 to 12 August 1993 under the convenership of Mr Miller. The report of the meeting is attached as Annex 4.

Review of Information from the Fisheries (Annex 4, paragraphs 3.1 to 3.40)

2.13 The Scientific Committee noted that WG-Krill had indicated it would be useful to obtain information on anticipated product demands as this might affect the location and activities of the fishery (Annex 4, paragraph 3.5).

2.14 With respect to the submission of data to WG-Krill, the Scientific Committee noted that analyses of Japanese fine-scale catch and effort data had been submitted for a number of years and that good use of these data had been made (Annex 4, paragraphs 3.13 and 3.14).

2.15 Dr Naganobu stated that last year Japan had agreed to submit krill fishery data at a resolution of 10 x 10 n miles and that data will continue to be provided in the future. Furthermore he stated that next year Japan plans to submit historical fine-scale data.

2.16 The Scientific Committee thanked Japan for providing the fine-scale data and also data on a scale of 10 x 10 n miles and looked forward to receiving further historical data in the near future.

2.17 The necessity for, and the continued difficulties experienced in, submitting historical commercial krill catch data at a variety of scales from the former Soviet Union were noted.

2.18 The Scientific Committee noted that data were held in the Russian Federation in three forms: as hard copy in summary reports and 15-day reports with additional information being held on magnetic tape. It was noted that the examples of fine-scale summaries of historic data provided to WG-Krill were in a format compatible with the CCAMLR database.

2.19 The Scientific Committee noted that it would be a major task to prepare all these data for submission to CCAMLR and Members were encouraged to assist with this effort where possible. It was noted that scientists from Russia and the USA were attempting to expedite this work.

2.20 Dr S. Kim (Republic of Korea) informed the Scientific Committee that since the preparation of Table 1 of Annex 4, the Republic of Korea had reported fine-scale data for 1988.

2.21 The observer from Ukraine stated that Ukraine has a substantial dataset on krill catches in Division 58.4.2 from 1978 to 1984 and that they would also like to explore ways in which these data, with the help of other Members, could be made available to CCAMLR. He noted that fine-scale data from 1978 were submitted at the meeting.

2.22 The Scientific Committee again noted the value of haul-by-haul data from both the Japanese and Chilean krill fisheries analysed in several papers submitted to the Working Group and the submission of length frequency data by Japan (Annex 4, paragraphs 3.22 and 3.23).

2.23 In this connection, the important role of Scientific Observers aboard commercial krill fishing vessels was also highlighted. The Scientific Committee took note of WG-Krill's indication that it will be some time before comprehensive observer reports become available under the Scientific Observers Scheme and the utility of the *Scientific Observers Manual* can be effectively assessed (Annex 4, paragraph 3.25).

2.24 The Scientific Committee reviewed developments concerning assessment of the incidental by-catch of fish during krill fishing operations (Annex 4, paragraphs 3.26 to 3.34) (see also paragraph 3.80).

2.25 The Scientific Committee noted recent developments and WG-Krill's deliberations on the problem of assessing the mortality of krill not retained during trawling (Annex 4, paragraphs 3.35 to 3.38). It endorsed the Working Group's call for independent validation by the Secretariat of the model addressing the problem, a need to undertake sensitivity tests of the model and for experiments to be undertaken to test some of its basic assumptions.

2.26 Preliminary results of a joint Chilean/US initiative to address the problem of deriving a Composite Index of Krill Abundance were noted (Annex 4, paragraph 3.39). A full report of these results will be submitted to the next meeting of WG-Krill.

Estimation of Krill Yield (Annex 4, paragraphs 4.1 to 4.83)

Krill Flux in Statistical Area 48 (Annex 4, paragraphs 4.1 to 4.10)

2.27 The Scientific Committee noted WG-Krill's deliberations on the effects of water movement on krill distribution, particularly in the context of improving the estimation of potential yield.

2.28 There was agreement that a considerable body of data could be brought to bear on the problem of krill fluxes. The Scientific Committee endorsed the Working Group's proposal for a workshop which would attempt to calculate integrated mass flows across subarea boundaries in Statistical Area 48 (Annex 4, paragraph 4.4).

2.29 This "Workshop on Evaluating Krill Flux Factors" should have the following terms of reference:

- (i) to use existing data to:
 - (a) determine water mass transport across the boundaries of selected ocean areas in terms of velocity profiles normal to the boundaries, integrated over the depth range 0 to 200 m;
 - (b) determine krill density along each of the selected boundaries;
 - (c) determine the mean retention time of particles in selected small areas;
- (ii) to use information from (i) to calculate the passive krill fluxes across the boundaries;
and
- (iii) to propose methods for further studies on questions of krill fluxes.

2.30 A steering committee comprising Drs de la Mare, Agnew and Naganobu and Mr Miller was appointed to oversee the Workshop preparations. The Scientific Committee agreed that the minimum dataset required for the Workshop should be a specified set of integrated water mass

transport velocity profiles obtained from the FRAM model, along with both hydrographic data and acoustic density estimates from the BIOMASS Program. Additional datasets should be prepared according to specifications set out in Annex 4, Appendix E. Data should be submitted to the Secretariat at least two months in advance of the Workshop in order for them to be incorporated into a database in the form required. It was agreed that it would be necessary to postpone the Workshop if the specified data were not available in good time.

2.31 The Steering Committee will correspond during the intersessional period with a view to evaluating whether the Workshop should take place and if it is to take place, to agree on the two invited experts.

2.32 Financial provision for the Workshop has been included in the proposed Scientific Committee budget for 1994. This budget includes provision for the attendance of two invited experts.

Estimation of Effective Biomass (Annex 4, paragraphs 4.11 to 4.40)

2.33 The Scientific Committee endorsed without comment WG-Krill's call for further work regarding acoustic methods (Annex 4, paragraphs 4.15, 4.16, 4.20 and 4.22).

2.34 With respect to estimating krill biomass in Statistical Area 48, the Scientific Committee noted that WG-Krill had re-analysed the FIBEX acoustic data in accordance with the Scientific Committee's request (SC-CAMLR-XI, paragraphs 2.35 and 2.107).

2.35 The Scientific Committee agreed with WG-Krill's conclusion that the estimates of krill biomass in Statistical Area 48 from FIBEX have now been refined as far as is practical.

2.36 The revised FIBEX biomass estimates (Annex 4, Table 4) differ from those presented to the Scientific Committee last year (SC-CAMLR-XI, Annex 4, Table 2):

- the total biomass for Subarea 48.1 is increased from 10.5 to 13.6 million tonnes (Annex 4, paragraphs 4.26, 4.27 and 4.31); and
- the total biomass for Subarea 48.2 is increased from 9.4 to 15.6 million tonnes (Annex 4, paragraphs 4.28 and 4.31).

2.37 Various other reports presented to WG-Krill on the estimation of krill biomass in Statistical Area 48 were noted (Annex 4, paragraphs 4.32 to 4.38).

Near-synoptic Survey(s) in Statistical Area 48
(Annex 4, paragraphs 4.41 to 4.54)

2.38 In response to requests from both the Scientific Committee (SC-CAMLR-XI, paragraphs 2.69, 2.107, 2.116 and 2.117) and Commission (CCAMLR-XI, paragraphs 4.14 and 4.15), WG-Krill had considered the question of carrying out near-synoptic surveys in various statistical areas in the near future.

2.39 The Scientific Committee agreed that the primary purpose of such surveys would be to improve estimates of B_0 (pre-exploitation biomass) used in the population model to estimate sustainable yield (see also paragraphs 2.41 to 2.47). It further agreed that designated survey areas would be most likely to include large portions of Statistical Area 48 and smaller portions of Statistical Area 58 (Annex 4, paragraph 4.41).

2.40 The Scientific Committee concurred with WG-Krill's conclusion that although current fishing levels in Statistical Area 48 are low with respect to the precautionary catch limit of 1.5 million tonnes set by Conservation Measure 32/X (Annex 4, paragraph 4.43), there is a need to begin developing plans for, and designing, suitable near-synoptic surveys in parts of Statistical Areas 48 and 58 (Annex 4, paragraphs 4.43 and 4.44).

2.41 The Scientific Committee agreed that the Convener of WG-Krill should coordinate an *ad hoc* correspondence group in the forthcoming intersessional period to tackle the problem of designing near-synoptic surveys to estimate B_0 . This group will report to WG-Krill's next meeting (Annex 4, paragraph 4.47).

2.42 In considering the question of krill surveys in general, the Scientific Committee agreed that there is no urgent need to put aside funds for the Russian KRAM project at this time (Annex 4, paragraphs 4.49 to 4.53).

2.43 Dr de la Mare stated that Australia plans to conduct a survey of part of Division 58.4.1 in February 1996 to estimate krill biomass. He sought expressions of interest from Members who might be able to participate in the survey so as to extend coverage to a larger proportion of Division 58.4.1. A detailed survey plan will be presented at the next meeting of the Working Group.

Refinement of Yield Estimate Calculations
(Annex 4, paragraphs 4.55 to 4.83)

2.44 The Scientific Committee noted that various refinements to the process and model used to calculate krill potential yield had been carried out during the intersessional period and were presented to WG-Krill (Annex 4, paragraphs 4.55 to 4.83 and papers WG-Krill-93/12, 13 and 42 in particular).

2.45 It was also noted that specific account had been taken of uncertainties in the values of various biological parameters and that the problems encountered in reconciling independent estimates of yield using the same underlying model (SC-CAMLR-XI, paragraphs 2.41 and 2.42) had been rectified through the verification procedure proposed by the Scientific Committee (Annex 4, paragraph 4.55).

2.46 Differences in this year's results compared with those presented last year were acknowledged (Annex 4, paragraphs 4.56 to 4.59).

2.47 The Scientific Committee endorsed WG-Krill's recommendations (Annex 4, paragraphs 4.60 to 4.64 and Appendix E) with respect to improving inputs into the model and the criteria used for selecting a value for γ (the multiplication factor that provides an estimate of potential yield).

2.48 Prof. J. Beddington (UK) welcomed the substantial progress that had been made. He stated that he believed it was now timely for the results to be related to particular CCAMLR areas so that the implications of the work for particular conservation measures could be assessed.

2.49 Dr de la Mare noted that the model was used for calculating the potential yields on which Conservation Measures were based. As such, the results were already related to particular areas. He agreed, however, with Prof. Beddington that this may not be obvious from the reports of WG-Krill.

2.50 The Scientific Committee agreed that there was a need for greater clarity in describing and presenting the relationships between the various components which go into calculating potential yield in particular areas. WG-Krill was requested to take note of this in its future presentations on this topic.

2.51 The Scientific Committee also agreed that a significant breakthrough had been made in WG-Krill's ongoing efforts to assess krill recruitment and its variability (Annex 4, paragraphs 4.65 to 4.73). It endorsed WG-Krill's proposals to investigate the effects of selectivity on numerical density-at-length samples (Annex 4, paragraphs 4.68 to 4.70) and that the Secretariat be tasked with validating the proposed recruitment model (WG-Krill-93/12) as well as the computer programs associated with its analysis (WG-Krill-93/13) (Annex 4, paragraph 4.73).

Ecological Implications of Krill Fishing (Annex 4, paragraphs 5.1 to 5.45)

Location and Timing of Fishery (Annex 4, paragraphs 5.1 to 5.32)

2.52 At its last meeting, the Scientific Committee had sought WG-Krill's advice on possible measures to ensure that krill catches are not concentrated in areas close to predator colonies (SC-CAMLR-XI, paragraphs 2.78 and 5.39 to 5.43). The Scientific Committee endorsed WG-Krill's discussion on this matter (Annex 4, paragraphs 5.1 to 5.11) and its deliberations may be found in paragraphs 8.30 to 8.44.

2.53 The Scientific Committee agreed that the Japanese study of 10 x 10 n miles catch data presented to WG-Krill not only offered an important contribution to the Working Group's work, but also served to emphasise the importance of reporting fine-scale data (Annex 4, paragraph 5.9). Further research along the lines of the Japanese study was encouraged.

Relation of Fishing to Krill Predators
(Annex 4, paragraphs 5.12 to 5.25)

2.54 Using the framework developed by the Joint Meeting of WG-Krill and WG-CEMP in 1992 (SC-CAMLR-XI, Annex 8, Appendix 1), WG-Krill reviewed initial attempts to model inter-relationships between krill, dependent predators and the fishery by means of a one-way interaction model (Annex 4, paragraphs 5.12 to 5.21).

2.55 The Scientific Committee noted that WG-Krill's discussion concerning the simulation analysis had resulted in a number of questions being posed to the originators of the data via WG-CEMP. It noted that WG-CEMP had responded to most of these questions in its report and had requested answers to the remaining ones by correspondence. Furthermore, WG-CEMP had indicated that the model would be significantly improved by using year-specific values and had requested that these data be supplied. The Scientific Committee endorsed this approach.

2.56 The Scientific Committee noted the suggestion of WG-Krill for future modifications to the model and agreed that it would be useful to undertake these once analyses based on the original model had been carried out with the corrected data and with the modifications suggested by WG-CEMP.

2.57 Some members of the Scientific Committee commented that the development of models of functional relationships between krill dependent predators and the fishery should run in parallel to field research.

Status and Role of CPUE Indices (Annex 4, paragraphs 5.26 to 5.32)

2.58 The Scientific Committee endorsed WG-Krill's view that it is important to distinguish between the use of CPUE information for the purpose of estimating krill biomass and its uses for other purposes, such as using CPUE as a measure of local density (Annex 4, paragraph 5.27). It reiterated the importance of collecting and submitting catch and effort data from the krill fishery.

2.59 In the context of using CPUE indices to improve current understanding of the relationship between local krill abundance and fishery, the Scientific Committee encouraged fishing nations to investigate the feasibility and cost of recording search time information from the fishery along the lines outlined by WG-Krill (Annex 4, paragraphs 5.31 and 5.32).

Effects of Management Measures on Krill Fishing (Annex 4, paragraphs 5.33 to 5.40)

2.60 A simulation study of the consequences of different extents and locations of closed areas on the krill fishery in Subarea 48.1 (SC-CAMLR-XI, paragraphs 5.41 and 5.42) had been submitted to the Working Group in response to a former request by the Scientific Committee (WG-Krill-93/14).

2.61 The Scientific Committee agreed with WG-Krill that the Secretariat model was a good first attempt and that it could serve as a basis for further developments. The availability of fine-scale data from vessels operating in different locations during the entire fishing season was recognised as important in future efforts to refine the model (Annex 4, paragraph 5.38). The submission of such data was again encouraged.

2.62 It also agreed that it would be useful to receive operational information from the fishery on the underlying reasons for fishing off both the Elephant and Livingston Islands (Annex 4, paragraph 5.37).

2.63 The Scientific Committee noted the desire of WG-Krill to continue the dialogue with fishing nations concerning the consequences of potential precautionary management measures for localised areas in Subarea 48.1 (see also Annex 4, paragraph 5.39). This topic is discussed further in paragraphs 8.42 to 8.44.

Liaison with WG-CEMP (Annex 4, paragraphs 5.41 and 5.45)

2.64 Close liaison between WG-Krill and WG-CEMP was endorsed in the interests of developing feedback management procedures and in developing predator/prey interaction models in Subarea 48.1 as well as other subareas (Annex 4, paragraphs 5.41 to 5.43).

2.65 The Scientific Committee noted that the continuing development of krill and krill-predator interaction models (see paragraphs 2.53 to 2.57 and 8.46 to 8.51) will facilitate future progress on evaluating the statistical performance/cost effectiveness of possible experimental harvest regimes to distinguish between natural variation in predator performance and effects due to fishing (Annex 4, paragraph 5.45).

Precautionary Catch Limits on Krill Catches (Annex 4, paragraphs 6.1 to 6.14)

2.66 Dr Naganobu indicated that WG-Krill had, at its 1992 meeting, used $\gamma=0.063$ in the estimation of krill potential yield even though Japan had submitted a paper suggesting that 6.3% is too low based on a simplified version of the yield estimation model (SC-CAMLR-XI, Annex 4, paragraph 2.41). He recalled that at WG-Krill's most recent meeting in Tokyo, the Working Group concluded that the adequate cross-checks of the yield estimation approach had been carried out by the Secretariat and Japanese scientists and that a value of $\gamma=0.165$ is consistent with criterion used previously by the Working Group.

2.67 However, Dr Naganobu stressed that he could accept the value of $\gamma=0.1$, given that:

- (i) the estimate of γ has changed over the past three meetings from 0.1 in 1991 to 0.063 in 1992, to 0.165 this year;

- (ii) $\gamma=0.1$ has been generally accepted as the traditional criterion for potential yield estimation; and
- (iii) $\gamma=0.1$ also takes implicit account of the agreed concepts of Article II (see discussion in Annex 4, paragraph 6.6).

2.68 Therefore, Dr Naganobu and some other Members concluded that, in their opinion, the Scientific Committee should endorse $\gamma=0.1$ as a working value at the present time until a more reliable value of γ becomes available.

2.69 The Scientific Committee agreed that for the time being $\gamma=0.1$ should be used.

2.70 The implications of the chosen γ level expressed as a proportion of median levels in the absence of exploitation are given in the following table. The Scientific Committee noted that the implication for future krill spawning biomasses contained in this table is consistent with the Commission's agreed concepts in relation to operational definitions of Article II set out in paragraph 6.5 of the WG-Krill report (Annex 4).

Statistic	$\gamma = 0.1$
Probability of biomass falling below 0.2 over 20-year harvest period	0.02
Biomass level at the end of 20 years:	
median	0.78
lower 5% -ile	0.41

2.71 The Scientific Committee agreed that the current best estimates of krill potential yield are as follows. These are shown together with the catch levels reported for the 1992/93 season.

Area/Division	B_0 (million tonnes)	Y (million tonnes) $\gamma = 0.1$	1992/93 Catch (million tonnes)
48.1 + 48.2 + 48.3	30.8	3.08	0.08
48.6	4.6	0.46	0
58.4.2	3.9	0.39	0

2.72 The Scientific Committee noted the following:

- (i) the estimates of B_0 are now some 12 years old;
- (ii) the current value for γ may be reconsidered following further development of the recently initiated krill-predator modelling studies (paragraphs 2.54 to 2.57);
- (iii) data derived estimates of certain biological parameters (particularly krill recruitment and variability - paragraphs 2.47 and 2.51) will only be available next year. The ranges of such parameters are vital for predicting the statistical distributions of krill biomass for different γ values; and
- (iv) only in 1994 will it be possible to take these estimates, along with other refinements to the krill potential yield model (Annex 4, Appendix E), into account in providing improved predictions for alternative choices of γ .

2.73 In this connection, Dr Naganobu stated that:

- (i) the Scientific Committee at its last meeting had endorsed the catch limits recommended by WG-Krill (SC-CAMLR-XI, paragraph 2.67; SC-CAMLR-XI, Annex 4, paragraph 6.1) prior to full validation of the model underlying estimation of krill potential yield (SC-CAMLR-XI, paragraph 2.41);
- (ii) WG-Krill had this year concluded that adequate validation of the yield estimation model had been carried out and that the ensuing results could be accepted (Annex 4, paragraph 4.55); and
- (iii) the best B_0 estimate of 30.8 million tonnes has been obtained from the re-analyses of the FIBEX data (paragraph 2.36).

2.74 For these reasons, Dr Naganobu concluded that the Scientific Committee should endorse the new yield estimate of 3.08 million tonnes contained in the table in paragraph 2.71 for Subareas 48.1, 48.2 and 48.3.

2.75 Lic. Marschoff indicated that the estimation of B_0 obtained from the re-analysis of the FIBEX data is associated with a high level of uncertainty and this fact should be drawn to the attention of the Commission.

2.76 The Scientific Committee noted that the information contained in the previous paragraphs may have some relevance for the precautionary catch limit currently contained in Conservation Measure 32/X. Similarly, it would also be relevant to the subarea allocation of this limit set out in Conservation Measure 46/XI.

2.77 The Scientific Committee advised the Commission that as developments in the scientific information underpinning such calculations of yield are made, the estimates of yield are likely to change. Noting the currently low prevailing catch levels in relation to the limit in Conservation Measure 32/X, the Scientific Committee sought the Commission's guidance on the frequency and magnitude by which krill catch limits may be adjusted in the light of changes in the scientific information underpinning such limits.

2.78 The Scientific Committee acknowledged that revision of current B_0 estimates for Division 58.4.2 should be available for consideration at WG-Krill's next meeting (Annex 4, paragraph 6.12).

2.79 It was agreed that high priority should also be afforded to planning a biomass survey in Division 58.4.1 since fishing was undertaken there during the most recent season (Annex 4, paragraphs 6.10 and 6.11) (see paragraph 2.43).

2.80 With respect to Division 58.4.2, the Scientific Committee agreed that the precautionary catch limit for this division set out in Conservation Measure 45/XI should not be revised at this stage, given the anticipated revision of the existing B_0 value, together with another estimate of this parameter based on the results of a recent survey undertaken by Australia in part of this division (Annex 4, paragraph 6.12).

Refining Operational Definitions of Article II (Annex 4, paragraphs 6.15 to 6.18)

2.81 The Scientific Committee noted that the method currently utilised by WG-Krill to provide estimates of krill potential yield already takes account of the first two concepts agreed by the Commission (CCAMLR-IX, paragraph 4.17) as operational definitions of Article II (Annex 4, paragraph 6.15).

FUTURE WORK OF WG-KRILL

2.82 The Scientific Committee noted that WG-Krill continues to make significant progress in its work. This refers, in particular, the refinement of procedures to calculate potential yield, the development of an approach to estimate recruitment variability, initial attempts to model functional relationships between krill, predators and the fishery, and the implementation of a procedure to plan future near-synoptic surveys of krill biomass.

2.83 The Scientific Committee endorsed the following topics as having the highest priority for WG-Krill in the forthcoming year:

- (i) the holding of a workshop to investigate water flux and krill movement in Statistical Area 48;
- (ii) estimation of total effective biomass in Division 58.4.2;
- (iii) further estimation, refinement and validation of methods to calculate potential yield and precautionary limits in various statistical areas and subareas, including refinements of the underlying model used to estimate yield as well as its input parameters (especially recruitment and recruitment variability);
- (iv) evaluation of procedures to collect search time information from the krill fishery and assessment of the associated practicalities and costs;
- (v) validation and sensitivity analyses of the model describing mortality arising from krill passing through net meshes during trawling; and
- (vi) refinement, in association with WG-CEMP, of models describing functional relationships between krill, predators and the fishery.

2.84 In addition, WG-Krill should continue to address issues associated with survey design, acoustic assessment of krill biomass, and the development of approaches to management.

2.85 In order to address the above issues, which are fundamental to the development of advice on krill, the Scientific Committee recommended that WG-Krill should meet during the intersessional period for approximately one week during 1994. The proposed Workshop on Evaluating Krill Flux Factors should be scheduled for a period of three days immediately prior to the Working Group's meeting.

2.86 The Scientific Committee noted the convergent nature of many of the matters being considered by WG-Krill and WG-CEMP. Members were requested to give consideration to an appropriate format whereby such matters could be most effectively dealt with in future meetings of the two Working Groups with a view to having more in-depth discussions at the Scientific Committee's 1994 meeting. Items to be considered would include some combination of WG-Krill and WG-CEMP's annual meetings and possible modification of WG-Krill's terms of reference. These topics will be included in the agenda for the Working Group's next meeting. A joint meeting of WG-Krill and WG-CEMP is planned for the annual meetings of the two Working Groups.

DATA REQUIREMENTS

2.87 The Scientific Committee was pleased to note the large number of papers tabled at WG-Krill and that these contained information relevant to the data requirements identified at the Working Group's 1992 meeting (SC-CAMLR-XI, Annex 4, Table 6). The Scientific Committee endorsed WG-Krill's updated table of information requirements (Annex 4, Table 6) and in particular:

- (i) the requirement to submit fine-scale catch and effort data from all subareas and the ISRs remains. Historical fine-scale catch data is still required for Statistical Area 58;
- (ii) the ongoing requirement to submit length frequency data from commercial vessels, haul-by-haul data (irrespective of proximity to CEMP sites) and information on the number/capacity of fishing vessels also remains;
- (iii) progress on the submission of historical fine-scale data from the former Soviet fishery is encouraged; and
- (iv) reports are encouraged on the anticipated costs and practicality of collecting and submitting search time information from the krill fishery in accordance with recommended procedures.

ADVICE TO THE COMMISSION

Specific Advice

2.88 Members are encouraged to investigate ways to facilitate the submission of historical catch data from the krill fishing fleets of the former Soviet Union (paragraph 2.17).

2.89 Analysis of the FIBEX data to estimate krill biomass has progressed as far as is practicable (paragraph 2.35).

2.90 Fishing nations are encouraged to investigate the feasibility and cost of recording search time information from the krill fishery (paragraph 2.59).

2.91 The Commission's attention is drawn to the Scientific Committee's deliberations on the estimation of krill yield in relation to the formulation of precautionary catch limits on krill (paragraphs 2.66 to 2.75).

2.92 Conservation Measures 32/X and 46/XI are currently in force. The latter measure applies to both the 1992/93 and 1993/94 seasons.

2.93 Conservation Measure 45/XI should not be revised at this stage, given the anticipated revision of the yield estimates for Division 58.4.2 (paragraphs 2.78 and 2.80).

2.94 The Commission's guidance is sought on the frequency and magnitude by which krill catch levels may be adjusted in the light of changing scientific information (paragraph 2.77).

General Advice

2.95 WG-Krill should hold an intersessional meeting during 1994 in order to continue work set out in paragraphs 2.83 to 2.86. A workshop on evaluating krill flux factors should be held immediately prior to this meeting. A joint meeting of WG-Krill and WG-CEMP will be held around the same time.

2.96 Members are requested to give consideration to an appropriate format whereby matters of common concern can be most effectively dealt with at future meetings of WG-Krill and WG-CEMP (paragraph 2.86).

2.97 Sensitivity tests and specific experiments should be undertaken to validate the proposed model on krill mortality resulting from passage through net meshes during trawling operations (paragraph 2.25).

2.98 An *ad hoc* correspondence group (coordinated by the Convener of WG-Krill) has been established to address the problem of designing future near-synoptic surveys during the forthcoming intersessional period (paragraph 2.41).

2.99 High priority should be afforded to designing a biomass survey in Division 58.4.1 in the near future (paragraph 2.79).

2.100 The Secretariat should validate and incorporate the new krill recruitment model into the procedures to calculate potential yield (paragraph 2.51).

2.101 To further assess the possible impact of krill fishing on krill predators, very fine-scale analyses of catch and effort data are encouraged (paragraph 2.53).

2.102 WG-Krill, in consultation with WG-CEMP, should continue developing functional models of interactions between krill, predators and fishery (paragraph 2.55).

2.103 The specific data requirements listed in paragraph 2.87 should be addressed as a matter of priority.

FISH RESOURCES

FISHERY STATUS AND TRENDS

3.1 The only reported finfish catches for the 1992/93 season were 3 049 tonnes of *D. eleginoides* from Subarea 48.3, 39 tonnes from Subarea 48.4 and 2 722 tonnes from Division 58.5.1 (SC-CAMLR-XII/BG/1). Catches of crabs are discussed under Item 4.

3.2 The Scientific Committee recognised that fishing plans are subject to decisions of the Commission. The following paragraphs describe plans which depend on these decisions.

3.3 Fishing plans for the 1993/94 season were considered. Russia plans to have two to three vessels fishing for toothfish in Subarea 48.3. Plans for icefish fishing have not yet been finalised but

at least one vessel would be involved. The total number would depend primarily on financial matters.

3.4 Mr Cielniaszek indicated that no Polish vessels fished for finfish during the 1992/93 season but that one or two vessels may operate in Subarea 48.3 in 1993/94. At this stage it is not clear whether these vessels would be fishing for finfish or for krill.

3.5 Chilean longliners operated in the Convention Area in 1992/93. The intention of Chilean authorities is to intensify the control of this fleet. This control could include no permission for fishing in the Convention Area during the 1993/94 season unless vessels comply with all legal requirements (CCAMLR-XII, Annex 5, paragraph 32). However, the current Chilean legislation does not allow such legal action.

3.6 Dr Naganobu indicated that no Japanese vessels would be fishing for finfish in the Convention Area in 1993/94.

3.7 Dr Kim indicated that one Korean vessel would be fishing for finfish in Subareas 48.3 and 48.4 in 1993/94.

3.8 Details of the fishing plans of Ukraine are given in CCAMLR-XII/BG/15. Two vessels intend to fish for toothfish in Subarea 48.3 but, because of financial considerations, plans for icefish have not yet been finalised.

3.9 CCAMLR-XII/MA/2 outlines the intentions of France for the next season. Two trawlers will be fishing in Division 58.5.1 for toothfish and icefish subject to French regulations for these species, particularly with regard to icefish.

REPORT OF THE WORKING GROUP ON FISH STOCK ASSESSMENT

3.10 The Working Group on Fish Stock Assessment (WG-FSA) met from 12 to 19 October 1993 at CCAMLR Headquarters in Hobart. The Convener of the Working Group, Dr Everson, presented the report of the meeting.

3.11 The Report of the Working Group is attached in Annex 5.

3.12 The largest part of the meeting was concerned with stock assessments. Additional topics were discussed at the meeting and are dealt with under other Scientific Committee agenda items.

These are: (i) the crab fishery in Subarea 48.3 (Annex 5, paragraphs 6.71 to 6.107); (ii) straddling and highly migratory stocks (Annex 5, paragraphs 6.147 to 6.165); and (iii) scientific observation (Annex 5, paragraphs 4.1 to 4.6)

Data Requirements Endorsed by the Commission in 1992

3.13 Various data were specifically requested by the Working Group in 1992 (SC-CAMLR-XI, Annex 5, Appendix D). Data submitted to the Secretariat in response to this request are listed in Appendix D.

3.14 Catch and biological information had been submitted from the two current fisheries for *D. eleginoides* at South Georgia and the Kerguelen Islands. Fine-scale data and length frequency information from the 1992 crab fishery in Subarea 48.3 had also been submitted. However, overall the submission of data requested by the Working Group from previous fishing seasons was disappointing.

Other Documents and Topics (Annex 5, paragraphs 5.11 to 5.24)

3.15 The Working Group discussed papers on various aspects relevant to applied ecology such as: feeding, growth and maturity studies, larval distribution, taxonomy and recruitment variability, as well as the distribution and trophic relations of Myctophidae. Papers on the rigging of codend meshes and estimation of seabed areas on the fishing grounds were also discussed.

3.16 Although these studies had little initial impact on the actual assessments, they are topics which need to be borne in mind when determining parameter values for many of the assessments.

New Fisheries (Annex 5, paragraphs 6.1 to 6.4)

3.17 Exploratory fishing had been undertaken for *D. eleginoides* in Subarea 48.4 by a Chilean vessel at the South Sandwich Islands. It was noted that a non-member state (Bulgaria) conducted a longline fishery in this subarea and forwarded haul-by-haul catch and effort data to CCAMLR. Catch rates were low and the area of fishable ground in the region investigated is small. The Working Group agreed that the prospects for developing a commercial fishery for *D. eleginoides* in the region are very poor. In the event that there is further interest in exploratory fishing in the area, WG-FSA recommended a TAC of 28 tonnes for *D. eleginoides* in the South Sandwich Islands.

3.18 In discussion it was noted that although catch rates of the Bulgarian vessel were far higher than the catch rates of the Chilean vessel, and also higher than catch rates of Bulgarian vessels fishing in Subarea 48.3, the Bulgarian catch rates in Subarea 48.4 declined rapidly. This was taken into account in the assessment and led to low estimates of biomass.

3.19 Dr C. Moreno (Chile) noted that the agreement between Chile and the UK to put Scientific Observers from both Member states on board the Chilean longliner that carried out the exploratory fishing in Subarea 48.4 was of great value. This sort of agreement can help to eliminate possible doubts about fisheries data and can provide valuable additional biological information.

3.20 The Scientific Committee drew attention to the fact that the Conservation Measure (44/XI) for 1992/93 with regard to this exploratory fishery allowed a TAC of 240 tonnes. This value was basically a sensible guess, thought to be a low value, since there was no information on which to base a TAC at the time. The assessment carried out at this year's meeting of WG-FSA indicates that a value of 240 tonnes is far too high and a TAC of 28 tonnes would be more appropriate.

3.21 It was noted that fishing only took place in the northern part of Subarea 48.4. Some Members felt that since the species reaches the southernmost limit of its distribution in the area and the bathymetry of the area was such that it was unlikely that large concentrations of toothfish would be found elsewhere within the subarea, the TAC calculated by WG-FSA could be related to the whole of Subarea 48.4. Other Members were of the opinion that the new fishery conducted in 1992/93 covered three islands in the north of Subarea 48.4, and therefore the catch level should relate only to these islands.

Management Advice

3.22 Most Members recommended a TAC of 28 tonnes for *D. eleginoides* in Subarea 48.4.

3.23 Some Members expressed doubt concerning the applicability of the TAC to the whole of Subarea 48.4.

3.24 The Scientific Committee also recommended that, because of the uncertainty about the applicability of this value to the entire subarea, the fishery continue to be viewed as a new fishery.

Assessments and Management Advice

3.25 Assessment summaries for the various fish stocks assessed by WG-FSA are presented in Appendix F of Annex 5.

Statistical Area 48 (South Atlantic)

Subarea 48.3 (South Georgia)

3.26 Catches from Subarea 48.3 are summarised in Table 1 of Annex 5. Apart from the 299 tonnes of *Paralomis* which is considered under Item 4, the only reported catches were 3049 tonnes of *D. eleginoides*.

3.27 Dr Kim indicated that one Korean vessel fished west of Subarea 48.3 in international waters between 9 April and 21 July 1993. The catch was 267 tonnes of *D. eleginoides*.

Dissostichus eleginoides (Subarea 48.3) (Annex 5, paragraphs 6.8 to 6.26)

3.28 The positions of catches (Annex 5, Figure 4) show that many hauls were reported from the north or west of Subarea 48.3 and outside of the Convention Area. Since these two fishing grounds are contiguous with Subarea 48.3, it was suggested that the fish taken on these grounds may belong to the same stock as that found within Subarea 48.3 and assessments were undertaken for all the fishing grounds.

3.29 Dr Shust stated that the stock assessment and potential yield level estimate were obtained with the use of a method which did not take into account the length and age data, presented by Dr Shust, for 1991 and 1992 catches of *D. eleginoides* taken in Subarea 48.3.

3.30 Drs de la Mare and E. Balguerías (Spain) responded that the Working Group had decided not to use length-based assessment methods because they assume the stock has been in equilibrium, that is, that the catch is equal to the sustainable yield. The assessment indicates that this assumption cannot be justified.

3.31 In discussion, Prof. Beddington expressed considerable doubts that all the catches reported from the western and northern grounds were taken outside the Convention Area.

Bathymetric charts show that the area to the north of Subarea 48.3 where catches were reported, forms part of a bank which is bisected by the northern boundary of Subarea 48.3. It therefore seems unlikely that fish concentrations would occur on the bank to the north of the boundary and not on the same bank to the south of the boundary. This same argument can be applied to the fishing ground to the west of Subarea 48.3, though the bathymetry is more complicated in this region.

3.32 Dr Moreno indicated that he shared these concerns about the catches reported from outside the Convention Area. The issue of whether these data were misreported or whether it is a case of a straddling stock can, however, not be resolved at this meeting. Scientific observers on board fishing vessels and research surveys could provide valuable information in this regard.

3.33 It was agreed that, at this stage, only assessments that assume that catches taken inside and just outside the Convention Area are from the same stock should be considered. In future, fishing vessels should be properly monitored to try and resolve the doubt about the catches reported outside the Convention Area. This can be done by, for example, transponders or observers on board vessels.

Management Advice

3.34 The Working Group noted that the stock projections indicate that the stock may have been depleted to around 30% of its unfished abundance. This is below the level which would be attained when the stock is fished at $F_{0.1}$. The Working Group recommended that a substantial reduction in catch is required to allow the stock to rebuild.

3.35 Advice on possible TACs is complicated by the fact that the stock may be vulnerable to fishing outside the CCAMLR Convention Area. Several scenarios were considered by the Working Group (Annex 5, paragraph 6.25) and all indicate a TAC between 900 and 1 700 tonnes. The Working Group also indicated that it would be advisable for any reduction in TAC to be accompanied by a reconsideration of the number of vessels involved in the fishery at any one time to avoid problems with stock assessment (Annex 5, paragraph 6.26).

3.36 Three views on management advice were expressed in the Scientific Committee.

3.37 Many Members were of the opinion that the recommendations of the Working Group should be endorsed and a TAC set in the range of 900 to 1 700 tonnes.

3.38 Several Members suggested that the fishery should be closed until the issues with regard to straddling stocks have been resolved. One of the problems is that fishing outside the Convention Area cannot be controlled, which brings more uncertainty in the catch reporting. This has been noted with regard to the Chilean fleet (paragraph 3.32). Another issue that needs to be resolved is how the Commission deals with management of straddling stocks.

3.39 Dr Shust suggested that, taking into account the great uncertainty in the assessment, a TAC around 3 000 tonnes, similar to last year's TAC, could be set.

Champscephalus gunnari (Subarea 48.3)
(Annex 5, paragraphs 6.27 to 6.62)

3.40 No catches were reported for icefish, *Champscephalus gunnari*.

3.41 A revised catch-at-age matrix was provided to the Working Group and this was used to re-run assessments made at previous meetings. Stock projections based on biomass estimates from the research survey in January 1992 were used to calculate TACs for the 1993/94 season.

3.42 The Scientific Committee accepted the assessments and noted the level of uncertainty associated with them.

3.43 The proposal by the UK to conduct a research survey of *C. gunnari* in Subarea 48.3 in January 1994 was welcomed by the Scientific Committee.

3.44 As in the past, the Working Group considered TACs taking account of possible by-catch of *Notothenia gibberifrons*, *Chaenocephalus aceratus* and *Pseudochaenichthys georgianus*. No new information was available for the by-catch species. Two options for TACs were recommended by the Working Group: (i) the TAC should remain at 9 200 tonnes; or (ii) providing by-catches could be satisfactorily monitored and reported, a higher TAC of 13 000 to 21 000 tonnes could be considered.

Management Advice

3.45 Most members of the Scientific Committee agreed with the recommendations of the Working Group regarding the possible levels of TAC (paragraph 3.44).

3.46 Lic. Marschoff suggested a closure of the fishery for *C. gunnari* in Subarea 48.3 until a survey has been undertaken to allow a direct estimate of the stock to be made. He noted that the current estimates of TACs are based on projections of biomass estimates from a survey undertaken in January 1992 and not based on VPA results. Furthermore, a very large drop in biomass between 1989/90 and 1990/91 was indicated by biomass estimates from research surveys. This large drop has not yet been explained. These factors indicate a high level of uncertainty which justifies the proposed closure.

3.47 Dr Shust said that the TAC calculations were based on a survey that was quite recent (January 1992). The TAC of 9 200 tonnes set for the 1992/93 season had also been based on that survey estimate. He indicated that it was because of financial and economic reasons that no catches of *C. gunnari* had been taken in the 1992/93 season. Because of the absence of commercial fishing in recent years he suggested a catch level somewhere in the range 13 000 to 21 000 tonnes.

3.48 The Scientific Committee endorsed the recommendation made by the Working Group that the following Conservation Measures be maintained:

- (i) Conservation Measure 51/XI (effort and biological reporting system);
- (ii) Conservation Measure 49/XI (closure between 1 April 1994 and the end of the Commission meeting in 1994, to protect spawning); and
- (iii) Conservation Measure 19/IX (mesh size regulation);

and recommended that the ban on bottom trawling currently contained as paragraph 4 in Conservation Measure 49/XI, be retained for the 1993/94 season.

Notothenia gibberifrons, *Chaenocephalus aceratus*,
Pseudochaenichthys georgianus, *Notothenia rossii*,
Patagonotothen guntheri and *Notothenia squamifrons*
(Subarea 48.3) (Annex 5, paragraphs 6.63 to 6.66)

3.49 The Scientific Committee endorsed the advice of WG-FSA and recommended that all Conservation Measures for these species should remain in force.

Electrona carlsbergi (Subarea 48.3)
(Annex 5, paragraphs 6.67 to 6.70)

3.50 It was noted that WG-FSA could not provide further advice because there is no new information and any TAC which might be considered would be based on a stock for which the age structure and biomass are unknown.

3.51 Fishing plans of Members (paragraphs 3.3 to 3.8) indicate that it is unlikely that there will be a fishery for this species in 1993/94.

Management Advice

3.52 On the basis of the known biological characteristics of the stock, the TAC of 245 000 tonnes set in Conservation Measure 53/XI for *Electrona carlsbergi* in Subarea 48.3 may be sustainable. However, any fishery would be based on a stock for which the age structure and biomass are unknown, and in the light of this uncertainty a precautionary TAC should be set below 245 000 tonnes. The species composition and biological characteristics of the by-catch are also unknown. Therefore the Scientific Committee recommends that a new biomass survey be conducted if any fishery on this species is resumed.

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

Champocephalus gunnari, *Notothenia gibberifrons*,
Chaenocephalus aceratus, *Pseudochaenichthys georgianus*,
Chionodraco rastrospinosus and *Notothenia kempfi*
(Subareas 48.1 and 48.2) (Annex 5, paragraph 6.108)

3.53 The Working Group reiterated the advice offered in 1992 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

3.54 The Scientific Committee endorsed the recommendations of the Working Group and recommended that Conservation Measures in force should be maintained.

3.55 The Scientific Committee also proposed that this would continue to be its advice until new data or survey results from one or both these areas are provided to the Working Group.

Statistical Area 58 (Indian Ocean Sector)

Kerguelen Islands (Division 58.5.1)

3.56 Disappointment was expressed that no scientist from France could attend the meeting of WG-FSA in 1993, since this hampered the effective provision of advice from WG-FSA. It was hoped that a scientist from France would be able to attend the 1994 meeting of WG-FSA.

Dissostichus eleginoides (Division 58.5.1) (Annex 5, paragraphs 6.112 to 6.132)

3.57 In 1992/93 the only fishery in Statistical Area 58 was for *D. eleginoides* in Division 58.5.1 (Kerguelen Islands). 826 tonnes were taken by France and 1 896 tonnes by Ukraine (CCAMLR-XII/BG/15). Two longliners operated for a limited period in the 1992/93 season and caught 92 tonnes in the western sector.

3.58 Three fishing grounds are recognised: north, northeast and west of Kerguelen. A detailed stock assessment was not possible for the stock in the western sector. A longterm sustainable yield of 1 400 tonnes was estimated from a 1988 trawl survey. No assessment was attempted for the northern sector and it was therefore impossible to determine whether the current catch level of 6 000 tonnes is sustainable.

3.59 Dr G. Duhamel (France) outlined regulations that are in force in the area around Kerguelen with regard to *D. eleginoides*. The fishery is managed separately for the northern and western sectors or fishing grounds.

- (i) In the western sector only a small-scale longline fleet of two vessels operated in the 1992/93 season with a TAC of 1 000 tonnes. The policy for this sector is likely to remain the same in future. No trawling is allowed in this sector.
- (ii) In the northern sector a TAC of 1 800 tonnes for the foreign fleet was in force in 1992/93 for the first time. The French fishery is controlled by the numbers of trips

per vessel. In 1992/93 one trip was allowed for one trawler only. This fishery is only conducted by trawlers.

(iii) The northeastern sector has not yet been exploited on a commercial scale.

3.60 Dr Duhamel added that additional measures also apply, for example, a closure between 1 May and 30 June and a mesh size regulation of 120 mm as adopted by CCAMLR. Last year two observers operated in the Kerguelen area through the year and the scientific data that were collected have been transmitted to CCAMLR.

Management Advice

3.61 The Scientific Committee endorsed the recommendations made by WG-FSA for a TAC of not more than 1 400 tonnes for the western sector. Concern was, however, expressed that a proper assessment could not be conducted at WG-FSA.

Notothenia rossii and *Notothenia squamifrons* (Division 58.5.1) (Annex 5, paragraph 6.111)

3.62 Dr Duhamel noted that although the fishery for *Notothenia rossii* was closed, research has continued to assess the juvenile stock and there are currently some indications of a recovery in the juvenile part of the stock, which is likely to imply an increase in the adult stock in the near future. A scientific survey on the adult stock would be welcome.

3.63 There is no direct fishery for *Notothenia squamifrons* and there is no information on the current status of the stock.

Management Advice

3.64 The Scientific Committee endorsed the recommendations of WG-FSA that the fisheries for these two species should remain closed.

Champocephalus gunnari (Division 58.5.1)
Kerguelen Plateau (Annex 5, paragraphs 6.133 to 6.140)

3.65 No new information on the recruiting cohort was available. Dr Duhamel explained that no data were available since the fishery was closed during the 1992/93 season. The reason for the closure was that individuals of the new cohort (1991) had not yet reached the minimum legal size of 25 cm. A recruitment study would be available at next year's meeting.

Management Advice

3.66 The Scientific Committee endorsed the recommendations of WG-FSA that fishing be delayed until the 1994/95 season and only restricted fishing on the 3+ age group that is expected to form the fishery in that year should be allowed. If any fishing occurs in the 1993/94 season the catch should be as low as possible.

Champocephalus gunnari (Division 58.5.1)
Skif Bank (Annex 5, paragraph 6.141)

3.67 No new information was available to allow WG-FSA to assess this stock.

Heard Island (Division 58.5.2)

3.68 A demersal fish survey was undertaken around Heard Island in August and September this year and information on this survey will be reported to next year's meeting.

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

3.69 No new information was available to WG-FSA to allow assessment of the stocks in these areas.

Ob and Lena Banks (Division 58.4.4)

3.70 It was noted that the planned survey to the Ob and Lena Banks did not take place and is now rescheduled for the 1993/94 season. The observer from Ukraine, Dr Yakovlev, indicated that there is still some uncertainty as to whether the survey would take place or not due to financial circumstances.

Management Advice

3.71 It was noted that a TAC is already in force until the end of the Commission meeting in 1994 (Conservation Measure 59/XI). The Scientific Committee again endorsed the recommendation of WG-FSA that a survey be conducted on both banks and the stock be re-assessed before the fishery is re-opened.

General Advice on the Management of Fish Stocks

High Seas Fisheries and Straddling Stocks

3.72 The Scientific Committee noted WG-FSA's comments that there was evidence that *D. eleginoides* in the South Atlantic is a straddling stock, occurring both in the Convention Area (Subareas 48.3 and 48.4) and along the Patagonian slope and associated banks inside and outside Chilean and Argentinian territorial waters, and that some other species occurring in the Convention Area were also straddling stocks (Annex 5, paragraph 6.148 and 6.149).

3.73 Dr Moreno recalled the concerns of the Working Group that there had been substantial exploitation of *D. eleginoides*, possibly from a single stock, both inside and outside the Convention Area, and emphasised the importance of further research on this stock and of harmonising management measures on stocks which occur both inside and outside the Convention's boundaries.

3.74 The Scientific Committee agreed that the matter of effective harmonisation of management measures across the Convention's boundaries was urgent and should be brought to the attention of the Commission.

High Seas Fisheries Statistics

3.75 The Scientific Committee endorsed the recommendation of the Working Group (Annex 5, paragraph 6.165) that the CCAMLR Secretariat be represented at an FAO *Ad Hoc* Consultation on the Role of Regional Fishery Agencies in Relation to High Seas Fishery Statistics (La Jolla, USA, 13 to 16 December 1993).

Safe Biological Limits

3.76 The Scientific Committee endorsed comments of WG-FSA on this subject (Annex 5, paragraph 6.162 and 6.163).

Consideration of Ecosystem Management Interactions with WG-Krill (Annex 5, paragraphs 7.1 to 7.6)

3.77 Three papers describing the potential impact of krill fishing on juvenile fish were discussed in WG-FSA. There is clear evidence of by-catch of juvenile fish in krill hauls. The Scientific Committee reiterated that a lot more information is needed to assess the extent of the problem. Of particular importance is information on temporal, spatial and between-fleet variability of the magnitude and species composition of the by-catch.

3.78 The Scientific Committee endorsed WG-Krill's deliberations on this matter (Annex 4, paragraphs 3.26 and 3.34) and noted that the Working Group had stressed that appropriate statistical procedures should be applied to studies of the by-catch of juvenile fish in the krill fishery. These procedures should be standardised as far as possible.

3.79 It was also noted that the potential impact on commercially harvested fish species can only be properly assessed if the species in the by-catch are identified.

3.80 The Scientific Committee recommended that more studies on by-catch of larval and juvenile fish in krill catches be conducted. It also requested WG-FSA to provide information on when and where juvenile fish are most vulnerable to the fishery.

Interactions with WG-CEMP (Annex 5, paragraphs 3.17 to 3.19)

3.81 These matters are dealt with under Item 8 of the Scientific Committee report.

Research Surveys (Annex 5, paragraphs 8.1 to 8.8)

Trawl Survey Simulation Studies

3.82 A revised algorithm for estimating standing stock and its variance by the swept area method was agreed. The Scientific Committee endorsed the comments made by WG-FSA in this regard.

Recent and Proposed Surveys

3.83 The UK intends to conduct a bottom trawl survey in Subarea 48.3 in January 1994.

3.84 The proposed survey of the Ob and Lena Banks in 1993 by Ukraine had not been carried out but may now be planned for 1994 (see paragraph 3.70).

3.85 It was noted that CCAMLR-XII/MA/7 indicates that Russia intends to conduct two research cruises to the Atlantic sector. No information on these proposed cruises was available at WG-FSA.

3.86 Dr Shust said that plans for these research cruises had not yet been finalised because they have not yet been financed. If the surveys were to proceed, the agreed bottom trawl survey design and recommended manual (SC-CAMLR-XI, Annex 5, Appendix H, Attachment E) would be adopted.

3.87 The Scientific Committee reiterated the need for submission of detailed proposals six months in advance of the proposed survey as required by the Commission (CCAMLR-V, paragraph 60).

3.88 Dr Everson noted that this requirement was of particular importance in the light of the research catch exemption provision, which is currently 50 tonnes. In Subarea 48.4, for example, WG-FSA has estimated that an appropriate TAC for *D. eleginoides* would be 28 tonnes, which is below this limit.

DATA REQUIREMENTS

3.89 The Scientific Committee endorsed the list of data requirements specified by WG-FSA and set out in Annex 5, Appendix D.

3.90 The Scientific Committee endorsed the recommendation of WG-FSA that the submission date for STATLANT data be changed to 31 August.

Software and Analyses Required for the 1994 Meeting
(Annex 5, paragraphs 9.2 to 9.5)

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

3.92 It was noted that the program to scan haul-by-haul data for use in local depletion analyses (Annex 5, paragraph 9.4) would not simply identify declining series of CPUE but would also use other criteria such as geographic extent and time-scale to estimate localised fishing activity.

MANAGEMENT UNDER CONDITIONS OF UNCERTAINTY
ABOUT STOCK SIZE AND SUSTAINABLE YIELD

3.93 Discussions in WG-FSA of this topic are reported in Annex 5, paragraphs 6.156 to 6.161.

3.94 Prof. Beddington said that the conclusions of WG-FSA are sensible and agreed that the approach used in the IWC is an appropriate methodology. In terms of CCAMLR, it is possible to look at the levels of uncertainty in each of the fisheries and advise on particular fisheries. Since the data and management procedures from the different fisheries are quite different, it would be difficult to come to general conclusions.

3.95 The Scientific Committee agreed that more work on this topic is required and welcomed papers that focus on particular fisheries.

3.96 It was suggested that, together with advice on management provided to the Commission, some indication of the level of uncertainty may be useful.

3.97 In terms of krill, the Scientific Committee agreed that the principles of management under uncertainty are being incorporated in the management approach for this stock and that work is advancing well in this regard. In terms of fish stocks, a lot more work is required to incorporate uncertainty in an objective way as outlined in WG-FSA (Annex 5, paragraphs 6.156 to 6.161).

3.98 The Scientific Committee was of the 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 as specific advice on TACs from traditional assessments became less reliable.

CRAB RESOURCES

4.1 Fishing for crabs in Subarea 48.3 during the 1992/93 season was undertaken by one US vessel, the *Pro Surveyor*, between 10 July and 12 November 1992. The catch was 299 tonnes (272 000 individuals).

4.2 Two species (*Paralomis spinosissima* and *P. formosa*) were caught with *P. spinosissima* being the targeted species. A description of the fishery is contained in SC-CAMLR-XI, Annex 5, paragraphs 6.1 to 6.7.

4.3 The Scientific Committee has recognised that in spite of the detailed information provided by the US fishery, very little life history, ecological or demographic data on *Paralomis* spp. are available (Annex 5, Appendix E, paragraphs 2.1 to 2.11) and that large uncertainties are associated with estimating the standing stock of the above species (SC-CAMLR-XI, paragraph 4.15). Consequently, the Commission has adopted a precautionary approach to the development of this fishery and Conservation Measure 60/XI was established as an interim management approach pending the development of a longterm management plan for the fishery (CCAMLR-XI, paragraph 9.52).

4.4 As a means to developing a longterm management plan for the crab fishery a workshop should be held to begin this process and to advise on data to be reported from the fishery (CCAMLR-XI, paragraphs 9.48 to 9.50).

WORKSHOP ON THE LONGTERM MANAGEMENT OF THE ANTARCTIC CRAB FISHERY

4.5 A workshop (Convener, Dr Holt) was held at the Southwest Fisheries Science Centre, La Jolla, USA from 26 to 28 April 1993. Its terms of reference are set out in SC-CAMLR-XI, paragraph 4.17. The Workshop report has been reviewed by WG-FSA and is attached as Appendix E of Annex 5.

POPULATION CHARACTERISTICS

4.6 The Scientific Committee endorsed the summary of research topics, data needs and their respective priorities for acquisition identified by the Workshop (Annex 5, Appendix E, Table 1).

4.7 The Scientific Committee agreed that host-parasite interactions in crab stocks subject to fishing should be more extensively modelled in order to assess more effectively the potential impact on demographic characteristics and stock yield(s) (Annex 5, Appendix E, paragraph 2.20 and 6.78).

STOCK ASSESSMENT

4.8 The Scientific Committee endorsed WG-FSA's and the Workshop's deliberations on various methods to assess the *Paralomis* fishery (Annex 5, paragraphs 6.79 and 6.82; Annex 5, Appendix E, paragraphs 3.1 to 3.21 and Table 2).

4.9 The Scientific Committee agreed that it would not be appropriate at this time to estimate a TAC for the 1993/94 fishery using the four production models tabled at WG-FSA (WG-FSA-93/23). Further development along these lines was encouraged.

DEVELOPING LONGTERM APPROACHES TO MANAGEMENT OF THE CRAB FISHERY

4.10 Interim management approaches (e.g., Conservation Measure 60/XI), currently being employed while a longterm approach is being developed, include both direct and indirect controls on harvesting. The Scientific Committee agreed that these should continue to be applied in management of the crab fishery and further measures may be deemed necessary in the course of development of a longterm management plan.

4.11 It was agreed that stock assessments based on depletion as well as production methods would constitute an integral component of such development and these should be considered in more detail (Annex 5, paragraphs 6.91 and 6.92).

4.12 The Scientific Committee specifically recommended that the following additional measures identified by the Workshop and endorsed by WG-FSA should have a high priority for investigation:

- (i) the use of time-release or biodegradable devices to reduce the effects of “ghost” fishing resulting from pot loss, should be considered;
- (ii) the adoption of a minimum mesh size and/or the incorporation of an escape port (usually a metal ring set into the side of the pot) in pots following research on mesh or port selectivity. This will serve to select only crabs of harvestable size more effectively in addition to reducing the number of potential discards. It will, however, reduce the ability to monitor parasitic infection; and
- (iii) the use of pots with finer mesh or escape ports in order to obtain more representative length frequency information from harvested stocks.

4.13 The Scientific Committee recognised that the development of a management approach for the crab fishery would need to be based on the following:

- (i) the design of methods (taking into account limitations of resources available) to acquire the necessary data for assessments of:
 - (a) target species,
 - (b) the strengths of multi-species interactions;
- (ii) evaluations (using simulations where appropriate) to determine whether such methods are likely, in principle, to achieve their objectives; and
- (iii) the development of a feedback management framework within which methods and assessments will be used for providing advice to the Scientific Committee and Commission (see CCAMLR-X, paragraph 6.13). An integral part of this will be to review the methods used for data acquisition on a regular basis.

4.14 The Scientific Committee therefore recommended that an experimentally-based approach should be applied to the commercial crab fishery in order to answer specific questions about the population dynamics of *Paralomis* stocks in Subarea 48.3 in general, and of *P. spinosissima* in particular. This approach was detailed in WG-FSA-93/22 and would comprise the following three phases, to be conducted over two consecutive fishing seasons.

Phase 1 - survey of the crab distribution around South Georgia at the start of the first fishing season by fishing in designated blocks. After completion, normal fishing

operations would continue until the TAC for that season was attained or the vessels voluntarily left the fishery.

Phase 2 - series of depletion experiments conducted in local areas to start at the beginning of the second fishing season. After Phase 2 normal fishing operations would be conducted.

Phase 3 - fishing effort would be redirected to the local areas depleted during Phase 2. This would occur towards the end of the second fishing season. It would commence just prior to cessation of the fishery resulting from the TAC being attained or by each vessel wishing to voluntarily leave the fishery.

4.15 The Scientific Committee noted that in order to maximise the potential output of the approach:

- (i) all phases of the experiment should be conducted by all vessels entering the fishery;
- (ii) that vessels should be required to participate independently in the experiment;
- (iii) the experiment's potential to provide useful data would grow as more vessels enter the fishery; and
- (iv) catches should be considered as part of any prevailing TAC for respective seasons.

4.16 The Scientific Committee agreed that this experimental approach offers the best alternative for obtaining the data necessary to undertake meaningful assessments, in particular, of crab stock dynamics and the fishery. It agreed that the following objectives can only be met by using this approach:

- (i) the elucidation of large-scale distribution patterns, how these change with time, and the identification of numbers and locations of centres of aggregation;
- (ii) the determination of trends in catchability/movement and how these affect length frequency distributions and estimates of local abundance;
- (iii) the determination of the effects of harvesting on the dynamics of localised populations and the importance of movement, recruitment and parasitism; and

- (iv) the comparison of the assessments of crab stocks using data from normal commercial fisheries operations compared with those derived from the more structured experimental approach.

4.17 The Scientific Committee noted that the experimental approach integrates experimental and commercial fisheries, thereby optimising available resources which are limited for stock assessment purposes. The incorporation of experimental and “ordinary” fishing also allows vessels to fish in a rational and controlled manner.

4.18 The Scientific Committee noted the various analyses which should be possible with the data likely to arise from an experimental approach (Annex 5, paragraph 6.97).

4.19 As part of developing a longterm management plan for the crab fishery, the Scientific Committee agreed that an important objective for Phase 1 would be to collect data necessary to evaluate the efficacy of Phases 2 and 3. As such, it endorsed WG-FSA’s proposed action in this regard (Annex 5, paragraphs 6.98 and 6.99) and took particular note of the questions posed in paragraph 6.100:

- (i) Is there value in monitoring a spatial square in which no fishing (control) for each experimental depletion square occurs? Such controls could be useful for determining the magnitude of effect of the experimental fishing on stock size. How many replicates are required to be able to discriminate between depletion and control treatments if an effect of depletion occurs? How much effort needs to be expended assessing the control squares?
- (ii) What size of area surrounding experimental squares is required in which commercial fishing should be excluded in order that the experimental fishing areas are kept independent of effects that may arise from the commercial fishery? Also, what configuration of experimental, control and commercially fished areas should be employed for cost-effective experimental and commercial operations?
- (iii) What magnitude of depletion is required for adequately addressing the objectives? How long should a square be fished to ensure a significant depletion has occurred?
- (iv) Should Phases 1, 2 and 3 recur in order to maintain adequate stock assessments in a longterm management plan? If so, at what frequency?

- (v) What method should the Secretariat use to advise when Phase 3 should begin such that the TAC will not be exceeded and Phase 3 will be completed.

4.20 The Scientific Committee emphasised, however, that stock assessment independent of the fishery is important for determining the utility of data from commercial operations in assessing the status of stocks. Consequently, it recommended that surveys of crab stocks independent of commercial fishing operations using trawls or video transects should be given a high priority. The investigation of these and various other fishery independent methods of assessing crab stocks should also be encouraged.

4.21 The Scientific Committee agreed that the following data are required for stock assessment of the crab fishery (Annex 5, paragraph 6.102; Annex 5, Appendix E, paragraphs 5.1 to 5.18):

Catch and Effort Data:

Cruise Descriptions

cruise code, vessel code, permit number, year.

Pot Descriptions

pot shape, dimensions, mesh size, funnel attitude, number of chambers, presence of an escape port.

Effort Descriptions

date, time, latitude and longitude of the start of the set, compass bearing of the set, total number of pots set, spacing of pots on the line, number of pots lost, depth, soak time, bait type.

Catch Descriptions

retained catch in numbers, by-catch of all species, incremental record number for linking with sample information.

Biological Data:

For these data, crabs are to be sampled from the line hauled just prior to noon, by collecting the entire contents of a number of pots spaced at intervals along the line so that between 35 and 50 specimens are represented in the subsample.

Cruise Descriptions

cruise code, vessel code, permit number.

Sample Descriptions

date, position at the start of the set, compass bearing of the set, line number.

Data

species, sex, length of at least 35 individuals, presence/absence of rhizocephalan parasites, record of the destination of the crab (kept, discarded, destroyed), record of the pot number from which the crab comes.

4.22 The Scientific Committee recognised that haul-by-haul data are important for the effective development of a longterm management approach for the crab fishery (Annex 5, paragraph 6.102).

4.23 The Scientific Committee drew the Commission's attention to the confidential nature of haul-by-haul data from the crab fishery. The Scientific Committee agreed that provision of haul-by-haul data would be difficult without consideration of methods to protect industrial confidentiality.

MANAGEMENT ADVICE

4.24 Topics of high priority for future research are identified in paragraph 4.13 and should be investigated as soon as possible.

4.25 The Scientific Committee noted that Conservation Measure 60/XI expires at the end of the Commission meeting.

4.26 The Scientific Committee recommended that a TAC of 1 600 tonnes should be imposed for the crab fishery in Statistical Area 48 for the next season. In addition, indirect controls (size, sex, gear and product storage) contained in Conservation Measure 60/XI should be continued.

4.27 The Scientific Committee also recommended that a new Conservation Measure should be adopted which had two components: a data reporting requirement and a requirement for vessels involved in the fishery to take part in an experimental fishery.

4.28 In the case of data reporting, the Scientific Committee believed that the most appropriate data would be in haul-by-haul form. However, they noted that at this stage of the fishery's development a question of industrial confidentiality arose (Annex 5, paragraphs 4.24 and 4.25).

4.29 At this early stage of the fishery, the Scientific Committee recommended that vessels operating should be required to take part in an experimental fishery. The proposed design of this experimental fishery is outlined in paragraphs 4.15 and 4.16 and detailed in WG-FSA-93/22. The Scientific Committee endorsed this design, but noted that it would be subject to review and in future seasons might be refined (see discussion in paragraph 4.21).

SQUID RESOURCES

5.1 There was no fishery for squids in the CCAMLR Convention Area in the 1992/93 season and no data on squids have been reported to the Secretariat.

5.2 A report on the First International Southern Ocean Cephalopods Symposium (5 to 9 July 1993, Cambridge, UK) was presented in SC-CAMLR-XII/BG/10. It was noted that 11 Members of CCAMLR had presented a total of 18 papers on cephalopods occurring within the CCAMLR Convention Area to the Symposium, representing a substantial body of cephalopod research amongst CCAMLR Members.

5.3 Of these papers, seven addressed octopod taxonomy and ecology, eight addressed demography and the ecology of squid, and a further three described the relationships between cephalopods and their natural predators.

5.4 Dr Croxall informed the Scientific Committee that a collaborative project being undertaken in the South Georgia area in the 1993/94 season by the UK, Spain and Germany would include ship-based research on squids. The Scientific Committee welcomed this initiative.

SCIENTIFIC RESEARCH EXEMPTION

6.1 Resolution 9/XI requires the Scientific Committee, in consultation with its Working Groups, to develop standardised guidelines and formats for Members to submit research plans for use of commercial fishing or support vessels of a similar capacity to conduct fishing for research purposes when the estimated catch may exceed 50 tonnes. The Scientific Committee endorsed the suggestion by WG-FSA that the format proposed in WG-FSA-93/12 is suitable for attachment to this resolution.

6.2 At CCAMLR-XI the Commission decided to review the status of the Register of Permanent Research Vessels, which was adopted in 1986 as part of the Scientific Research Exemptions (CCAMLR-V, paragraph 60). The Chairman introduced CCAMLR-XII/13 which outlines possible definitions of permanent research vessels. The Scientific Committee agreed that no distinction need be drawn between different categories of vessels. Any plans for research fishing are required to be notified and provided in prescribed detail when the estimated catch may exceed 50 tonnes. (This corresponds to Option 3 presented in the paper).

6.3 However, the Scientific Committee noted that a system of notification is required for designating research vessels in those cases where the expected catch is likely to be less than 50 tonnes, but where research catching would not comply with other Conservation Measures, for example, mesh regulations, prohibition of bottom trawling and closed areas and seasons.

NEW AND EXPLORATORY FISHERIES

7.1 At its 1992 meeting, the Commission noted that in the past, some Antarctic fisheries had been initiated and subsequently expanded in the Convention Area before sufficient information was available upon which to base management advice (CCAMLR-XI, paragraph 4.27). It agreed that exploratory fishing 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 set forth in Article II of the Convention (CCAMLR-XI, paragraph 4.28).

7.2 The Commission noted that Conservation Measure 31/X had succeeded in providing a useful mechanism for evaluating new fisheries as they begin, and it agreed that it would be desirable to extend some of these requirements for new fisheries so that the provision of information would continue during the fishery's exploratory phase (CCAMLR-XI, paragraph 4.29).

7.3 The Commission had therefore requested the Scientific Committee and its Working Groups to consider this matter during 1993 (CCAMLR-XI, paragraphs 4.32 and 4.33). In response to this request, the Delegation of the USA prepared a draft document (CCAMLR-XII/5), which addressed the points specified by the Commission. This draft document was tabled at each of the intersessional meetings of the Scientific Committee's three Working Groups, and a revised draft was presented for consideration at the present meeting.

7.4 Following a discussion of that document, the Scientific Committee recommended that the Commission consider the approach outlined in paragraphs 7.5 to 7.8 when developing a formal procedure pertaining to fisheries during their exploratory phase.

7.5 Definitions: A primary objective in defining exploratory fisheries is to characterise the period immediately following the initiation of a new fishery, during the time when a fishery's commercial potential and the nature of its possible interactions with dependent and related species are being evaluated. Therefore, exploratory fisheries are defined as follows:

- (i) an exploratory fishery should be defined as a fishery that was previously classified as a "new fishery", as defined by Conservation Measure 31/X;

- (ii) an exploratory fishery should continue to be classified as such until sufficient information is available:
 - (a) to evaluate the distribution, abundance, and demography of the target species, leading to an estimate of the fishery's potential yield,
 - (b) to review the fishery's potential impacts on dependent and related species, and
 - (c) to allow the Scientific Committee to formulate and provide advice to the Commission on appropriate harvest catch levels, as well as effort levels and fishing gear, where appropriate.

7.6 Activities While a Fishery is Classified as Exploratory: The principal reason for classifying fisheries as exploratory is to ensure that adequate information is made available to the Scientific Committee for evaluation during a fishery's early phases. During the period when a fishery is classified as exploratory:

- (i) the Scientific Committee should develop (and update annually as appropriate) a Data Collection Plan, which will identify the data needed and describe the actions necessary to obtain the relevant data from the exploratory fishery;
- (ii) each Member active in the fishery should annually (by the specified date) submit to CCAMLR the data specified by the Data Collection Plan developed by the Scientific Committee;
- (iii) each Member active in the fishery or intending to authorise a vessel to enter the fishery should annually prepare and submit to CCAMLR by a specified date a Research and Fishery Operations Plan for review by the Scientific Committee and the Commission;
- (iv) prior to any Member authorising its vessels to enter an exploratory fishery that is already in progress, that Member should notify the Commission not less than three months in advance of the next regular meeting of the Commission, and the Member should not enter the exploratory fishery until the conclusion of that meeting;
- (v) if the data specified in the Data Collection Plan have not been submitted to CCAMLR for the most recent season in which fishing occurred, continued exploratory fishing by

the Member which failed to report its data should be prohibited until the relevant data have been submitted to CCAMLR and the Scientific Committee has been allowed an opportunity to review the data;

- (vi) fishing capacity and effort should be limited to a level not substantially above that necessary to obtain the information specified in the Data Collection Plan and required to make the evaluations outlined in paragraph 7.5(ii);
- (vii) the name, type, size, registration number, and radio call sign of each vessel participating in the exploratory fishery should be registered with the CCAMLR Secretariat at least three months in advance of starting fishing each season; and
- (viii) each vessel participating in the exploratory fishery should carry a Scientific Observer to ensure that data are collected in accordance with the agreed Data Collection Plan, and to assist in collecting biological and other relevant data.

7.7 Data Collection Plan: The Data Collection Plan to be formulated and updated by the Scientific Committee should include, where appropriate:

- (i) a description of the catch, effort, and related biological, ecological, and environmental data required to undertake the evaluations described in paragraph 7.5(ii), and the date by which such data are to be reported annually to CCAMLR;
- (ii) a plan for directing fishing effort during the exploratory phase to permit the acquisition of relevant data to evaluate the fishery potential and the ecological relationships among harvested, dependent, and related populations and the likelihood of adverse impacts; and
- (iii) an evaluation of the time-scales involved in determining the responses of harvested, dependent and related populations to fishing activities.

7.8 Research and Fisheries Operations Plan: Research and Fisheries Operations Plans to be prepared by Members participating or intending to participate in the exploratory fishery should include as much of the following information as the Member is able to provide:

- (i) a description of how the Member's activities will comply with the Data Collection Plan developed by the Scientific Committee;

- (ii) the nature of the exploratory fishery, including target species, methods of fishing, proposed region and maximum catch levels proposed for the forthcoming season;
- (iii) biological information from comprehensive research/survey cruises, such as distribution, abundance, demographic data, and information on stock identity;
- (iv) details of dependent and related species and the likelihood of them being affected by the proposed fishery; and
- (v) information from other fisheries in the region or similar fisheries elsewhere that may assist in the evaluation of potential yield.

7.9 In outlining this approach, the Scientific Committee recognised that the specified reviews and evaluations could, of course, only be undertaken with the best information currently available. For example, a review of an exploratory fishery's potential impacts on dependent and related species would not necessarily be able to describe or quantify all possible contingencies. Instead, the review's objectives should be to identify potential impacts, draw attention to situations that require careful attention, and highlight the need for particular studies to fill information gaps.

7.10 It was noted that the objective of limiting the amount of fishing effort during an exploratory fishery was to prevent a rapid expansion of the fishery before the appropriate evaluations could be made; there was no intention to prevent modest levels of commercial fishing that would generate the data needed for these evaluations. A good example of this principle was the setting of a TAC in 1992 for the exploratory fishery for *D. eleginoides* in Subarea 48.4 (Conservation Measure 44/XI).

ECOSYSTEM MONITORING AND MANAGEMENT

8.1 The Seventh Meeting of the Working Group on the CCAMLR Ecosystem Monitoring Program (WG-CEMP) was held in Seoul, Republic of Korea, from 16 to 23 August 1993 under the convenership of Dr Bengtson. The report of the meeting is attached as Annex 6.

8.2 The Scientific Committee noted that attendance at the Seventh Meeting had significantly improved on recent meetings, possibly reflecting the Convener's intersessional activities in soliciting enhanced participation. However, the absence of scientists from Brazil, France and New Zealand, all of whom have active programs of research in the Convention Area relative to the work of WG-CEMP, was regretted.

8.3 The Scientific Committee endorsed the suggestion that a newsletter describing the major results and conclusions of the work of WG-CEMP should be prepared by the Convener and distributed annually to interested individuals, initially comprising members of relevant groups within SCAR and scientists on the current mailing lists of WG-CEMP and WG-Krill.

MONITORING PROCEDURES

8.4 The Draft Management Plan for the Protection of Cape Shirreff and San Telmo Islands, South Shetland Islands (SSSI No. 32) as a site included in CEMP, prepared by Chile and the USA, had been revised following discussions at WG-CEMP and was submitted as SC-CAMLR-XII/9. The Scientific Committee approved the Management Plan and authorised its submission to the Commission.

8.5 The Scientific Committee noted that no other proposals for protection of CEMP sites, for revision of existing standard monitoring methods, for new standard methods or for the inclusion of new species in CEMP had been received.

8.6 Specifically, the Scientific Committee felt that it would now be timely to receive Members' proposals regarding methods for those selected species for which no standard methods yet exist (viz, crabeater seals, Antarctic petrel, cape petrel). Given the extent of recent current research on breeding population size and breeding success of the two petrel species by, *inter alia*, Australia, France, Norway and South Africa, it should be possible to prepare draft standard methods for these parameters. The Members named above, in conjunction with other Members as appropriate, were urged to undertake this as a matter of some priority.

8.7 The Scientific Committee welcomed the progress made with initiatives designed to lead to the development of standard methods for studying, recording and reporting on diving behaviour and foraging performance of penguins and seals using data collected by time-depth recorders and related instruments. It endorsed the proposal of the Working Group (Annex 6, paragraphs 4.20 and 4.21) and approved including the suggested workshop as an item in the projected 1995 budget of the Scientific Committee, pending a formal recommendation from WG-CEMP next year.

8.8 Dr Croxall noted that the UK had tabled a paper on delimitation and analysis of Antarctic fur seal foraging bouts and indices derived therefrom requested in Annex 6, paragraph 4.14. It had also supplied Dr Boveng with all the data requested in Annex 6, paragraph 4.21. He suggested that prompt circulation of this paper and data submission might be of assistance to other Members who were preparing their own submissions.

8.9 The Scientific Committee congratulated the USA on its initiative in convening the workshop on researcher-seabird interactions and encouraged WG-CEMP to evaluate the implications of the workshop findings for CEMP Standard Methods; it endorsed the recommendation that Members maintain a detailed register of the use of implanted electronic tags, especially until a central database can be developed by SCAR (see Annex 6, paragraph 4.27).

8.10 The Scientific Committee noted with interest the research by Argentinian scientists into the use of otoliths retrieved from shag pellets as potential indices of the abundance of certain fish species in inshore waters. Discussions of this topic by WG-CEMP and WG-FSA (Annex 6, paragraphs 4.32 and 4.33; Annex 5, paragraph 7.8) indicated the need for detailed validation studies; the Scientific Committee encouraged Members to undertake such research.

8.11 The Scientific Committee noted the intention of WG-CEMP to consider at its next meeting the topic of expanding CEMP beyond its exclusive focus on the krill-based system. Some Members were concerned that there were at present insufficient time and resources adequately to undertake the work of WG-CEMP as currently circumscribed. Incorporating additional species and interactions might detract from the attention given to the topics of highest priority.

8.12 It was recalled, however, that amongst the reasons given by some Members for limited or no participation in the work of WG-CEMP was that their research was focussed on predator-prey interactions involving species and sites where krill was not, or not the main, dietary component of predators. This particularly applied to much research in the sub-Antarctic Indian Ocean sector.

8.13 In addition, the fish *Pleuragramma antarcticum* is a species selected by WG-CEMP as suitable for monitoring yet its principal predators, on which considerable research is being conducted, are not themselves species selected within the CEMP Program. It was possible, therefore, that expansion of the scope of CEMP would not necessarily detract from the attention being given to existing priorities.

8.14 It was agreed that it was appropriate to review this whole topic at the 1994 meeting of WG-CEMP, ideally as one of the items to be considered in conjunction with the work of WG-Krill.

8.15 The Scientific Committee commended the work of the Data Manager in the analysis of sea-ice data to provide indices contributing to the environmental monitoring within CEMP. It approved the recommendation of WG-CEMP that all available historical data should be added to the database and noted that the creation of this database represented a valuable service to all Members of the Commission.

MONITORING RESULTS

8.16 The Scientific Committee noted the detailed review of the submitted data (Annex 6, paragraphs 5.3 to 5.20). It echoed the concern of WG-CEMP that only three Members (Australia, UK and USA) had submitted data this year and that only the UK had submitted any historical data.

8.17 Members collecting data under WG-CEMP procedures were reminded that they have an obligation to provide these data in time for analysis prior to the annual meeting of WG-CEMP. The work of WG-CEMP is being significantly impaired by the continuing failure of Members to provide data and it was agreed that the Commission should be asked to remind Members of the importance of submitting their data in a timely fashion.

8.18 The Scientific Committee welcomed the provision to WG-CEMP of a substantial volume of relevant information on prey in response to a request for:

- (i) fine-scale catch data, and particularly their distribution with respect to predator colonies;
- (ii) estimates of krill biomass in the Integrated Study Regions (ISRs); and
- (iii) results of fine-scale surveys and research on distribution, movements and behaviour of krill, especially in the vicinity of CEMP sites.

8.19 Of particular importance in this regard was the analysis by Japanese scientists of fine-scale fishery data from the 1991/92 season. The Scientific Committee commended this work and endorsed the suggestion of WG-CEMP that similar analyses of the Japanese data for previous years should be made available and encouraged Russia and Ukraine to follow suit, especially for data from fishing grounds near CEMP sites.

8.20 Dr Shust indicated his interest in undertaking this task but noted that it would involve re-processing of existing fishery data. He stated that efforts are continuing to secure sufficient resources to allow this work to proceed.

8.21 The Scientific Committee noted the request of WG-CEMP for information on the availability of:

- (i) fine-scale fisheries data within 50 km 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 (Annex 6, paragraphs 5.33 and 5.34).

8.22 Some Members noted that information and data answering these questions was already available in the reports of earlier discussions by WG-Krill (e.g., with reference to CPUE and related matters). Other Members, however, noted that it was not always clear from these reports the extent to which reliable annual indices were actually or potentially available. In any case, there was an obvious need for joint discussions between WG-Krill and WG-CEMP on this topic.

8.23 The Scientific Committee welcomed the considerable volume of data presented in relation to fine-scale surveys of krill in ISRs (Annex 4, paragraphs 5.35 to 5.45), noting especially the work of scientists from Germany, Japan, Republic of Korea and USA.

ECOSYSTEM ASSESSMENT

8.24 The Scientific Committee noted the large number of reports tabled under the WG-CEMP review of background information (Annex 6, paragraphs 6.3 to 6.28), representing much valuable research data from studies of predator population dynamics, predator-prey interactions, at-sea behaviour of birds and seals, krill population dynamics and interactions with the environment and surveys (including remote sensing) of the physical and biological properties of the marine environment.

8.25 The methods employed in the overall assessment of predator, prey, environment and fishery data (Annex 6, Table 5) by WG-CEMP were basically very similar to those used last year. That is, for some sites the assessments are based on the submitted quantitative data but for others they are based mainly on subjective assessments from other sources. Few, even subjective, environmental data are currently available and assessment of the krill catch and related data had been deferred for the attention of WG-Krill.

8.26 Nevertheless, even with these constraints, the Scientific Committee agreed that the assessment provided a valuable survey of available data. The Scientific Committee further noted the discussion by WG-CEMP of the performance of predators in 1993 and their conclusion that, generally, it was a year of normal-to-good conditions.

8.27 The Scientific Committee endorsed the view of WG-CEMP that it was desirable, at least for the predator data, to move to objective assessment based on the calculation of year-to-year changes and associated statistical significance of differences. This required a more rigorous process for the consideration of data by WG-CEMP and the Scientific Committee approved the guidelines set out in Annex 6, paragraph 6.35.

8.28 The success of this procedure will depend on the availability of adequate data of good quality. The Scientific Committee noted that WG-CEMP will be unable to perform adequate assessments unless more Members submit data.

8.29 The fact that WG-CEMP had finally reached the stage where, at least for some sites, it would be able to produce quantitative interannual comparisons of predator population characteristics and reproductive performance, re-emphasised the need to make progress with linking these predator-derived indices to the conventional management approaches being applied to the krill fishery. Some work on this topic has been initiated at the Joint Meeting of WG-Krill and WG-CEMP in 1992 but it should receive further consideration at the proposed joint meeting in 1994.

8.30 The Scientific Committee reiterated its concern that, despite the development of detailed guidelines for the conduct of standard surveys to estimate krill biomass in ISRs and in particular in the vicinity of CEMP sites, very few such data had been collected. The experiences of those Members who had undertaken such work would be of particular interest in respect of:

- (i) analysing and reporting the results of such data to facilitate interannual comparisons;
and
- (ii) suggesting improvements to the existing recommended survey methods.

POTENTIAL IMPACT OF LOCALISED KRILL CATCHES

8.31 The magnitude and significance of the persistent geographical overlap between the krill harvests and the foraging range of krill-dependent predators during their breeding season, particularly in Subarea 48.1, have been the subject of considerable discussion and concern at previous meetings of WG-CEMP and the Scientific Committee. A thorough review of past discussions of the widespread concern about the situation and of the differing views about the requirements for precautionary action can be found in SC-CAMLR-XI, Annex 7, paragraphs 6.37 to 6.57 and SC-CAMLR-XI, paragraphs 5.24 to 5.37.

8.32 Up to and including 1992/93, the assessment of geographical overlap between the fishery and predators in Subarea 48.1 has been based on comparison of the fishery data at a scale of 0.5° x 1°, with the foraging ranges of predators (mainly penguins) based on the assumption of uniform distribution out to a nominal mean maximum distance. The analysis of the 1992/93 data in WG-Krill-93/10 indicates that the situation was broadly similar to that in previous years.

8.33 For the 1993 meetings of WG-CEMP and WG-Krill, Japanese scientists had, for the first time, used the very fine-scale data (10 x 10 n miles) for the krill fishery to investigate the spatial overlap between fishing and penguin foraging ranges (WG-Krill-93/7). The results indicated that at this finer scale of resolution, there was much less spatial overlap than hitherto calculated between fishing locations and penguin foraging areas, with the bulk of the krill catches coming from areas with smaller populations of penguins (and hence smaller krill requirements) and less of the catch being located in areas adjacent to high concentrations of penguins (WG-Krill-93/7).

8.34 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 foraging areas of the majority of local penguin populations and the areas from which the main catch of krill by the fishery is taken is low; and
- (ii) the current catch by the krill fishery is low compared with the local krill biomass.

8.35 Furthermore, Mr T. Ichii (Japan) indicated that he intended to submit a revision of WG-Krill-93/7 to take account of some of the points raised by WG-CEMP (Annex 6, paragraph 6.53).

8.36 Notwithstanding this, some Members felt that, despite their recognition of the valuable contribution made in WG-Krill-93/7, their fundamental concerns over the situation have not changed significantly. In particular:

- (i) that the current catch in the area is low compared with local krill biomass does not mean that krill availability in the very restricted area open to predators with dependent offspring is sufficiently high to remain unaffected by krill catches in the same or adjacent areas; and

- (ii) even accepting that the analysis in WG-Krill-93/7 indicates reduced spatial overlap between fishing and predators would not mean that the smaller penguin populations associated with the larger local harvests were not adversely affected.

8.37 Consequently, some Members still felt that the Scientific Committee should recommend the establishment of additional precautionary measures to offer some prospect of mitigating potential problems for predators without imposing unnecessary or unacceptable restrictions on the krill fishery, given the assessment by some Members that:

- (i) at least some penguin populations were likely to be potentially significantly affected by fishing close to their breeding colonies;
- (ii) the likelihood of establishing whether or not any impact actually occurred without a decade or more of detailed research was low; and
- (iii) existing precautionary catch limits at area or subarea scale was inadequate to provide protection to these limited areas at critical times of year.

8.38 Other Members, however, stated that establishing additional measures was inappropriate and unnecessary in the light of present information. Furthermore, Mr I. Nomura (Japan) was critical of the rationale presented in paragraphs 8.36 and 8.37, since Mr Ichii's findings are based on quantitative data, albeit requiring some revision, and the arguments on uncertainties cited above were based only on conjectures of qualitative nature.

8.39 Last year there was agreement that the question of the potential impact of localised catches was one in which it was appropriate and useful to continue to explore the options and consequences of various management strategies.

8.40 In this context the Scientific Committee commended the Data Manager for carrying out the simulation analysis requested last year and described in SC-CAMLR-XI, paragraphs 5.42 and 5.43. Detailed discussion of the results of the simulation exercise are provided in Annex 4, paragraphs 5.34, 5.35 and 5.37 and summarised in Annex 6, paragraph 6.60. It had been agreed that this initial simulation had reproduced, at least in a general way, the magnitude and distribution of the catch (Annex 6, paragraph 6.62).

8.41 The Scientific Committee endorsed the suggestion for refinement of the model (Annex 6, paragraph 6.63) and hoped that further discussions of the implications of the existing and projected analyses would take place at the joint meeting of the WG-Krill and WG-CEMP in 1994.

8.42 As another aspect of this dialogue, Members engaged in krill fishing had been invited at the 1992 Scientific Committee meeting to consider and report on what potential measures or combination of measures would be acceptable for application with Subareas 48.1 and 48.2 in order to address the problem of providing some precautionary protection for land-based krill predators foraging within 100 km of breeding colonies between December and March (SC-CAMLR-XI, paragraph 5.40).

8.43 It was noted that in their response to this question (Annex 6, paragraph 6.66), discussions amongst Japanese fishermen had focussed on whether or not there was a need to impose fishing restrictions on the fishery rather than on exploring options for precautionary measures.

8.44 In light of the preceding discussion, the Scientific Committee agreed unanimously that it would be helpful for scientists from both fishing and non-fishing countries to continue their discussion exploring potential options for measures supporting a precautionary approach to the issue of potential impacts of localised fishery activity. In doing so, the Scientific Committee drew a clear distinction between discussions of the options of types of potential precautionary measures and the need to implement specific measures. It was emphasised that the current discussion should focus on potential options for precautionary measures. The possible need for implementing measures should be considered separately.

8.45 Several Members noted that there were numerous precedents within CCAMLR for the identification and implementation of precautionary measures, including those already in existence for krill. All these have come about through several years of prolonged, intensive discussion between scientists from fishing and non-fishing nations and their enactment had attracted widespread support for CCAMLR from within the Antarctic Treaty System and from other international resource management bodies.

PREY REQUIREMENTS FOR KRILL PREDATORS

8.46 The Scientific Committee noted the advice of WG-CEMP that data assembled in 1992 on krill consumption by predators were adequate for most estimates of krill consumption by penguins, fur, crabeater and leopard seals. It noted further that Members requiring additional or more detailed information should contact the scientists responsible for the different elements of this compilation (see SC-CAMLR-X, Annex 7, paragraphs 6.8 to 6.24; SC-CAMLR-XI, Annex 7, paragraphs 7.2 to 7.9).

8.47 The approach to understanding functional relationships between krill availability and predator performance, initiated at the Joint Meeting of WG-Krill and WG-CEMP in 1992 (SC-CAMLR-XI, Annex 8), had made substantial progress during the year. The results of the analysis in WG-Krill-93/43 by Drs Butterworth and Thomson (South Africa) based on predator data submitted intersessionally by Drs Bengtson, Boveng (USA), Boyd, Croxall (UK) and Trivelpiece (USA) (Annex 6, paragraphs 7.9 and 7.10) had been extensively discussed by WG-Krill (Annex 4, paragraphs 5.12 to 5.21) and WG-CEMP (Annex 6, paragraphs 7.11 to 7.39).

8.48 There was general agreement that the analysis represented an important step forward and Drs Butterworth and Thomson and the scientists providing the data were thanked for enabling such rapid progress to be made.

8.49 Nevertheless, the initial analysis had identified a number of problems with, and questions relating to, the data submitted for the modelling exercise. In its report, WG-CEMP has responded to most of the queries which had arisen (Annex 6, paragraphs 7.17 to 7.28 and 7.32) but four questions had to be referred back to the originators of the data with a request to respond before 31 December 1993 (Annex 6, paragraph 7.31).

8.50 The Scientific Committee noted the discussion in WG-CEMP concerning the topic of assessment of functional relationships (Annex 6, paragraphs 7.34 to 7.38) and particularly the recommendation that all the analyses described in WG-Krill-93/43 need repeating using the correct data. It endorsed the request of WG-CEMP that Members should undertake these analyses as soon as the remaining data had been circulated. It would be extremely valuable to have some of these analyses available in time for the joint meeting of the two Working Groups next year.

8.51 The Scientific Committee agreed with WG-Krill (Annex 4, paragraph 5.16) that work on a two-way model (accounting also for effects of differing levels of krill consumption by predators) should not be started until the results of the re-analysis of the one-way model had been evaluated.

8.52 In further discussion it was emphasised that the intention was to use the one-way model to study the functional relationship by simulating the effects of different harvest levels on predator performance. The two-way interaction had related objectives but would require the compilation and analysis of significant amounts of new data.

LIAISON BETWEEN WORKING GROUPS

8.53 The Scientific Committee noted that numerous topics had arisen in the consideration of the reports of WG-Krill and WG-CEMP where joint discussions were essential to make effective progress. The Scientific Committee recommended that these two Working Groups should hold joint meetings in 1994 and welcomed the offer of South Africa to arrange these. Dr Holt, Vice-Chairman of the Scientific Committee, was asked to form an *ad hoc* group, including the Conveners of these Working Groups, to draw up the terms of reference and work program for the joint meeting.

OTHER BUSINESS

8.54 The Scientific Committee noted that most items of Other Business in the report of WG-CEMP were being discussed as part of other agenda items.

ADVICE TO THE COMMISSION

8.55 The Scientific Committee recommended that a short newsletter, describing major results and conclusions of WG-CEMP, be prepared and distributed annually following the completion of the Scientific Committee meeting (paragraph 8.3).

8.56 The Scientific Committee recommended that the draft Management Plan for the Protection of Cape Shirreff and San Telmo Islands, South Shetland Islands, be considered for adoption by the Commission (paragraph 8.4).

8.57 Members should be encouraged to maintain national registers of electronic tags and related banding data associated with their seabird research activities (paragraph 8.9).

8.58 The Scientific Committee suggested including funds in the projected 1995 budget for supporting a workshop on at-sea behaviour methodology, pending a formal recommendation from WG-CEMP next year (paragraph 8.7).

8.59 The Scientific Committee recommended that the Secretariat be asked to continue to obtain and process JIC data on sea-ice distribution and that all available historical data should be added to the database (paragraph 8.15).

8.60 Members should be reminded of the importance of submitting their CEMP data in a timely fashion and therefore were strongly encouraged to submit to the CCAMLR Data Centre all available predator data collected in accordance with CEMP Standard Methods (paragraph 8.17).

MARINE MAMMALS AND BIRD POPULATIONS

MARINE MAMMALS

9.1 No new information was available to the Scientific Committee on the status of marine mammal populations. However, as recommended by the Scientific Committee at recent meetings (SC-CAMLR-XI, paragraph 6.4; SC-CAMLR-X, paragraphs 7.10 to 7.12), the USA reported that it planned to conduct aerial censuses of pack-ice seals during the 1993/94 austral summer.

THE ANTARCTIC PACK-ICE SEALS (APIS) PROGRAM

9.2 Dr Bengtson introduced a draft prospectus describing SCAR's Antarctic Pack-Ice Seals (APIS) Program (SC-CAMLR-XII/BG/20). This document was prepared following a workshop convened by the SCAR Group of Specialists on Seals in May, 1993, in St Paul, USA, and supported in part by CCAMLR. The workshop's main objectives were to discuss priority pack-ice seal research topics and to develop a plan for a coordinated, multi-national research initiative.

9.3 It was noted that although the draft prospectus was currently being reviewed by the SCAR Executive prior to being finalised, it was provided to the Scientific Committee at this time to inform CCAMLR of the results of the workshop that it had helped to support.

9.4 The APIS Program, as described in the draft prospectus, will address several research topics of direct relevance to CCAMLR, especially in relation to the CCAMLR Ecosystem Monitoring Program and the status and trends of marine mammal populations. For example, although crabeater seals have been selected as a CEMP monitoring species, implementation of CEMP activities in the pack-ice zone has been modest because of the limited availability of logistic and financial support. The crabeater seal research outlined in the APIS Program would therefore represent a valuable contribution to CEMP.

9.5 The Scientific Committee identified a number of specific topics of special interest to WG-CEMP regarding crabeater seals. These included predator/prey functional relationships, feeding ecology, and temporal and spatial distribution of seals in relation to fisheries. The potential

development of behavioural, condition, or physiological indices that could be included in CEMP monitoring of crabeater seals is also an area of special interest.

9.6 Because recent census data for pack-ice seals are unavailable, it has not been possible to determine the status and trends of these populations. It was agreed that the APIS Program could play an important role in producing information that would help to confirm whether or not crabeater seal populations had been declining in abundance in recent decades.

9.7 The Scientific Committee noted a number of general points that it suggested should be considered when implementing the APIS Program. The Program's emphasis on obtaining data from months in all seasons was felt to be important. As possible, the Program should try to ensure that studies are conducted in various geographic areas that are representative of the various sectors around the continent (e.g., between the Ross Sea and Prydz Bay as well as between Prydz Bay and the Weddell Sea). Obtaining data from sectors with different patterns of sea-ice, productivity, or oceanography will strengthen the comparisons made among different areas.

9.8 The Chairman of the Scientific Committee was requested to correspond with the Convener of the Group of Specialists on Seals during the intersessional period, advising him of those areas of particular interest to CCAMLR. In addition, Members with specific suggestions on improving the text of the draft prospectus (e.g., comments on the cross-references included in Tables 1 and 2) were encouraged to send these comments directly to the Secretary of the Group of Specialists on Seals.

9.9 The Scientific Committee welcomed the research initiative represented by the APIS Program, noting that it was likely to make a strong contribution to the work of CCAMLR, and that the Commission's attention should be drawn to this important new program. The Scientific Committee agreed that efforts should be made to ensure that close coordination and effective communication are developed and maintained with the APIS Program. To this end, Dr Bengtson was nominated to serve as CCAMLR's liaison with the APIS Program.

BIRDS

9.10 A major review prepared by Dr R. Gales for the Australian Nature Conservation Agency on the status of trends of albatross populations was available in SC-CAMLR-XII/BG/22. The review emphasised the vulnerability of albatross populations to depletion from incidental mortality due to their low reproduction rates. Attention was drawn to the paucity of data on population size and trends for a number of species. However, observations on fishing vessels both inside and outside the CCAMLR Convention Area indicate that albatrosses of most species are incidentally killed in fishing

operations, and that this mortality is implicated in the decline of a number of populations. The review drew attention to the need for reliable census data for most populations and longterm studies on demography. The need for studies on diet, foraging behaviour and movement patterns was identified, along with the requirement for more detailed studies on the interactions between albatrosses and fishing vessels.

9.11 The Scientific Committee commended the author for such a comprehensive review. However, it was noted that the assertion in the document that there had been no effort by longline fishing nations, other than Japan, to apply deterrent methods failed to take account of the efforts by CCAMLR and its Members in adopting and deploying streamer lines and other measures in the longline fisheries in the CCAMLR Convention Area. The Scientific Committee endorsed the need for further studies and monitoring programs for albatross populations found in the Convention Area. A number of recommendations in the review pertinent to the Scientific Committee's consideration of incidental mortality were taken up under Agenda Item 10.

INCIDENTAL MORTALITY

INCIDENTAL MORTALITY IN LONGLINE FISHERIES

10.1 Drs Croxall and Moreno presented SC-CAMLR-XII/BG/8 Rev. 1, on seabird interactions with longline operations during the exploratory fishing cruise for *D. eleginoides* at the South Sandwich Islands (Subarea 48.4). Based on the observations (by Scientific Observers on board the fishing vessel) of all seven sets on this cruise, no incidental mortality was seen and only one bird (a penguin) was caught on hooks. However, the number of seabirds present during day hauling operations suggested that incidental mortality could be expected from setting operations in daylight hours and in the absence of mitigating measures (such as the tori poles and streamer lines used on this cruise). The seabirds present included rather few individuals of the albatross species most vulnerable to longlining in the South Georgia region.

10.2 SC-CAMLR-XII/BG/8 Rev. 1 also presented some observations and anecdotal reports of incidental mortality of albatrosses in the South Georgia area. In the absence of streamer lines up to six albatrosses were being hooked and drowned per set, which, for the 406 sets for Subarea 48.3 in 1992/93, would extrapolate to a mortality of 2 346 albatrosses. This estimate does not include the activities of vessels in waters adjacent to the Convention Area.

10.3 Dr D. Robertson (New Zealand) reminded the Scientific Committee of the direct observation and measurement of incidental mortality of seabirds in the South Georgia *Dissostichus*

longline fishery. These measurements were submitted by ASOC in 1991 (CCAMLR-X/BG/18). These data, which were presented in SC-CAMLR-X (paragraph 8.14(iii)), were re-worked and published in *Polar Record* earlier this year. The re-worked data gave a very high seabird catch rate of 0.66 birds per thousand hooks.

10.4 Estimated albatross mortality of this magnitude is supported by reports (recorded in CCAMLR-XII/BG/6) of hundreds of albatrosses attempting to take bait off hooks as longlines are set, resulting in two to five albatrosses being caught per day. Two rings taken from dead albatrosses came from birds in the Bird Island study population.

10.5 CCAMLR-XII/BG/6 also reported continuing evidence of South Georgia birds being caught in longline fisheries outside the Convention Area, and particularly in the Indian Ocean sector, and in the Atlantic Ocean off Brazil and Uruguay.

10.6 Dr Croxall noted that last year the Scientific Committee had received the first report of seabirds impaled with fishing hooks being observed at breeding colonies (SC-CAMLR-XI, paragraph 8.13). SC-CAMLR-XII/BG/7 was tabled in response to the request for more information contained in SC-CAMLR-XI, paragraph 8.20. It documents the highest annual incidence yet recorded of similar evidence from albatrosses at South Georgia. At least some of these birds were likely to have swallowed hooks locally. Such records are likely to result from birds becoming entangled when lines are hauled and then cut free. The number of observations from a single site in one season is of concern, especially given that many birds may not survive swallowing, or being impaled on, fishing hooks.

10.7 Dr Croxall presented SC-CAMLR-XII/BG/21 on the population dynamics of black-browed and grey-headed albatrosses at Bird Island, South Georgia from 1975 to 1991. Significant population declines are reported from all but two of 14 grey-headed albatross colonies and from over half the 23 black-browed albatross colonies. Detailed work at four study colonies indicates that the main reason for the decline is a decrease in the juvenile survival rate. In comparing birds born in the 1960s (recruiting as breeders in the early 1970s) with the 1970s (recruiting in the early 1980s), survival was halved for black-browed albatrosses and reduced by 84% in grey-headed albatrosses.

10.8 These changes coincided with the development of longline fisheries for tuna outside the Convention Area and most recent records of mortality of juvenile albatrosses relate to entanglement in longlines. Although survival rates of adult black-browed and grey-headed albatrosses had fluctuated considerably there had been no clear trend, except for a substantial decline in the survival rates of adult black-browed albatrosses since 1988. This is of particular concern as it coincides with

the development of the *D. eleginoides* longline fishery carried out in very close proximity to the breeding colonies of black-browed albatrosses under study. Not only is the black-browed albatross a species particularly prone to associate with fishing vessels but satellite-tracking data show that birds breeding at South Georgia forage mainly around the shelf and shelf-edge areas. This is in contrast to grey-headed albatrosses which associate less with ships and whose foraging is rather less associated with areas where longlining is currently undertaken.

10.9 Dr Robertson introduced SC-CAMLR-XII/BG/14, which reported on a large amount of data collected by observers on tuna longline vessels in New Zealand waters. Twelve taxa of seabirds, including high numbers of albatrosses and species also found in the CCAMLR Convention Area, were taken incidentally in this fishery. A number of seabird populations subject to incidental mortality have declined after the introduction of longline fishing to the New Zealand region in 1962. A substantial reduction (by a factor of 10) in bird mortality has been observed between 1988 and 1992, following the introduction of mitigation measures including streamer lines and the setting of longlines at night. However, he considered that the magnitude of this result should be interpreted with caution because preliminary observer data from 1993 shows a return to higher levels of incidental mortality.

10.10 The study has led to a number of recommendations which are also relevant to CCAMLR. These included:

- the need for observer coverage at a level which can provide statistically robust measurements;
- the need to provide rapid feedback between observers and managers on the effectiveness of mitigation measures under different prevailing circumstances;
- the desirability of having two observers to obtain complete coverage of all longline sets;
- the requirement for vessel masters to record details of bird capture as a part of normal catch and effort reporting;
- the use of streamer lines (which CCAMLR has already implemented); and
- techniques which lead to faster sinking of the bait, for example using thawed rather than frozen bait.

10.11 SC-CAMLR-XII/BG/13 described some practical problems which had been encountered with using the streamer line with the design specified in Conservation Measure 29/XI on a Japanese longliner in New Zealand waters. A series of modifications which improve the durability and ease of use of the streamer line was developed in collaboration between a New Zealand observer and the crew of the Japanese tuna vessel.

10.12 The Scientific Committee congratulated New Zealand and Japan for the work they had carried out, and thanked New Zealand for presenting it to the Committee.

10.13 SC-CAMLR-XII/BG/18 reported on measures taken to reduce incidental bird mortality by Russian longline vessels fishing in Subarea 48.3. Observations were made on the numbers of birds attracted to the bait in order to evaluate the effectiveness of different mitigation measures. It was established that the best time for setting lines was from 0300 to 0400 local time, when the least number of birds were observed following the vessels. Disposal of offal and food scraps ceased at least 30 minutes prior to setting the line.

10.14 The relative effectiveness of each prescribed measure, as well as compliance with minimum lighting requirements, was estimated to be about 5 to 10%. Bright moonlight negated the effectiveness of setting at night and the use of minimum lighting. The streamer line was a much more effective preventative measure (60 to 80%), however, birds begin to become habituated to the streamers after about 1.5 hours. Therefore, it was recommended that the lines should be set as quickly as possible after deploying the streamer line. The paper also reported on improvements to the specification and rigging of the streamer line.

10.15 The Scientific Committee welcomed the studies reported in SC-CAMLR-XII/BG/18, and encourages the authors to prepare a paper for the next meeting giving full details on the research methods and data used to calculate the effectiveness of the various mitigation measures.

10.16 At its last meeting Dr T. Øritsland (Norway) reported on successful experiments in reducing bird mortality in longline fisheries in the North Atlantic, and undertook to provide a paper giving details on these experiments to this meeting. At this meeting, he reported that this paper was not prepared because the experiments showed that the methods of mitigation were very successful, and that the experiments were cut short in order to proceed with the implementation of the measures to all the vessels in the fishery as quickly as possible. The Scientific Committee considered that such results made it all the more important to receive further details on the methods used, along with such data as existed on their effectiveness. Accordingly, the Scientific Committee encouraged Dr Øritsland to prepare a paper on the mitigation methods developed in Norway for the next meeting of the Scientific Committee.

10.17 The Scientific Committee noted that Japan and Australia are collaborating on a project to test various types of streamer lines for effectiveness in reducing bird mortality in waters to the north of the Convention Area, and undertaking the development of a manual on longlining techniques which takes into account the problem of incidental mortality. The Scientific Committee encourages those involved to complete this work as soon as possible and is interested in receiving further reports on this work as well as copies of the manual.

10.18 The Scientific Committee is concerned that there continues to be problems in giving effect to measures designed to reduce the incidental mortality of seabirds in longline fishing operations. In particular the Scientific Committee is concerned about:

- (i) substantial lack of compliance with reporting requirements agreed by the Commission (CCAMLR-IX, paragraph 5.4 and given further effect in Conservation Measures relating to the data reporting system for the *D. eleginoides* fishery); and
- (ii) possible non-compliance with Conservation Measure 29/XI.

10.19 The Scientific Committee recognised that incidental mortality, particularly from longline fishing, was an increasingly important part of its deliberations. It was now difficult for the Scientific Committee to review adequately the amount of material becoming available and to develop management advice for the Commission in the time available at its annual meeting. Accordingly, the Scientific Committee decided to establish an *ad hoc* working group to consider incidental mortality arising from longline fishing, with the following terms of reference:

- (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;
- (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.

10.20 The first meeting of the *ad hoc* group is to be convened by Dr Moreno, and will be held in Hobart between the next meetings of WG-FSA and the Scientific Committee.

INCIDENTAL MORTALITY IN TRAWL FISHERIES

10.21 In 1991 the Commission adopted Conservation Measure 30/X, which prohibited the use of net monitor cables in the Convention Area starting with the 1994/95 fishing season. The Scientific Committee was pleased to learn that almost all trawlers operating in the Convention Area have already complied with this measure. Mr Cielniaszek reported that Polish vessels, which still use net monitor cables may operate in the coming season. Last year these net monitor cables were deployed in accordance with the procedure set out in Annex 6 of CCAMLR-X and this practice will continue for the next season.

MARINE DEBRIS

10.22 Member's reports on the assessment and avoidance of incidental mortality and impacts of marine debris on biota in the Convention Area have been received from the UK, Australia, South Africa, Japan, USA and Brazil (CCAMLR-XII/BG/6, 8, 9, 10, 12 and 18).

10.23 SC-CAMLR-XII/BG/6 reported the results of surveys of Antarctic fur seals entangled in marine debris carried out for the third consecutive winter and fifth consecutive summer at Bird Island, South Georgia. In winter 1992, 97 entangled fur seals were seen, a tenfold increase over the previous two years. In summer (1993), 84 entangled seals were seen, which was a 75% increase from 1992. About 50% of the entanglements involved plastic packing bands (probably from bait boxes), and about 25% involved net fragments. These results reversed a steady decline in entanglements which had been observed over the preceding four years.

10.24 CCAMLR-XII/BG/12 reported that 14 entangled fur seals were found on Seal Island in the South Shetland Islands. The number of fur seals hauling out on the island was much higher than

usual, and this is reflected in the larger number of entangled seals observed. The majority of entanglements was from plastic packing bands, although some net fragments were also observed.

10.25 The Scientific Committee noted that entanglement of fur seals with packing bands from bait boxes is a persistent problem. The Scientific Committee reiterates that these bands should not be disposed of at sea. At its last meeting, the Scientific Committee drew attention to the availability of bait boxes which do not use plastic packing bands. In light of the availability of an alternative bait box, the Scientific Committee recommends that the Commission prohibits the use of bait boxes which use plastic packing bands, over a short phase-out period.

10.26 CCAMLR-XII/BG/8 reported three fur seals entangled in net fragments on Heard Island.

10.27 In the intersessional period the Secretariat had prepared and circulated a draft set of guidelines for conducting surveys of beached marine debris. After taking into account the comments received, a final version of the guidelines was prepared (CCAMLR-XII/BG/15). The Scientific Committee thanked the Secretariat for undertaking this task. The Scientific Committee encourages Members to conduct future beach surveys for marine debris in accordance with the guidelines, and to suggest any further refinements which may be required.

10.28 A number of Members indicated that they would be undertaking beached debris surveys in the near future in accordance with the guidelines.

10.29 SC-CAMLR-XII/BG/15 reported the first ever observation of penguins contaminated with oil at Bird Island, South Georgia. One chinstrap and five gentoo penguins were found contaminated with oil in July and August 1993. Because gentoo penguins feed close inshore in winter, they must have been contaminated from nearby pollution. Krill fishing vessels were known to be operating nearby at about this time.

10.30 Mr S. Uno (Japan) stated that the Government of Japan has strictly prohibited the discharge of oil and wastes from vessels at sea under its maritime law since 1970. Japanese vessels were in effect complying with the provisions of the Antarctic Treaty pertaining to the prevention of marine pollution long before they were adopted in 1991. He reported that no Japanese vessels deliberately discharge oil and other wastes at sea, and that no accidental discharges had been reported.

ADVICE TO THE COMMISSION

10.31 The Scientific Committee recalled that paragraph 8.24, SC-CAMLR-XI, advises the Commission that if reports on incidental mortality and the effectiveness of mitigation measures were not forthcoming, then the Commission may have to consider adopting measures which would allow an effective assessment of incidental mortality. The Scientific Committee noted with regret that reporting of data on incidental mortality of seabirds on longlines and the effectiveness of mitigation measures was incomplete.

10.32 The Scientific Committee noted that experience in other fisheries has shown that reliable data collection on incidental mortality required Scientific Observers on fishing vessels, and that a high proportion of the vessels requires observer coverage if the total amount of incidental mortality is to be estimated reliably. The Scientific Committee therefore recommends that the Commission consider means for placing Scientific Observers on a high proportion of longline fishing vessels in the Convention Area for at least one fishing season to collect the data required for a reliable assessment of the numbers and species of birds incidentally captured on longlines in the CCAMLR Convention Area.

10.33 Experience by some Members in using the streamer line specified in Conservation Measure 29/XI has shown that there may be some problems in its design in terms of durability and ease of use. Members should report on their experience in using any type of mitigation measure inside or outside the Convention Area. The Scientific Committee advises that until it receives further detailed reports on improved streamer designs and other potential mitigation methods it would not be prudent to devise new Conservation Measures. However, the Scientific Committee agreed that in the interim it would be appropriate to revise Conservation Measure 29/XI to:

- (i) allow some flexibility in the design of the streamer line to increase its robustness and ease of use, so long as the effective sea surface area covered by the streamers is no less than that covered by the currently specified design;
- (ii) include a recommendation that only thawed bait should be used; and
- (iii) explicitly include provisions for reporting the data on incidental mortality required on form C2 (instead of giving effect to this requirement through the *D. eleginoides* biological data reporting system).

10.34 The Scientific Committee recommends that the Commission prohibits the use of bait boxes which use plastic packing bands, over a short phase-out period.

CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION

11.1 The Scheme of International Scientific Observation was adopted last year by the Commission. The first observation under this Scheme was conducted in accordance with an agreement between Chile and the UK (SC-CAMLR-XII/BG/4). The Scientific Observer nominated by the UK together with the observer nominated by Chile, undertook scientific observations on board the Chilean longliner, *Frio Sur V*, fishing for *D. eleginoides* in Subarea 48.4 (South Sandwich Islands). WG-FSA considered the report of this observation in detail (SC-CAMLR-XII/5, paragraphs 4.1 to 4.6). In commenting on this observation the Convener of WG-FSA, Dr Everson, stated that it worked extremely well and a lot of useful information had been collected. Dr Moreno also commended the fishing company Frioaysen S.A. for this effort.

11.2 The pilot version of the *Scientific Observers Manual* was published and distributed to Members. The WG-FSA and WG-Krill reports contain some comments on the Manual (Annex 5, paragraphs 4.3 to 4.6; Annex 4, paragraph 3.25). The Scientific Committee endorsed the recommendation of both Working Groups that in the light of the limited experience acquired so far in using the Manual, it should be revised and a new edition published only after more information about its use becomes available.

11.3 Members were then invited to report their plans for implementation of the Scheme in the 1993/94 season. Both Japan and the USA indicated their intention to participate in the Scheme. However, at present it is premature to inform the Scientific Committee of any plans which would be known only after the completion of the required bilateral arrangements between Members.

11.4 Dr Moreno pointed out that the required bilateral arrangements should be specifically designed in order to make more flexible the placement of observers on ships of participating Members throughout the year.

11.5 Lic. Marschoff noted that should the number of observers increase in the future, it will be necessary for the Scientific Committee to establish research priorities for observers. Each observation conducted under the Scheme should be cost-effective. The Scientific Committee, however, agreed that it is premature to assign research priorities. Individual Members can pick up any studies which conform with their scientific objectives from the general list of research priorities identified by the Scientific Committee (*Observers Manual*, page 5).

COOPERATION WITH INTERNATIONAL ORGANISATIONS

ICES

12.1 The observer to the 81st statutory meeting of ICES (Dr Agnew) presented his report (SC-CAMLR-XII/BG/23). Over 500 participants attended the meeting (23 September to 1 October 1993, Dublin, Ireland) and more than 500 papers were presented.

12.2 A Bureau Working Group on Strategic Planning for ICES which met this year made several recommendations for changes to the structure of ICES which are of interest to CCAMLR. These included: placing more emphasis on Theme sessions at the statutory meeting; merging the Pelagic, Demersal and Baltic Fish Committees into a single Fish Ecology Committee; and integrating studies from disciplines such as fisheries science and socio-economics to look at, for example, information requirements of different management options.

12.3 Details of plans for several symposiums to be held in 1994 and 1995 were given in the paper.

12.4 Dr Everson reported that the ICES Fisheries Acoustics Science and Technology Working Group was preparing a report on methods for the estimation of acoustic target strength.

IWC

12.5 The observer to the IWC (Dr de la Mare) introduced his report of the meeting of the Scientific Committee of the IWC (April to May 1993, Kyoto, Japan) (SC-CAMLR-XII/BG/9). The Scientific Committee completed its refinements of the Revised Management Procedure and the development of the Revised Management Scheme, and after examining the results from implementation tests for the application of the procedure to Antarctic minke whales recommended that should catch limits be set for these stocks, 'small areas' corresponding to 10° longitudinal sectors should be used.

12.6 Continuing its comprehensive assessment of Southern Hemisphere baleen whales, the IWC this year produced a revised estimate of humpback whale numbers south of 60°S, amounting to 5 600 animals. A new population estimate for Area V minke whales of 93 000 animals, calculated from 1991/92 sightings, was substantially less than the two previous estimates (295 000 and 178 000), but this was probably a reflection of year-to-year differences in the distribution of whales.

IWC Resolution on Research on the Environment and Whale Stocks

12.7 In response to a request from the IWC for information relevant to a Resolution on Research on the Environment and Whale Stocks, adopted at the 1993 meeting of the IWC, the Executive Secretary had informed the IWC of CCAMLR's programs relevant to this resolution (SC-CAMLR-XII/BG/24).

12.8 The Scientific Committee noted that a framework for the collection of data applicable to this resolution has not yet been established. However, the Scientific Committee asked the Secretariat to write to the IWC, further to the letter described in SC-CAMLR-XII/BG/24, expressing its interest in assisting the IWC in this resolution and providing a listing of CCAMLR data holdings which might be of relevance to the resolution.

IOC

12.9 One of the observers from the IOC, Lic. Marschoff, reported that the IOC is reorganising its program in respect of Antarctic activities. He offered to compile a summary of the relevant sections of Working Group reports and report back to the IOC.

12.10 Dr Marín informed the Scientific Committee that the first meeting for evaluation of living marine resources within the GOOS Program (Marine Living Resources Module/GOOS/IOC-FAO) will take place in San Jose, Costa Rica, from 7 to 10 December 1993. He noted that it may be appropriate to inform this group about the aims and research interests of CCAMLR, and the Secretariat was asked to bring this to the attention of the IOC.

12.11 The Convener informed the Scientific Committee that the next edition of the General Bathymetric Chart being produced by the IOC Ocean Mapping Project would probably appear in 1996, and that at present a high precision International Bathymetric Chart of the Weddell Sea is being created as part of this program.

FAO

12.12 Participation of the Secretariat in an *ad hoc* meeting on high seas fisheries statistics has been discussed in paragraph 3.75.

12.13 Dr Shotton, the observer from FAO, informed the Scientific Committee that FAO has considerable interest in the potential of ecosystem approaches for the management of fisheries, particularly in developmental situations, and the experience and methods of CCAMLR in this regard are of particular relevance. FAO wishes to strengthen contacts with CCAMLR so that its experience can be of benefit to other regions where such a management approach might be effective.

12.14 He further stated that the implications of the precautionary principle for fisheries management are of direct relevance to FAO's mandate and its Fisheries Resources Division is preparing an analysis of the implications (and means of implementation) of this principle for operational fisheries management. This paper should be completed by December 1993. FAO continues to provide technical support on this and other issues to the UN.

SCAR

12.15 The Data Manager informed the Scientific Committee that the BIOMASS Database should be available by December 1993. The Scientific Committee once more expressed its thanks to SCAR for making these data available to CCAMLR, and especially acknowledged the work of Mr M. Thorley, BIOMASS Database Manager, and his staff for their work in preparing the data for dissemination. It noted that these data have been of use to CCAMLR Working Groups for the last two years in the development of calculations of krill potential yield, and that the proposed krill flux workshop is expected to make further extensive use of them.

12.16 SC-CAMLR-XII/BG/16 gives details of the completed SCAR Antarctic digital topographic database. Dr Croxall, the observer from SCAR, informed the Scientific Committee that discussions are being held on the possibility of extending the database to include offshore bottom topography.

12.17 At its meeting in 1992, the Scientific Committee had asked the Data Manager to write to SCAR expressing CCAMLR's interest in participating in discussions of the SCAR-COMNAP *ad hoc* planning group on Antarctic Data Management. Following this request, CCAMLR has been invited to participate as observer at the meetings of this group.

12.18 The first stage towards integrated Antarctic data management proposed by the group is the establishment of a Data Directory system (SC-CAMLR-XII/BG/5). The Scientific Committee agreed that it would be appropriate for CCAMLR to lodge information about its data holdings and data access rules with the Data Directory when it becomes functional.

12.19 It was noted that information on data of use to CCAMLR would also be available through the Data Directory and, therefore, the system could be of value to the Scientific Committee. However, reservations were expressed about participation of CCAMLR in the second stage of the project, the construction of a database, since this might conflict with CCAMLR's data access rules. It was pointed out, however, that participation in the first part of the project would not imply automatic participation in the second.

12.20 In order that the development of the Directory proceed in a manner appropriate to CCAMLR's needs and that CCAMLR is able to provide advice to SCAR on the project, the Scientific Committee recommended that the Data Manager should represent CCAMLR at the next meeting of the SCAR-COMNAP group.

12.21 SO-GLOBEC (co-sponsored by SCAR) had been extensively discussed in the WG-Krill, WG-CEMP and WG-FSA reports (see Annex 4, Appendix F). The Scientific Committee endorsed the recommendations of all Working Groups that it should maintain close liaison with the SO-GLOBEC Program to ensure coordination of research programs of interest to both GLOBEC and CCAMLR.

12.22 The observer from SCAR (Dr Croxall) informed the Scientific Committee that the next meeting to discuss implementation of SO-GLOBEC was due to be held in June 1994, probably in Cambridge, UK. Until the structure of SO-GLOBEC is further developed it would be premature to nominate observers from each of the Working Groups of CCAMLR. However, a number of regular participants at CCAMLR Working Groups were also involved with the SO-GLOBEC subcommittees, and these people would be best placed to maintain liaison between the groups for the time being.

12.23 Accordingly, the Scientific Committee nominated Dr Croxall as its primary liaison with the Steering Committee of SO-GLOBEC, requesting him to seek assistance from the other members of the Scientific Committee's Working Groups who also attend SO-GLOBEC meetings.

12.24 Dr Croxall also drew the attention of the Scientific Committee to the development of the SCAR-sponsored Coastal Zone EASIZ (Ecology of the Antarctic Sea-Ice Zone) Program which had its first implementation meeting in Bremerhaven in September 1993. This program is designed to be complementary to SO-GLOBEC, focusing on interactions in the coastal zone especially concerning ice and ice biota, coastal community composition, nutrient cycles and benthic dynamics, and attempts to coordinate the coastal station work of SCAR members, with particular attention to longterm datasets.

12.25 It was noted that another important interaction between SCAR and CCAMLR was represented by the APIS Program which was discussed in more detail in paragraphs 9.2 to 9.9.

IUCN

12.26 The observer from IUCN (Mr A. Graham) informed the Scientific Committee that IUCN attaches great importance to CCAMLR, especially in relation to Article II. It continues to assist its Members in developing conservation strategies for its sub-Antarctic islands, and is seeking funding for a workshop on the impacts of human activities in the Antarctic. He noted that, at its next General Assembly (Argentina, January 1994), the IUCN will discuss a resolution identifying the importance it attaches to CCAMLR and recommending CCAMLR principles and practices be applied to all regional fisheries.

NOMINATION OF OBSERVERS

12.27 The following observers were nominated as observers at meetings in 1994:

- 82nd Statutory Meeting of ICES, 22 to 27 September 1994, St Johns, Canada: Dr Balguerías;
- 46th Annual Meeting of the IWC, May 1994, Puerto Vallarta, Mexico: Dr de la Mare;
- XXIII Meeting of SCAR, Rome, 29 August to 9 September 1994: Dr Croxall, with assistance from Dr Bengtson and Mr Miller at the meetings of SCAR specialist and subsidiary groups;
- Vth SCAR Symposium on Antarctic Biology, Venice, 30 May to 3 June 1994: Dr Sabourenkov; and
- SO-GLOBEC Implementation Meeting, Cambridge, UK, June 1994: Dr Croxall.

12.28 The Secretariat was also nominated to represent CCAMLR at the SCAR-COMNAP *ad hoc* Antarctic data management meeting (Boulder, USA, September 1994); and at the FAO *ad hoc* consultation on the Role of Regional Fishery Agencies in relation to high seas fishery statistics (La Jolla, USA, 13 to 16 December 1993).

UNITED NATIONS CONFERENCE ON STRADDLING STOCKS AND HIGHLY MIGRATORY SPECIES

13.1 The Chairman noted that Chile had requested that this item be added to the Agenda in order to obtain the Scientific Committee's advice on the possible contribution by CCAMLR to two matters under special consideration by the UN Conference, namely:

- (i) the suitability of the concepts of maximum sustainable yield and optimum sustainable yield in comparison with the approach described in Article II of the Convention; and
- (ii) the experience of CCAMLR in implementing the so-called precautionary approach in fisheries management.

13.2 The Scientific Committee noted that the task of providing the UN with technical information on MSY and the precautionary approach had been charged to FAO. Dr Marín emphasised that Chile had intended only that CCAMLR could provide a useful contribution to the international debate on this topic in the light of its unique convention, and was not seeking to advise the FAO or UN directly.

13.3 The Scientific Committee endorsed WG-FSA's comments (Annex 5, paragraphs 6.150 to 6.152) that MSY was not considered by CCAMLR to be an appropriate management objective because:

- it usually leads to highly variable catch limits from year to year which is in conflict with another frequent objective of management, the maintenance of stable catches over a number of years; and
- the MSY approach becomes hardly meaningful when biological interactions are taken into account as it is not possible to maximise the yield from both a predator and prey species simultaneously.

13.4 In this respect, Article II, as interpreted by the Scientific Committee, has an advantage over MSY in that it allows for consideration of multi species and predator-prey interactions in formulating management advice.

13.5 Mr Miller noted that the Commission's operational definitions of Article II (CCAMLR-IX, paragraph 4.17) had encouraged WG-Krill in its work on krill potential yield to include provisions for the calculation of levels of krill biomass which would allow sufficient escapement to meet the requirements of krill predators (Annex 4, paragraph 6.5). These considerations would not have been possible following a simple MSY approach (see Annex 4, paragraph 6.5).

13.6 The concept of Optimum Sustainable Yield, involving both economic and biological considerations, has not been discussed by the Scientific Committee in its sessions to date.

13.7 The Scientific Committee endorsed the deliberations of WG-FSA on the Precautionary Approach (Annex 5, paragraphs 6.153 to 6.155).

13.8 The guiding principle of a precautionary approach should be to evaluate in advance if the methods used for fisheries management are sufficient to achieve their management objectives. The Revised Management Procedure (RMP) recently developed by the Scientific Committee of the International Whaling Commission is an example of such a precautionary approach.

13.9 Dr Nomura stated that the RMP developed by the IWC is far too specialised to be applied to the management of fisheries in general.

13.10 The Scientific Committee noted that the term "precautionary approach" is also applied to management procedures which take into account uncertain or unknown effects of that management so that, on available information at least, the chances of the management objectives not being met are reduced. The Scientific Committee noted that CCAMLR has been using this principle for a number of years in its approach to management.

13.11 The Scientific Committee agreed that the best example of the use of a precautionary approach by CCAMLR was the introduction of precautionary catch limits for krill fisheries in the Convention Area to prevent uncontrolled expansion of the krill fishery. Other examples were (Annex 5, paragraphs 6.154 and 6.155):

- instituting advance notification and data requirements prior to the development of new fisheries, which led to catch and effort regulations being applied to exploratory fishing (e.g., crabs in Subarea 48.3 and *D. eleginoides* in Subarea 48.4);
- safeguarding against unknown effects of bottom trawling on mixed fish communities and benthos by prohibiting bottom trawling; and
- the practice of providing a range of management options together with an evaluation of the risks associated with these options, a format adopted by WG-FSA in the past.

13.12 Dr Yakovlev had prepared a document (in Russian) entitled "Definitions and Applicability of Various Criteria to the Management of Marine Living Resources" (SC-CAMLR-XII/BG/27). This document was not discussed. Dr Yakovlev informed the Scientific Committee that it contained an

analysis of the questions discussed at the UN Conference on Straddling Fish Stocks and Highly Migratory Species and that this was applicable to the Convention Area.

PUBLICATION OF SCIENTIFIC PAPERS

14.1 The first volume of *CCAMLR Scientific Abstracts* was published in 1993 and has been well received by Members.

14.2 The Scientific Committee considered at its present meeting the proposal made last year to upgrade the standard of *Selected Scientific Papers (SSP)* to that of an internationally recognised scientific journal (SC-CAMLR-XI, paragraph 11.2).

14.3 The Secretariat had submitted a paper describing the decisions of the Editorial Board at its meeting of 26 to 27 October 1993 and the actions taken by the Secretariat towards developing the framework for publication of a journal by CCAMLR (SC-CAMLR-XII/7 Rev. 1).

14.4 The Board recommended that the Scientific Committee approve publication of the new peer-reviewed Journal with the first issue to be published in 1994. The Science Officer will be the Editor-in-Chief of the new Journal. The Journal will be published in English with abstracts and captions to tables and figures in all CCAMLR official languages.

14.5 The Board suggested that the Journal be named "*CCAMLR Science*" with the following subtitle: "*Journal of the Scientific Committee and the Commission for the Conservation of Antarctic Marine Living Resources*". This name emphasises the Journal's affiliation to CCAMLR. It was also proposed that a cover page design for the Journal should reflect patterns and colours already used on the cover page of the *CCAMLR Scientific Abstracts*.

14.6 The question of processing papers submitted in languages other than English (French, Russian, Spanish) was discussed. The Board recommended that the following policy be adopted:

For discussion at CCAMLR meetings, papers are accepted in any of the official CCAMLR languages: English, French, Russian and Spanish. However, if the author wishes his/her paper to be considered for publication in the *CCAMLR Science* Journal, the paper should be submitted in English. If only a copy in English is submitted, it is the responsibility of the author to ensure that the language is of a high standard. In order not to discourage any author whose native language is one of the other official CCAMLR languages and in order to

assist in the review of the English version, a copy in the other language is also helpful.

14.7 The report of the meeting of the Editorial Board is given in Annex 7.

14.8 The Scientific Committee endorsed the recommendations of the Editorial Board. It drew the attention of the Commission to the fact that the upgraded journal will be of considerable benefit since it will not only allow peer review of scientific research undertaken as part of the Commission's activities, it will also ensure that important research findings are documented in such a way as to raise the profile of CCAMLR within the international scientific community. Both these factors would serve to further the Commission's work and status.

14.9 To further increase the international profile of CCAMLR science, a suggestion was made that the Scientific Committee might benefit from the publication of a 'digest' of its work in a journal such as *Polar Record*, *Antarctic Science* or *CCAMLR Science*. Other organisations, such as SCAR, regularly submit such digests for publication.

14.10 The Scientific Committee asked the Secretariat to contact various journals which specialise in polar science (e.g., *Antarctic Science*, *Polar Record*) to see whether they would be interested in publishing a digest of the proceedings of the Scientific Committee. It was agreed that should this suggestion be favourably received, the Chairman should be responsible for compiling such a digest.

14.11 The Scientific Committee suggested that the Commission might consider whether it should contribute an abstract of its activities suitable for publication in this digest. Some Members felt that the CCAMLR Newsletter, prepared annually by the Secretariat, would be an ideal format for publication as such a digest.

14.12 The Scientific Committee decided that the question of the digest should be addressed at its next meeting.

ACTIVITIES OF THE SCIENTIFIC COMMITTEE

1993/94 INTERSESSIONAL ACTIVITIES

15.1 The Scientific Committee agreed that all three Working Groups should meet during the intersessional period. In addition, a workshop on krill flux (paragraphs 2.29 to 2.31) and a joint meeting of WG-CEMP and WG-Krill will be held.

15.2 An offer was made by South Africa to host the meetings of WG-Krill and WG-CEMP, the krill flux workshop and the joint meeting. Mr Miller reported that currently it was planned to hold the workshop first, followed by parallel sessions of the two Working Groups including the joint meeting. The whole set of meetings would probably take about two weeks and take place some time between mid-July and mid-August 1994.

15.3 The Scientific Committee expressed its thanks to South Africa and accepted its generous offer to host these four intersessional meetings. It was noted that the plan to hold the two Working Group meetings in parallel for some of the time was a welcome contribution towards increased efficiency and cost saving. Dr Bengtson noted that the plan would involve a higher intensity of work for the Secretariat which might necessitate the inclusion of an extra day for flexibility.

15.4 The Joint Meeting of WG-Krill and WG-CEMP will have as its objective the facilitation of interaction between WG-Krill and WG-CEMP on matters of common concern. This facilitation should be primarily directed at the development of an ecosystem approach to management.

15.5 The draft agenda of the Joint Meeting will include the following as its primary items:

- (i) Ecosystem interactions:
 - (a) Potential impacts of localised krill catches; and
 - (b) Krill/predator functional relationships.

- (ii) Ecosystem assessment:
 - (a) Development of prey, fishery, and environmental indices;
 - (b) Integration of predator, prey, environmental, and fishery indices into ecosystem assessments;
 - (c) CEMP experimental approach; and
 - (d) Mechanisms for incorporating ecosystem assessments into the Scientific Committee's management advice to the Commission.

- (iii) Organisation of future work:
 - (a) Review of the effectiveness of current Working Groups' organisation;
 - (b) Identification of priority tasks best addressed by Working Groups; and
 - (c) Suggested terms of reference and Working Group organisation.

15.6 This framework will be developed intersessionally by the Working Group Conveners in consultation with the Chairman of the Scientific Committee and members of both Working Groups.

15.7 The Scientific Committee agreed that it should be represented at the VIth SCAR Symposium on Antarctic Science in Venice by the Science Officer (paragraph 12.27), and that CCAMLR should present a poster to the meeting which would be prepared through correspondence between the Secretariat and the Chairman of the Scientific Committee.

15.8 It was further agreed that it would significantly assist the work of the Scientific Committee if the Chairman, Dr Kock, also attended the Symposium.

15.9 The Scientific Committee agreed that following the practice established in 1992, there should be a coordination meeting between the Chairman, Vice-Chairmen and Conveners of Working Groups during the 1993 meeting of the Commission.

15.10 There has been an increase in the amount of information relevant under Item 10 “Assessment of Incidental Mortality” of the Scientific Committee’s agenda in recent years (paragraph 10.18). In light of the difficulty of giving all this information due consideration during the course of the Scientific Committee, the Committee agreed that its work would be facilitated if an *ad hoc* working group on incidental mortality could meet just prior to the Scientific Committee to consider this matter.

15.11 The *ad hoc* group would produce a report for consideration of the 1994 meeting of the Scientific Committee. Dr Moreno was nominated to convene this *ad hoc* group.

ORGANISATION OF FUTURE WORK OF THE SCIENTIFIC COMMITTEE

15.12 During the last few years, the Scientific Committee has become increasingly aware of the need to evaluate the relevance of terms of reference for its Working Groups. This is because the work conducted by the Working Groups has become more integrated as progress has been made in implementing an ecosystem approach to study Antarctic marine living resources. The original terms of reference are attached as Annex 8.

15.13 Furthermore, the scope and complexity of the Scientific Committee’s work have increased in recent years. For example, Members submitted 120 and 108 working papers to the 1992 and 1993 meetings of the Working Groups respectively (Annex 8, Table 2). Of these papers, 19 and

27, respectively, were reviewed by at least two Working Groups. In addition, during the last two years there were approximately 29 and 40 instances where topics or papers were addressed by at least two of the Working Groups.

15.14 In addition to identifying which work can best be done by Working Groups, the Scientific Committee agreed that the format of its present meeting agenda must be revised. For example, as more information becomes available under agenda items Marine Mammal and Bird Populations and Assessment of Incidental Mortality, a modification of procedures to better address these issues is needed (see paragraph 15.10).

15.15 The Scientific Committee has recognised the need for increased liaison among groups by conducting a joint meeting of WG-Krill and WG-CEMP during the 1992 intersessional period and by planning another joint meeting of the two groups during 1994. In addition, it agreed to begin considerations of how best to conduct its work at future Working Group meetings. The Scientific Committee has recognised that careful consideration must be given by Members to ensure that the most appropriate format is identified and adopted for future work. It agreed that the present format which has a structure determined by species groups (e.g., fish, crab, krill, predators) results in some duplication. However, some Members felt that structure determined by function (e.g., modelling, stock assessment) may result in excessive separation of the disciplines.

15.16 The Scientific Committee agreed, therefore, that during the 1993/94 intersessional period Members should be encouraged to consider the broad issue of ways to efficiently organise the future work of the Scientific Committee. To assist in this effort, each Working Group should be requested to discuss this matter at their intersessional meetings. Those discussions, while focusing most immediately on the specific work within each Working Group, should take place within the fuller context of the entire scope of the Scientific Committee's work. In particular, Members and the Working Groups should:

- (i) identify the work of the Scientific Committee that can most effectively be undertaken by the Working Groups;
- (ii) evaluate the relevance of the terms of reference for the current Working Groups;
- (iii) identify elements of work currently being undertaken by Working Groups that are being addressed well and those elements which could be improved;
- (iv) suggest ways in which priority work can be accomplished most efficiently; and

- (v) identify Scientific Committee activities that should be reduced or deleted.

15.17 The Scientific Committee will, at its next meeting, consider modification of the structure and terms of reference of its Working Groups and provide appropriate advice to the Commission.

BUDGET FOR 1994 AND FORECAST BUDGET FOR 1995

16.1 The draft budget is attached as Annex 9.

16.2 Provision is made for the three permanent Working Groups to meet, for a joint meeting of the WG-Krill and WG-CEMP, and for an *ad hoc* workshop on krill flux (paragraphs 2.28 and 15.1).

16.3 Provision is also made for CCAMLR to be represented by the Secretariat at the Vth SCAR Symposium on Antarctic Science and at a SCAR-COMNAP Data Management workshop (paragraphs 12.27 and 12.28), and for the continuation of the acquisition of sea-ice data by the Secretariat. This data acquisition was initiated by WG-CEMP in 1992.

ELECTION OF VICE-CHAIRMEN OF THE SCIENTIFIC COMMITTEE

17.1 In accordance with Rule 8 of the Rules of Procedure of the Scientific Committee there was an election for two Vice-Chairmen. Dr R. Holt (USA) nominated Dr M. Naganobu (Japan) and Dr E. Balguerías (Spain) nominated Dr C. Moreno (Chile) as Vice-Chairmen of the Scientific Committee. In making the nomination, Dr Holt and Dr Balguerías referred to the considerable experience of Dr Naganobu and Dr Moreno in Antarctic marine research, their long association with CCAMLR and dedication to the work of the Scientific Committee.

17.2 Drs Naganobu and Moreno were unanimously elected as Vice-Chairmen of the Scientific Committee for the period from the end of the Twelfth Meeting until the end of the Scientific Committee meeting in 1995.

17.3 The Chairman congratulated the new Vice-Chairmen on their election and expressed a view that, in future, more active involvement of Vice-Chairmen in the work of the Scientific Committee would be desirable. The Scientific Committee fully supported this point of view. The Chairman also paid tribute to the former Vice-Chairmen, Dr Holt and Dr Balguerías and thanked them for their support and valuable contributions to the work of the Scientific Committee during the past two years.

NEXT MEETING OF THE SCIENTIFIC COMMITTEE

18.1 The next meeting of the Scientific Committee will take place in Hobart from 24 to 28 October 1994.

OTHER BUSINESS

19.1 Dr Kim reported that informal discussions during the course of the meeting between eight Members planning cruises to the Antarctic Peninsula region in the 1994/95 season had helped significantly with the planning for these cruises. Suggestions had been made for scientist exchange, coordination of survey areas and periods and the inclusion of land-based research activities together with oceanographic work. Discussion will be continued during the intersessional period by correspondence and an informal meeting is tentatively scheduled to be held in Venice (with SCAR), South Africa (Working Group meetings) or any other convenient venue. The Scientific Committee commended this initiative and encouraged this type of cooperation between Members.

19.2 The Chairman invited ASOC to speak on the question of ozone depletion in the Antarctic.

19.3 ASOC drew attention to the 1993 Antarctic spring ozone hole (SC-CAMLR-XII/BG/26). This hole is the deepest ever recorded, and substantial areas of the Southern Ocean have been exposed to elevated levels of UV-B radiation. ASOC urged Members to address the causes of ozone depletion both domestically and in relevant international forums with the aim of stopping the production and use of ozone-depleting substances.

19.4 ASOC further stated that in the light of evidence that increased UV-B levels may result in a reduction of primary production and may alter the phytoplankton community structure, and of the lack of knowledge of impacts at higher taxonomic levels, it would be appropriate for CCAMLR to:

- ensure that potential UV-B impacts on the marine ecosystem are considered when making decisions concerning catch levels for commercial stocks; and
- encourage Members to expand research into UV-B impacts at the Southern Ocean ecosystem level as well as initiate research into potential effects on fish, birds and marine mammals.

19.5 Whilst the Scientific Committee recognised that direct action in regard to UV-B research was being addressed by other programs, such as SO-GLOBEC, it was considered appropriate that

CCAMLR maintain a watching brief concerning ozone depletion considering the potentially serious effects of UV-B radiation.

19.6 However, it was agreed that this should be the concern of Working Groups, which should take note of the possible effects of ozone depletion when considering the development of their advice on management. For instance, information on longterm changes in mortality, phytoplankton productivity and uncertainty of environmental change should be considered along with other factors in the assessment of potential yields and other advice.

19.7 Dr P. Penhale (USA) drew the attention of the Scientific Committee to a volume she is co-editing on the effects of UV-B radiation on the Antarctic ecosystem which will be published in 1994. Dr Roberston reminded the Scientific Committee of a bibliography on the subject which he had made available at last year's meeting of the Scientific Committee. This bibliography is currently being updated and will be available on request.

ADOPTION OF THE REPORT

20.1 The Report of the Twelfth Meeting of the Scientific Committee was adopted.

CLOSE OF THE MEETING

21.1 In closing the meeting, Dr Kock thanked Members and observers for their excellent cooperation, hard work and good spirit throughout the meeting. He extended his gratitude to the Vice-Chairmen, Conveners of the Working Groups and rapporteurs for their assistance. He congratulated the Secretariat and the interpreters for their never-ending and professional support which helped considerably in making the meeting a success.

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SC-CAMLR-XII/3	REPORT OF THE WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM (Seoul, Republic of Korea, 16 to 23 August 1993)
SC-CAMLR-XII/4	REPORT OF THE FIFTH MEETING OF THE WORKING GROUP ON KRILL (Tokyo, Japan, 4 to 12 August 1993)
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CCAMLR-XII/BG/20	SCIENTIFIC RESEARCH EXEMPTION PROVISIONS Delegation of Spain
CCAMLR-XII/BG/21	UN CONFERENCE ON STRADDLING FISH STOCKS AND HIGHLY MIGRATORY FISH STOCKS Delegation of Chile
CCAMLR-XII/BG/22	THIRD INTERNATIONAL CONFERENCE, MARINE DEBRIS. SEEKING GLOBAL SOLUTIONS Delegation of USA

CCAMLR-XII/MA/1	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1992/93 Poland
CCAMLR-XII/MA/2	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1992/93 France

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

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

1. Opening of the Meeting
 - (i) Adoption of the Agenda
 - (ii) Report of the Chairman

2. 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

3. Fish Resources
 - (i) Fishery Status and Trends
 - (ii) Report of the Working Group on Fish Stock Assessment (WG-FSA)
 - (iii) Data Requirements
 - (iv) Management under Conditions of Uncertainty about Stock Size and Sustainable Yield
 - (v) Advice to the Commission

4. 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

5. Squid Resources
 - (i) Review of Activities Related to Squid Resources
 - (ii) Advice to the Commission

6. Scientific Research Exemption

7. New and Exploratory Fisheries

8. 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
9. Marine Mammal and Bird Populations
10. Assessment of Incidental Mortality
 - (i) Incidental Mortality in Longline Fisheries
 - (ii) Incidental Mortality in Trawl Fisheries
 - (iii) Marine Debris
 - (iv) Advice to the Commission
11. CCAMLR Scheme of International Scientific Observation
12. Cooperation with Other Organisations
 - (i) Reports of SC-CAMLR Representatives at Meetings of Other International Organisations
 - (ii) Cooperation with SCAR
 - (iii) Nomination of SC-CAMLR Observers to Meetings of Other International Organisations
13. United Nations Conference on Straddling Fish Stocks and Highly Migratory Species
14. Publication of Scientific Papers
15. Activities of the Scientific Committee during the 1993/94 Intersessional Period
16. Budget for 1994 and Forecast Budget for 1995
17. Election of Vice-Chairmen of the Scientific Committee
18. Next Meeting
19. Other Business
20. Adoption of the Report of the Twelfth Meeting of the Scientific Committee
21. Close of the Meeting.

**REPORT OF THE FIFTH MEETING
OF THE WORKING GROUP ON KRILL**
(Tokyo, Japan, 4 to 12 August 1993)

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**REPORT OF THE FIFTH MEETING
OF THE WORKING GROUP ON KRILL**
(Tokyo, Japan, 4 to 12 August, 1993)

INTRODUCTION

1.1 The Fifth Meeting of the Working Group on Krill (WG-Krill) was held at the Hotel Mariners Court, Tokyo, Japan, from 4 to 12 August 1993. The meeting was chaired by the Convener, Mr D.G.M. Miller (South Africa).

1.2 The Working Group was welcomed to Tokyo by Mr Michio Chinzei, the Director-General of the Fisheries Agency of Japan.

REVIEW OF THE MEETING OBJECTIVES
AND ADOPTION OF THE AGENDA

2.1 The Convener briefly outlined the major objectives of the meeting (SC-CAMLR-XI, paragraph 2.97), which had been set out in detail and circulated prior to the meeting (SC CIRC 93/14).

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.J. Agnew (Secretariat), M. Basson (UK), Prof. D. Butterworth (South Africa), Drs W. de la Mare (Australia), R. Hewitt (USA), R. Holt (USA), V. Marín (Chile) and S. Nicol (Australia).

REVIEW OF FISHERIES ACTIVITIES

Fisheries Information

Data Submission

3.1 A summary of all fine-scale data from the krill fishery that had been submitted to the Secretariat was produced (Table 1). The Working Group noted the availability of this information and made use of it in its discussions.

Catch Levels

3.2 The following preliminary information from the commercial krill catch for the 1992/93 season was available:

Country	Subarea 48.1	Subarea 48.2	Subarea 48.3	Other	Total
Russia			2 948	50 (48.4)	2 998
Japan	31 784	4 089	17 636	5 762 (58.4.1)	59 271
Poland				15 863 (48)	15 863
Chile	3 262				3 262
Total	35 046	4 089	20 584	21 675	81 394

The total krill catch was substantially less than in 1991/92 (302 961 tonnes). Total catches in all statistical subareas were well below the precautionary catch limits set out in Conservation Measures 32/X, 45/XI and 46/XI. The Working Group noted that krill had been caught in Division 58.4.1 which is a statistical division not covered by a precautionary catch limit or other conservation measures.

Fishing Activities

3.3 Five Japanese krill fishing vessels operated in the Convention Area during 1992/93. Three vessels operated in waters off South Georgia (Subarea 48.3) between July and September 1992 and 11 717 tonnes of krill were caught. Between January and March 1993, four vessels operated in the South West Scotia Sea (Subarea 48.1) catching 23 700 tonnes. One vessel caught 5 762 tonnes off Wilkes Land (Division 58.4.1). In April 1993, one vessel fished in the central Scotia Sea (Subarea 48.2) and three vessels operated in the South West Scotia Sea (Subarea 48.1). In May one vessel operated in the central Scotia Sea (Subarea 48.2). Through April to June five vessels

caught 18 092 tonnes of krill. A total of five vessels caught 59 271 tonnes of krill during the 1992/93 season. Japan plans to maintain its current fishing effort during 1993/94 with about five vessels catching a similar amount to the 1992/93 season.

3.4 The Japanese krill catch from Division 58.4.1 was taken by one vessel. This vessel had been deployed in the area to catch krill of different quality from that taken from the South Atlantic region. The experience of the Japanese fleet has been that catches off the South Shetlands (Subarea 48.2) contained larger and greener animals, as well as a greater proportion of gravid females than off Wilkes Land, depending on the fishing season. Such changes in fishing location were the result of Japanese consumer demand for a variety of krill products.

3.5 The Working Group noted that this implied some predictability in the characteristics of the krill concentrations being fished. In future it would be useful to obtain information on anticipated changes in product demands as this might affect the location and activities of the fishery. It was also noted that such information may provide useful data on biological aspects of krill in different areas. The Working Group noted that such information would be in accordance with the Scientific Committee's and Commission's requests for submission of plans on the operational characteristics and anticipated activities of the commercial krill fishery (SC-CAMLR-XI, paragraphs 2.94, 2.95, 5.40, 16.4 and CCAMLR-XI, paragraphs 4.8 and 4.9).

3.6 Chile reported krill catches from one vessel fishing in two areas: north of Elephant Island and north of Livingston Island (Subarea 48.1). In total, 3 262 tonnes were taken between 3 March and 8 April 1993. Substantial catches of salps caused problems in the fishing operations in the Elephant Island region during this period and most of the catch came from the Livingston Island area. One Chilean fishing vessel would operate in the same regions during 1993/94.

3.7 Polish catches, as reported monthly to the Secretariat, increased from the 1991/92 level of 8 607 to 15 863 tonnes in 1992/93. Catches occurred in Subareas 48.1, 48.2 and 48.3 with no subdivision of the catch being reported. The Working Group agreed that details of future Polish fishing plans should be sought.

3.8 Russian fishing operations were confined to the period July and August 1992, when two vessels caught a total of 2 948 tonnes in the South Georgia area (Subarea 48.3), and one vessel caught 50 tonnes in Subarea 48.4. Although Russia was proceeding with privatisation of its fisheries operations and was concentrating on fishing grounds less remote than the Convention Area, there was a possibility that as many as three vessels would be sent to harvest krill during 1993/94, possibly in joint venture arrangements with other countries.

3.9 To the best available knowledge, no krill fishing was undertaken by Ukraine during 1992/93, although Ukrainian companies were reported to be keen to proceed with krill exploitation. Up to three vessels are likely to be deployed on the traditional fishing grounds during 1993/94.

3.10 The Republic of Korea undertook no krill fishing in 1992/93 and there were no plans to fish for krill in 1993/94.

3.11 Australia is still considering an application to harvest krill, but legal, administrative and financial delays have meant that this project is unlikely to proceed during 1993/94.

3.12 The Working Group noted press reports (*Fishing News International*) indicating India's interest in entering the krill fishery. The Working Group drew the Scientific Committee's attention to this and suggested that further information on India's krill fishing intentions be sought.

Data Submission

3.13 The Working Group appreciated that analyses of Japanese fine-scale catch and effort data had been presented in papers submitted to the present meeting and to earlier meetings (WG-Krill-93/25 and references therein; see also SC-CAMLR-XI, paragraph 2.92).

3.14 Japanese catch rates (catch-per-minute fishing) in the vicinity of the South Shetland Islands for 1991/92 (WG-Krill-93/25) indicated that there had been a substantial change in this index during the period April to May 1992. It was pointed out that this might represent a seasonally related change in local density rather than biomass over a large area. It might also reflect an unusual lack of ice in this area during this period which allowed late season fishing. The Working Group encouraged an examination of Japanese fishing log-books from the 1992/93 season to ascertain whether the observed decline in CPUE could be correlated with environmental factors such as sea-ice conditions.

3.15 Severe difficulties had been encountered in the acquisition of fine-scale data from 1991/92 from the fishing fleets of the former Soviet Union. These had been exacerbated by the privatisation of the Russian and Ukrainian fisheries.

Historical Commercial Krill Catch Data from the Former Soviet Union

3.16 At its 1992 meeting, the Scientific Committee had encouraged Members with previously unreported historic data on krill catches to evaluate the accessibility of these data, to assess the

feasibility of processing these data into standard formats, and to submit the data to the CCAMLR Data Centre (SC-CAMLR-XI, paragraphs 2.23 to 2.25). In particular, it was noted that a considerable amount of historic data from the krill catches of the former Soviet Union has not yet been submitted to CCAMLR.

3.17 An inventory was compiled of the former Soviet Union's total krill catch data from Statistical Area 48, as submitted to CCAMLR on STATLANT forms. Those years for which the data had been submitted to the Data Centre in fine-scale formats were also identified. This inventory is attached as Table 2. Dr K. Shust (Russian Federation) indicated that there were three possible sources of historical fine-scale data:

- (i) Summary reports that provide general accounts of fishing activities (e.g., catch totals, charts showing approximate locations of the fleet's fishing activities) for the years 1973/74 through 1976/77. These reports are believed to be accessible at either VNIRO (Moscow) or AtlantNIRO (Kaliningrad).
- (ii) 15-day reports that had been prepared and submitted to regional fisheries offices throughout the duration of the fishery for the years 1977/78 through 1982/83. These reports are currently kept in various locations depending on the home port of vessels operating during a particular season (reports were submitted to the regional offices responsible for vessels operating out of that region's ports). It is believed that most of these reports should still be accessible through staff at the following facilities: VNIRO (Moscow), AtlantNIRO (Kaliningrad) or YugNIRO (Kerch).
- (iii) Magnetic tape on mainframe computers, with fishery data for the years 1983/84 through 1991/92. These data require some manipulation to transform them into formats suitable for submitting to the CCAMLR Data Centre. The magnetic tape records are accessible through staff at VNIRO (Moscow).

3.18 Dr Shust presented examples of initial fine-scale summaries of historic data that he had prepared. The Data Manager noted that these summaries used a format that would be compatible with the database used by the Secretariat. As a next step, it was agreed that the historic data should be processed into fine-scale summaries for submission to CCAMLR. The possibility of reporting these historic data in a finer scale (e.g., 10 x 10 n miles or haul-by-haul) should also be investigated.

3.19 In addition to historic catch data from Statistical Area 48, it was recalled that the former Soviet Union had undertaken krill catches in Statistical Area 58 in the late 1970s and early 1980s. It was agreed that obtaining fine-scale information about the locations of catches during that period

would be useful. It was noted that most of the catch data from the former Soviet Union in Statistical Area 58 are presently located at YugNIRO (Ukraine).

3.20 The Working Group welcomed the information provided by the historic catch data inventory and the examples of fine-scale summaries, and encouraged Dr Shust and his colleagues to proceed with processing and submitting these data to CCAMLR as soon as possible. The Working Group appreciated that this would not be a small task, and Members were encouraged to assist with this effort where possible. It was noted that scientists from Russia and the United States were collaborating in an attempt to expedite this work.

3.21 The Working Group drew the Scientific Committee's attention to the above situation and suggested that Members might investigate ways in which this work be facilitated.

Haul-by-haul Data and Length Frequency Analysis of Samples from the Commercial Krill Fishery

3.22 The Working Group noted that haul-by-haul and length frequency data from both the Japanese and Chilean krill fisheries had been used in analyses presented in WG-Krill-93/14 and 25. These papers were based on very fine-scale catch information and had enabled improved analyses of krill fishing fleet activities.

Length Frequency Data from the Fishery

3.23 It was noted that Japan has submitted length frequency data since they were initially requested in 1987 (CCAMLR-VI, paragraph 92). The collection and submission of haul-by-haul and length frequency information was again requested by the Working Group.

Location of Catches

3.24 The Working Group at its 1992 meeting (SC-CAMLR-XI, paragraph 2.91), requested that the Secretariat contact FAO to determine whether any krill catch information had been reported for FAO Statistical Area 41. FAO reported that it had no information on any krill catches in Area 41.

Reports of Observers/Use of Draft Observer's Manual

3.25 The Scientific Observers Scheme has only been in operation since its endorsement by the Commission at its Eleventh Meeting (CCAMLR-XI, paragraphs 6.10 and 6.11). As yet, no reports have been received by observers on commercial krill fishing vessels. Similarly, there has been no feedback on the utility of the draft Observer's Manual. The Working Group noted that it might be some time before such reports are available and the utility of the Observer's Manual can be effectively assessed.

By-catch of Young Fish in the Krill Fishery

3.26 Three papers reported on the by-catch of young fish in the krill fishery. These assessed the by-catch in research trawls off the South Shetland Islands in summer 1990/91 (WG-Krill-93/50), the by-catch during winter off South Georgia by the Japanese krill fishery (WG-Krill-93/51), and the by-catch by the Ukrainian fishery off South Georgia in 1992 (WG-FSA-93/8).

3.27 The results from these studies indicate that the by-catch of young fish during krill fishery operations in the South Shetlands might be much less than at South Georgia. The Working Group accepted, however, that it was difficult to assess the extent of such apparent differences given the different techniques and equipment used by research vessels when compared with commercial operations, and by differences in the analytical procedures used.

3.28 Japanese data from the South Georgia region indicated that a by-catch of fish occurred in a minority of hauls examined (20 out of 74 stations) and that only three fish species were involved, with *Lepidonotothen* [*Nototheniops*] *larseni* predominating (93.9% by number observed). The total number of fish in each haul was low.

3.29 Ukrainian results indicated that the fish by-catch of krill fishing operations may be substantial, although fish were only evident in 10 out of 55 stations sampled. *Champscephalus gunnari* and *N. larseni* were dominant. Extrapolating the by-catch rate to the entire Ukrainian krill fishery off South Georgia, the estimated by-catch induced mortality of these two species in 1991/92 would have been 27.2 million individuals and 22.5 million individuals respectively.

3.30 It was noted that the largest by-catch of fish in the Ukrainian fishery occurred when krill catch rates were low. This might be because the fishery was targeting dense krill aggregations thereby minimising by-catch or possibly because the by-catch was highest when krill were more dispersed.

3.31 Full details of the methodology underlying the estimation of the average level of fish by-catch in the Ukrainian krill fishery were not provided in paper WG-FSA-93/8. The Convener will contact the senior author and encourage him to provide this information to WG-FSA.

3.32 The Working Group stressed that appropriate statistical procedures (see Pennington, 1983¹) should be applied to take account of the large number of zero observations in studies of fish by-catch in krill fishing operations.

3.33 The Working Group recognised that different levels of by-catch might be induced by differences in the operational characteristics of various fishing fleets. This could include effects caused by different trawling speeds or towing depths.

3.34 Because there may also be seasonal or diurnal differences in by-catch, the Working Group suggested that the Working Group on Fish Stock Assessment (WG-FSA) might consider when the fish species most often encountered as by-catch would be most vulnerable to krill fishing operations.

Other Information

Excess Krill Mortality Associated with Commercial Trawling

3.35 A mathematical model of excess krill mortality associated with commercial krill trawling was presented in WG-Krill-93/34. This model updated that which was presented to the 1990 meeting of the Working Group (Zimarev *et al.*, 1990²), and indicated that mortality resulting from krill not being retained by trawl meshes could range between 1.5% and 26% of the landed catch depending on the fishing intensity.

3.36 One of the assumptions of the above model was that all krill coming into contact with the fishing net die. This may be a pessimistic assumption since at low densities some animals may pass through the mesh without damage. In addition, the model does not include hydrodynamic effects which could reduce the probability of krill striking parts of the net. The Working Group considered that these assumptions had important implications and suggested that it should be tested

¹ Pennington, M. 1983. Efficient estimators of abundance, for fish and plankton surveys. *Biometrics*, 39: 281-286.

² Zimarev, Yu.V., S.M. Kasatkina and Yu. Frolov. 1990. Midwater trawl catchability in relation to krill and possible ways of assessing gross catch. *Selected Scientific Papers, 1990 (SC-CAMLR-SSP/7)*. CCAMLR, Hobart, Australia: 87-113.

experimentally. Factors to be taken into account in such experiments would include the size of the mesh and trawling speed.

3.37 Dr H. Hatanaka (Japan) drew the Working Group's attention to a paper, WG-Krill-92/29, tabled at the previous meeting, in which this topic was considered. It was concluded that the mortality rate during net retrieval seemed to be small in the case of the Japanese commercial fishery. He further pointed out that there are two aspects in the mortality during trawl hauling: krill escapement through meshes and mortality rate of such escaped animals, and that the latter is difficult to estimate.

3.38 The Working Group also agreed that the results of the model described above are important and consequently the model should be independently validated and sensitivity analyses should be carried out on the critical input parameters. The author was requested to provide the Secretariat with a copy of the computer code for validation; this would also be made available to interested Working Group members who could then undertake the necessary sensitivity analyses.

Development of CPUE Indices

3.39 The preliminary results of a joint US/Chilean study using a combination of catch-per-fishing time from the Chilean krill fishery and US acoustic survey data around Elephant Island in 1992 were presented to the Working Group. These results indicated that some of the parameters required for the Composite Index of Krill Abundance (SC-CAMLR-VIII, Annex 4, Appendix 7) such as the characteristic radius of concentrations, are extremely difficult to estimate. Furthermore, the acoustic survey data showed intense temporal variability and this has the potential to confound combined analyses of fisheries and acoustic survey data which are not collected simultaneously. Updated results will be submitted to the Scientific Committee in the near future.

3.40 Further discussion on the development and application of CPUE indices is reported in paragraphs 5.26 to 5.32.

ESTIMATION OF KRILL YIELD

Krill Flux in Statistical Area 48 and Other Areas

4.1 During the 1991 meeting, WG-Krill identified the need for hydrographic and other data which might be used to indicate possible immigration and emigration rates and retention times of krill in the

various fishing grounds and statistical subareas. In particular, the Working Group specified that, as a first step, integrated mass flow paths across the boundaries of the Statistical Subareas in Area 48 should be calculated. At that meeting the Working Group also developed a simple model in the form of figures (SC-CAMLR-X, Annex 5, Figures 2 and 3) which hypothesised a number of krill flows in Statistical Area 48 on the basis of available knowledge of general hydrographic features.

4.2 A number of papers containing relevant information from geostrophic flow calculations and experiments with drifting buoys has been submitted to WG-Krill over the last three meetings. Based on this information, a revised table summarising information on possible water movements between subareas has been produced (Table 3).

4.3 The Working Group also received paper WG-Krill-93/11 which was a comprehensive bibliography of publications on Antarctic oceanography which might be useful in tackling this task.

4.4 The Working Group agreed that there was a considerable body of data that could be brought to bear on this question, and that a process was needed to calculate the integrated mass flows across the subarea boundaries in Statistical Area 48. It was also agreed that a high priority should be afforded to the development of methods which would allow the available information to be used in estimating possible ranges of immigration/emigration rates and retention times. It was reiterated that the transport of krill was not necessarily a purely passive process governed only by water movements since active migration of krill has been documented - Kanda *et al.* (1982)³, Siegel (1988)⁴.

4.5 Attention was drawn to the OPEN Program in Nova Scotia in which current meters and drifter buoys have been used to track a specified body of water in order to follow the development of recruits in a cod stock. It was suggested that similar methods could be used to follow a water mass containing a krill concentration in the Antarctic to determine the extent to which the concentrations and the water mass moved in concert.

4.6 Dr I. Everson (UK) drew attention to the results of Everson and Murphy (1987)⁵ which indicated that in the Bransfield Strait the transport of krill was virtually coincident with the speed of water movement in that area.

³ Kanda, K., K. Takagi and Y. Seki. 1982. Movement of the larger swarms of Antarctic krill *Euphausia superba* off Enderby Land during 1976-77 season. *J. Tokyo Univ. Fish.*, 68 (1/2): 24-42.

⁴ Siegel, V. 1988. A concept of seasonal variation of krill (*Euphausia superba*) distribution and abundance west of the Antarctic Peninsula. In: Sahrhage, D. (Ed.). *Antarctic Ocean and Resources Variability*. Springer-Verlag, Berlin Heidelberg: 219-230.

⁵ Everson, I. and E. Murphy. 1987. Mesoscale variability in the distribution of krill *Euphausia superba*. *Mar. Ecol. Prog. Ser.*, 40 (1-2): 53-60.

4.7 Results of surveys conducted over a very small area in Subarea 48.3 are presented in WG-Krill-93/35. The main aim of this study was to estimate krill transport rates rather than biomass *per se*. The authors conclude that, since transport rates are very similar to current speeds, the observed changes in biomass may be caused by krill transport.

4.8 It was noted that the application of geostatistical methods to these data would be particularly appropriate. The importance of estimating the variance of parameters or quantities (e.g., biomass) was again highlighted.

4.9 It was also noted that the small area that was deliberately chosen for the study may or may not be typical of the whole of the area around South Georgia. There are, for example, large areas with high retention capacity to the east of the islands. Other areas around the islands are less likely to retain krill. Although the study is useful in trying to estimate transport rates of krill, results should be interpreted with care.

4.10 The Working Group agreed that, as a first step, it would be useful to consider krill as passive drifters, at least with respect to horizontal transport, and that incorporation of active krill movement into the estimation of krill fluxes would follow at a later stage. Noting initiatives such as reported in WG-Krill-93/19, the Working Group further agreed that a special workshop was needed to bring together appropriate aspects to carry these calculations forward. A conceptual model and terms of reference for this workshop are presented in Appendix D.

Estimation of Effective Biomass

Techniques

4.11 Various techniques for estimating krill biomass have been identified in the past. Of these, two direct methods are acoustic surveys and net surveys. One indirect method is the use of indices (e.g., CPUE indices) to estimate relative abundance.

4.12 Four papers on technical details of acoustic methods were tabled: WG-Krill-93/6, 21, 24 and 48.

4.13 Dr K. Foote (Norway) presented WG-Krill-93/6. The background for this study, the Krill Target Strength Experiment (KTSE), was conducted under the aegis of British Antarctic Survey during the austral summer 1987/88. It consisted of, first, simultaneous measurements of the echo energy from encaged aggregations of live krill at 38 and 120 kHz; secondly, biological and physical

measurements of the same specimens, including measurements of mass density of individuals and speed of sound in an animal; and thirdly, application of the fluid-sphere model.

4.14 Because there was rather poor agreement between the fluid sphere model predictions and KTSE measurements in the previous analysis, the deformed fluid-like cylinder model of Stanton (1989)⁶ was applied in the new paper (WG-Krill-93/6). Using the same physical parameters and animal dimensions as were measured during the KTSE, new computations of target strength were performed, but as a function of krill orientation. Since the orientation was not measured during the experiment, the orientation distribution was inferred by requiring that the difference between predicted echo energy and that from two frequency measurement pairs be a minimum in a least squares sense.

4.15 The new results show a strong agreement between model predictions and measurements. The authors believe that the new model may prove useful in acoustic applications where krill number density is to be determined. They call particular attention to the importance of measurements of mass density and sound speed, as well as animal morphometry.

4.16 Such measurements are also important to another new model of krill scattering, that by Drs M. Furusawa and Y. Miyanoana (Japan), described in WG-Krill-93/21. The study developed a target strength (TS) model where krill is represented by a liquid prolate spheroid. As in the case of the model used in WG-Krill-93/6, the results in this study are also sensitive to the internal density, and sound speed of krill. One of the conclusions of this paper was that at low frequency the target strength is low, the signal to noise ratio (SNR) is low and results are sensitive to krill length, but not orientation. At high frequency, on the other hand, target strength is high, the SNR is high but results are sensitive to the orientation of krill. The authors recommended that a frequency of 70 kHz be used for krill surveys.

4.17 Consequently, it was noted that there were advantages in operating at more than one frequency. It was further noted that operating at dual frequencies allows for improved discrimination of targets. For example, the characteristic difference in mean volume backscattering strength (MVBS) at 38 and 120 kHz is around 5 dB for krill from field observations (Hampton, 1990⁷).

⁶ Stanton, T.K. 1989. Sound scattering by cylinders of finite length. III. Deformed cylinders. *J. Acoust. Soc. Am.*, 86: 691-705.

⁷ Hampton, I. 1990. Measurements of differences in the target strength of Antarctic krill (*Euphausia superba*) swarms at 38 kHz and 120 kHz. In: *Selected Scientific Papers, 1990 (SC-CAMLR-SSP/7)*. CCAMLR, Hobart, Australia: 75-86.

4.18 Paper WG-Krill-93/24 presented results from target strength experiments on krill in tanks. Observations confirm the sensitivity of target strength to orientation of krill, as well as the physical characteristics of the animals (e.g., size, sex, maturity and reproductive stage).

4.19 A correction for acoustic survey bias introduced by the vertical migration of krill was proposed in WG-Krill-93/48. In each of five surveys, conducted in the Elephant Island area during the austral summer of 1992, krill were observed to be dispersed in the upper portion of the water column at night and more concentrated and deeper during the day, suggesting that substantial numbers of krill may be above the acoustic observation window during dark hours. A polynomial function was fitted to the data and subsequently used to adjust the original surveys; resulting biomass estimates were 2.3 to 99.6% higher than those disregarding bias due to diel vertical migration.

4.20 Alternative ways of correcting for animals in the surface layer, and therefore not detected by the downward-looking transducer, were discussed. There are many problems, particularly regarding noise (e.g., caused by bubbles or reflections from the sea surface), associated with upward and sideways-looking transducers. These techniques are, however, being investigated. The possibility of using recently-developed laser-based system (LIDAR) for looking at the surface layer was mentioned.

4.21 It was further noted that if the target-strength model is correct, then the TS of an animal with fixed orientation is the same whether the transducer is downward or upward-looking. For transducers looking in other directions, the TS will in general be different.

4.22 The importance of regular net hauls during acoustic surveys was again highlighted. Such hauls are essential for target identification and collection of biological data.

4.23 No further developments or technical matters regarding net surveys for the estimation of biomass were presented.

4.24 The use of CPUE indices for biomass estimation was briefly considered. Further discussion is given in paragraph 5.27.

Estimates of Biomass in Statistical Area 48

4.25 In SC-CAMLR-XI (Annex 4) possible problems with some aspects of the FIBEX data, which had been re-analysed to estimate total krill biomass in Statistical Area 48, were indicated. The

principal question related to the data from the *Walther Herwig*. Estimates of biomass from these data were substantially higher than estimates from other survey vessels in adjacent areas.

4.26 Results of further exploratory analyses of the FIBEX acoustic data are presented in WG-Krill-93/31. Data from surveys in the West Atlantic sector were re-examined. The high densities of the *Walther Herwig* survey were largely due to the presence of a superswarm near Elephant Island although the occurrence of a high biomass there is not an unusual phenomenon. Furthermore, there was a good level of consistency between the distributions of MVBS and estimates of density from four of the vessels, *Itzumi*, *Eduardo L. Holmberg*, *Odissey* and *Walther Herwig*. While there is some uncertainty associated with the combinations of data collected at 50 kHz (*Walther Herwig* survey) with data collected at 120 kHz (all other vessels), it is concluded that this does not materially affect the estimated biomass.

4.27 Results in WG-Krill-93/31 show that data from the *Professor Siedlecki* survey do not provide distributions of MVBS and estimates of density that are consistent with the other surveys. The authors could find no explanation for this difference.

4.28 Whilst checking all FIBEX acoustic datasets, a further complication came to light regarding the data from *Eduardo L. Holmberg*. Following correspondence between Dr P. Trathan (British Antarctic Survey) and colleagues at Instituto Antártico Argentino it became clear that an incorrect value for integrator gain had been used for the analysis. Applying the correct integrator gain value resulted in a 10 dB increase in MVBS values. The distribution of corrected MVBS values has a mode close to that for *Itzumi* and the same as that for *Odissey* (WG-Krill-93/31). These corrected MVBS values give a tenfold increase in the estimated mean density of krill from that survey. The corrected values of density and standing stock appear in the version of WG-Krill-92/20 published in *Selected Scientific Papers, 1992 (SC-CAMLR-SSP/9)*.

4.29 WG-Krill-93/20 reports on a re-examination of data from the *Eduardo L. Holmberg* FIBEX survey for incorporation into the BIOMASS database in the appropriate standardised format. The results indicate the krill were concentrated to the western end of the South Orkney Islands. Density values are consistent with those from other FIBEX surveys (see Figure 1 in WG-Krill-93/20 and Figure 3 in WG-Krill-93/31).

4.30 The analyses presented in papers WG-Krill-93/31 and WG-Krill-93/20 basically resolve the questions about the *Walther Herwig* data but raise new questions regarding the *Professor Siedlecki* data. Fortunately, the area surveyed by the *Itzumi* overlaps largely with that surveyed by the *Professor Siedlecki*. Furthermore, the *Itzumi* survey covers the area of anticipated high krill density. In conclusion the Working Group therefore felt that, for the purposes of calculating effective

biomass in Statistical Area 48 for use in the calculation of potential yield, there was no urgent need to resolve the questions regarding the *Professor Siedlecki* data.

4.31 Given the problems associated with the *Professor Siedlecki* survey data, the estimates of biomass from FIBEX given in Table 2 of the revised version of WG-Krill-92/20 were recalculated excluding those data. Results of recalculations are given in Table 4. The values differ materially from those given in SC-CAMLR-XI, Annex 4, Table 2 in the following ways:

- (i) the total biomass for Subarea 48.1 is increased to 13.6 million tonnes due to the inclusion of the *Walther Herwig* and the exclusion of *Professor Siedlecki* data (paragraphs 4.26 and 4.27); and
- (ii) the total biomass for Subarea 48.2 is increased to 15.6 million tonnes following correction of the integrator gain from *Eduardo L. Holmberg* (paragraph 4.28).

4.32 Annual acoustic estimates of krill biomass in the Elephant Island area for the years 1981 through 1993 were presented in WG-Krill-93/49. Survey results prior to 1992 were adjusted in consideration of the definition of krill target strength recommended by WG-Krill at its 1991 meeting. Average krill biomass densities during January to March were also presented for all years except 1982, 1983 and 1986, together with qualitative evaluations of krill recruitment from WG-Krill-93/8. In six out of seven cases, good (or bad) recruitment corresponded to an increase (or decrease) in krill density the following year. A table of these estimates, both in terms of abundance and areal density, is included below and attached as Figure 1:

Year	Month	Survey Area (10 ⁶ m ²)	Biomass (10 ³ t)	Adj. Biomass (10 ³ t)	Areal Density (g/m ²)	Reference
1981	March	17 338	790*	1 187	68.5	Macaulay (unpub. ms)
1983	Oct/Nov	36 038	52	480	13.3	Klindt, 1986
1984	March	17 338	260	390	22.5	Macaulay (unpub. ms)
1984	Nov/Dec	34 663	380	2 200	63.5	Klindt, 1986
1985	March/April	31 840	16	81	2.5	Klindt, 1986
1987	January	17 338	660	992	57.2	Macaulay (unpub. ms)
1988	January	17 338	480	721	41.6	Macaulay (unpub. ms)
1989	February	17 338	950*	1 428	82.4	Macaulay (unpub. ms)
1990	early January	40 902	465	699	17.1	Amos <i>et al.</i> 1990
1990	late January	36 271	1 132	1 702	46.9	Amos <i>et al.</i> 1990
1990	early February	40 902	2 133	3 206	78.4	Amos <i>et al.</i> 1990
1990	late February	40 902	2 475	3 720	90.9	Amos <i>et al.</i> 1990
1991	late January	43 474	689	1 036	23.8	Macaulay & Mathisen, 1991
1991	late Feb-early Mar	42 960	822	1 236	28.8	Macaulay & Mathisen, 1991
1992	late January	36 271	2 220	2 220	61.2	Hewitt & Demer, in press
1992	early March	36 271	1 075	1 075	29.6	Hewitt & Demer, in press
1993	January	36 271	4 880	4 880	134.5	Hewitt & Demer, submitted
1993	February	36 271	3 220	3 200	88.2	Hewitt & Demer, submitted

* excluding biomass of observed superswarm

Amos, A.F., J.L. Bengtson, O. Holm-Hansen, V.J. Loeb, M.C. Macaulay and J.H. Wormuth. 1990. Surface water masses, primary production, krill distribution and predator foraging in the vicinity of Elephant Island during the 1989/90 austral summer. Document *WG-CEMP-90/11*. CCAMLR, Hobart, Australia: 65 pp.

Hewitt, R.P. and D.A. Demer. (In press). Dispersion and abundance of krill in the vicinity of Elephant Island in the 1992 austral summer. *Mar. Ecol. Prog. Ser.*

Hewitt, R.P. and D.A. Demer. (Submitted). AMLR Program: distribution and abundance of krill in the vicinity of Elephant Island in the 1993 austral summer. *US Antarctic Journ.*

Klindt, H. 1986. Acoustic estimates of the distribution and stock size of krill around Elephant Island during SIBEX I and II in 1983, 1984 and 1985. *Arch. Fischwiss.*, 37: 107-127.

Macaulay, M.C. and O.A. Mathisen. 1991. AMLR Program: hydroacoustic observations of krill distribution and biomass near Elephant Island, austral summer 1991. *US Antarctic Journ.*, 26 (5): 203-204.

4.33 The total areas related to the abundance estimates in the above table differ greatly and the question was raised whether estimates for a standardised area would be more helpful for the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP). Dr Hewitt indicated that, in principle, it would be possible to extract subsets of data from each survey, coinciding with a pre-defined area, and re-estimate abundance from this subset.

4.34 Preliminary results of the 1992/93 Korean Antarctic Research Program cruise are presented in WG-Krill-93/41. Only some of the data has so far been analysed but the authors intend to complete analyses and present final results to CCAMLR. The Working Group encouraged the authors to complete this work as soon as possible.

4.35 Dr S. Kim (Republic of Korea) also indicated that the intention was to continue the mesoscale surveys that have been conducted annually for the past five seasons around the South

Shetland Islands and in the Bransfield Strait. Scientists interested in being involved in the multidisciplinary survey planned for 1994 were invited to contact Dr Kim.

4.36 It was noted that results in WG-Krill-93/41 indicated the presence of *Thysanoessa* in areas where *Euphausia superba* were also found. Acoustically these species are very similar and acoustic survey results may therefore, in some cases, be contaminated by the presence of *Thysanoessa*.

4.37 The problem is that net hauls are only taken at intervals and do not provide information on the species composition for the sections of track between hauls. In this regard, multi-frequency systems may help in distinguishing between the two species.

4.38 Dr M. Naganobu (Japan) indicated that the Japanese RV *Kaiyo Maru* will conduct an austral summer cruise during the 1994/95 season to carry out an oceanographical and ecological survey in relation to the distribution and abundance of krill in the vicinity of the South Shetland Islands. He also noted that the US and the Republic of Korea plan similar research cruises during the same time and in this area. It is anticipated that there will be close coordination between these Members.

Other Areas

4.39 No new estimates of biomass were reported for areas other than Statistical Area 48.

Biomass Estimation for CEMP Integrated Study Regions

4.40 There has been a continuing request from WG-CEMP for estimates of krill biomass in ISRs (SC-CAMLR-X, Annex 7, paragraph 5.6). The Working Group noted that, aside from the changes in biomass estimates for Subarea 48.1 due to recalculation of FIBEX data, there have been no changes in estimates of krill biomass in the ISRs since last year's summary (SC-CAMLR-XI, Annex 4, Table 2, Figure 2).

Future Near-synoptic Acoustic Survey(s) in Statistical Area 48

4.41 The Working Group agreed that the primary purpose of a near-synoptic survey for krill would be to provide an estimate of B_0 (pre-exploitation biomass estimated from a survey) used in

the population model to estimate sustainable yield. It was further agreed that appropriate survey areas would be large portions of Statistical Area 48 and smaller portions of Statistical Area 58.

4.42 It was noted that some of the problems with the FIBEX survey data encountered last year had now been resolved (WG-Krill-93/20 and 31). These data are currently used to estimate B_0 . It was further noted that the 1992/93 krill fishery took approximately 81 000 tonnes, well below the precautionary limit of 1.5 million tonnes, and that the fishery is not expected to increase substantially in the next year.

4.43 The Working Group thus concluded that a near-synoptic survey was a not a matter of immediate urgency, but that survey designs should be prepared which specify the resources required to achieve the desired precision. For example, during FIBEX approximately four ship-months were required to survey 1 000 000 km² (10%) of Statistical Area 48 with a 15% coefficient of variation (CV), and three ship-months were required to survey 1 777 000 km² (15%) of Statistical Area 58 with a CV of 32% (Table 4).

4.44 The Working Group agreed that there was a need to start developing plans and designs for future near-synoptic surveys. It was noted that planning and organising surveys would take at least two to three years. Therefore plans should be prepared as far in advance as possible to reduce the lead time should further specific surveys be required.

4.45 The basic aim of such a survey would be to estimate a value of B_0 which is used in calculation of potential yield of krill. In addition to parts of Statistical Area 48, parts of Statistical Area 58 should be considered first. Areas where high krill abundance may be anticipated should be identified. There may also be other aggregation parameters that would be required for survey design.

4.46 The net hauls used for target identification can, in principle, be used to improve estimates of mean recruitment and its variability. Procedures to ensure that the necessary length density data (WG-Krill-93/12 and 13) are obtained should be taken into account in the survey design process.

4.47 The Working Group agreed that an *ad hoc* correspondence group, coordinated by the Convener, should be set up to tackle the problem of designing near-synoptic acoustic surveys to estimate B_0 in the intersessional period. The group should report to WG-Krill at its next meeting.

4.48 The Working Group agreed that, for the purposes of monitoring and managing the krill fishery, additional surveys and/or indices of population abundance derived from catch and effort data will be required.

Collection of Other Essential Data

KRAM Project

4.49 The Scientific Committee has requested WG-Krill's advice (SC-CAMLR-XI, paragraph 2.32) on a Russian proposal (KRAM) to model interactions between krill aggregations and the subsequent design/implementation of acoustic surveys to estimate biomass (SC-CAMLR-XI-BG/13).

4.50 The Russian proposal was considered with respect to the following:

- (i) the project's origins as a priority item in the various initiatives being developed by WG-Krill;
- (ii) whether the future work of WG-Krill is likely to be hampered by non-acquisition of the kind of information envisaged to arise from the project; and
- (iii) whether there is sufficient expertise within WG-Krill to undertake research of the type proposed.

4.51 It was agreed that many of the studies proposed by KRAM were, or already had been, addressed by specialists in the field of krill ecology both within and outside the CCAMLR community. Furthermore, although KRAM is of general interest, the kind of information envisaged to be of use in developing advice on krill management is likely to be somewhat different from that of KRAM.

4.52 WG-Krill members also felt that there is sufficient expertise on krill aggregation dynamics within the Working Group. In this regard, many participants indicated that the study of krill aggregation is a continuing research priority in their respective countries and that results pertinent to the work of WG-Krill are anticipated in the near future.

4.53 Consequently, WG-Krill recommended that there is no urgent need for the Scientific Committee to put aside funds to support KRAM. Nevertheless, given the anticipated need for near-synoptic krill surveys in the near future (paragraph 4.43 to 4.44), and in view of other associated initiatives, WG-Krill encouraged the KRAM proposers to seek funds from granting bodies for the project's implementation. In this connection, the Working Group expressed regret that the principal KRAM investigator had not attended the current meeting.

4.54 Details of the collection of other data are given in Table 6. Attention is drawn to the need for more information on length density from random net hauls to use in the estimation of the mean and variance of recruitment.

Refinement of Yield Estimate Calculations

Evaluation of Population Models

4.55 Prof. Butterworth presented WG-Krill-93/42, which detailed the results of modifications requested by the two previous meetings of the Working Group to the procedure used to relate krill yield to a pre-exploitation survey estimate of krill biomass. It was noted that the code for these computations had been validated by the Secretariat. It was noted further that algebraic errors detected by Dr K. Hiramatsu (Japan) in the evaluations presented at the previous meeting had been corrected, and that independent computations by Dr Hiramatsu had provided results essentially identical to those of WG-Krill-93/42. Accordingly, the Working Group concluded that adequate cross-checks had been carried out, and that the results presented could be accepted.

4.56 The major advance in these new results, compared to those used by the Working Group in 1991 as a basis to recommend precautionary catch limits for krill⁸, was to take uncertainties in the values of a number of biological parameters (e.g., natural mortality, recruitment variability) into account by averaging results over the perceived ranges for these uncertainties. These new results did not differ greatly from those of Butterworth *et al.* (1992)⁹: the median depletions at the end of a 20-year period of harvesting were scarcely affected, while probabilities of the spawning biomass dropping below a certain critical level increased only slightly. Of the three different fishing seasons (summer, winter and all year) for which the revised calculations had been carried out, winter fishing offered marginal advantages (the risks of depletion are less for the same value of γ , where γ is the fraction of B_0 which is harvested each year).

4.57 One modification agreed by the previous meeting of the Working Group did produce a marked effect on results. This was the imposition of an upper bound of 1.5 on the effective annual fishing mortality, which means that the intended constant catch is not fully harvested in years when harvesting would involve removal of more than 80% of the exploitable biomass of krill. This led to marked reductions in the probability of the spawning biomass falling below small fractions of its median size in the absence of exploitation. Further, although median depletions were little affected for $\gamma < 0.2$, the 1.5 bound prevents these values from dropping to zero as γ is increased above 0.2.

⁸ Butterworth, D.S., A.E. Punt and M. Basson. 1991. A simple approach for calculating the potential yield of krill from biomass survey results. In: *Selected Scientific Papers, 1991 (SC-CAMLR-SSP/8)*. CCAMLR, Hobart, Australia: 207-217.

⁹ Butterworth, D.S., G.R. Gluckman and S. Chalis. 1992. 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. Document *WG-Krill-92/4*. CCAMLR, Hobart, Australia.

4.58 It was noted that these computations could be updated relatively easily, given improved estimates for biological parameters and their associated uncertainties. WG-Krill-93/42 showed that results were sensitive to the length at 50% recruitment to the fishery (particularly for $\gamma > 0.2$), which emphasised the need to analyse newly available information in this regard with special care.

4.59 The Working Group agreed that this further work has been a valuable exercise and that the problems encountered at last year's meeting have been solved. Thanks were extended to all those involved in testing, validation and further development of the model.

4.60 The Working Group discussed the improvement of inputs into the model and the criteria to be used in selecting a value for γ (the multiplication factor that provided an estimate of potential yield).

4.61 In the case of inputs to the model, attention was drawn to results in WG-Krill-93/40 which show a difference in size at maturity between males and females. The current model effectively considers females only, with input parameters appropriate for females.

4.62 Other inputs include estimates of M (natural mortality) and recruitment variability. In this regard attention is drawn to papers WG-Krill-93/12 and 13 as well as paragraphs 4.65 to 4.73.

4.63 In the past, the choice of a γ value has mainly been with regard to the probability of the stock falling below a critical value (a 10% probability that the krill spawning biomass falls below 20% of its median pre-exploitation level over a period of 20 years). In addition to this criterion, the calculations presented in WG-Krill-93/42 allow the consideration of quantities such as average escapement of spawning biomass. This is of importance, not only with regard to the krill population, but also with regard to predators.

4.64 The Working Group was informed that the Secretariat had already incorporated the procedures for generating recruitment as set out in WG-Krill-93/13 into the computer code used for the calculations. It was agreed that further calculations using this new method for generating recruitment and updated parameters should be carried out and presented to WG-Krill at its meeting in 1994. Details of these calculations and other associated recommendations are given in Appendix E.

Evaluation of Demographic Parameters

4.65 Dr de la Mare introduced paper WG-Krill-93/12 which describes a method developed along the lines suggested in Appendix E of last year's WG-Krill report. The method is a modification of

McDonald and Pitcher's method for the decomposition of a mixture of length at age distribution into their separate components. The method uses numerical density at length data from random samples from net haul surveys. The statistical properties of these data are different from those usually considered in length decomposition problems so that the first modification of McDonald and Pitcher's method was to use a likelihood function based on Aitchison's delta distribution as the criterion for fitting a mixture distribution to the data.

4.66 The second modification was to define the parameters of the mixture distribution only in terms of the proportion of recruits in the samples, that is, the proportion of the sample in the youngest age class. This means that this proportion is estimated directly when fitting the mixture distribution to the data, and allows asymptotic confidence interval and a variance estimate to be made for the proportions of recruits. WG-Krill-93/12 described the results of the application of the method for a number of net haul surveys from the BIOMASS database and the Australian Antarctic Division. WG-Krill-93/12 described the assumptions needed for valid estimates of the proportion of recruits as:

- (i) the net samples are representative of the length structure of a self-sustaining krill population, for the range of age classes considered;
- (ii) increasing age leads to a monotonic increase in mean length at age, which gives rise to a mixture distribution; and
- (iii) krill do not naturally shrink to the extent that the smallest component considered in the mixture becomes polluted with animals of greater ages.

4.67 The main potential problem with this approach is selectivity in the numerical density-at-length samples. There are two possible sources of bias. First, (gear) net selectivity may mean that the first age class is over- or under-represented. Different types of nets would have different selectivity characteristics. Second, the timing and positions of net hauls may be such that the entire population is not represented. This may be as a result of insufficient coverage and/or the inhomogeneous distribution of krill by size. Selectivity would lead to biased estimates of the mean and variance of proportional recruitment.

4.68 The Working Group agreed that it was essential to address these questions and to assess whether selectivity is indeed a serious problem. Here it is important to bear in mind that the estimates of the mean and variance of proportional recruitment are used in the potential yield calculations which may prove not to be particularly sensitive to this problem.

4.69 Three approaches should be considered. First, small-scale simulation studies to investigate the sensitivity of the potential yield calculations to selectivity should be undertaken. Second, field experiments to try to assess the selectivity of different types of gear should be encouraged. Third, more data from random net hauls should be analysed. Net hauls from acoustic surveys are appropriate for this analysis, provided that numerical densities at length (rather than only length frequencies) can be calculated.

4.70 It was also agreed that attention should be given to sampling design, particularly in areas where krill are known to segregate by maturity (or life history) stage (e.g., WG-Krill-93/8). When analysing existing datasets, information on time, location and gear type should be considered. In connection with net avoidance, for example, Everson and Bone (1986)¹⁰ advise that RMT8 gear should ideally only be used at night (i.e., when dark).

4.71 In spite of the concerns about selectivity, the Working Group agreed that the results of WG-Krill-93/12 were encouraging. Estimates from this study offered a great improvement over previous estimates which were essentially educated guesses, since no information had been available.

4.72 Dr de la Mare then introduced WG-Krill-93/13 which describes a simulation model for krill recruitment which uses the information obtained from the application of the method presented in WG-Krill-93/12. The model produces random numbers of recruits each year required to match the observations on proportional recruitment.

4.73 The Secretariat was requested to validate the models and computer programs associated with the analyses presented in WG-Krill-93/12 and 13 (see Appendix E).

4.74 WG-Krill-93/8 highlighted three interesting aspects of krill dynamics. A relatively long time series of data from the Antarctic Peninsula indicates that the distribution (or segregation) by maturity stage is quite consistent from year to year. There is some evidence that recruitment success may depend on the maturity stage of females at a specific time of year. The authors further hypothesised that the presence of salps may cause a reduction in the number of female krill in spawning condition compared to numbers observed when salps are absent.

4.75 It was noted that high salp abundance in a given year may lead to low krill recruitment in the following year. The issue of salps is also raised in WG-Krill-93/17 and 29.

¹⁰ Everson, I. and D.G. Bone. 1986. Effectiveness of the RMT8 system for sampling krill (*Euphausia superba*) swarms. *Polar Biol.*, 6: 83-91.

4.76 Further attention should be given to the demography of salps and to problems associated with distinguishing between salps and krill in echo survey data. In order to support modelling exercises to investigate acoustic discrimination of krill and salps or to estimate relative scattering levels of the two, it is important that measurements be made of mass density and speed of sound in salp specimens. Morphometric data are also needed in acoustic modelling.

4.77 Dr Naganobu also indicated that WG-Krill-93/27 presents results of maturity of krill for the 1990/91 and 1991/92 seasons around the South Shetland Islands, which are very similar to results in WG-Krill-93/8. WG-Krill-93/26 deals with the relationship between krill and interannual variation of the ice edge, and gives some suggestions for possible interactions between salps, krill and oceanographic conditions.

4.78 WG-Krill-93/36 presents analyses of size data from the South Orkneys for the period October 1989 to June 1990. The author is encouraged by the Working Group to conduct further analyses with these data. It would, for example, be useful if growth curves could be fitted to the size frequency data.

4.79 WG-Krill-93/44 presents estimates of mortality (M) from samples taken in the Indian Ocean sector. It was noted that there are difficulties with methods that estimate M from relationships between M and growth parameters. Such estimates of M tend to have very large variances (Pauly, 1980¹¹) and are generally not as reliable as estimates made directly from size frequency data.

4.80 The analyses in WG-Krill-93/12 and 13 can be used to estimate M directly from numerical density at size data, provided that samples are representative and from random net hauls. There is no need to separate all age classes in the data; it is enough to separate the first age class from the rest. This means that many of the problems encountered with the large degree of overlap in size for older age classes and the choice of number of age classes to fit do not arise.

4.81 One of the methods used in WG-Krill-93/44 was Pauly's method which requires an estimate of water temperature together with growth parameters to estimate M . The Working Group felt that these estimates should be interpreted with great caution since the reliability of the method for polar organisms is not known.

4.82 Demographic studies of krill in the Indian Ocean sector were presented in WG-Krill-93/45. The authors of this paper are encouraged to continue this work.

¹¹ Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. *J. Const. Int. Explor. Mer.*, 39: 175-192.

4.83 The submission of papers WG-Krill-93/44 and 45 from a non-Member state (Ukraine) was noted with thanks.

ECOLOGICAL IMPLICATIONS OF KRILL FISHERY

Location and Timing of the Fishery

Statistical Subareas 48.1 and 48.2

5.1 The Scientific Committee had requested advice from WG-Krill on additional management measures aimed at ensuring that krill catches are not concentrated in areas close to predator colonies (SC-CAMLR-XI, paragraphs 2.78 and 5.39 to 5.43), particularly within Subarea 48.1.

5.2 The Scientific Committee further requested that the Secretariat should conduct simulation studies to analyse potential changes in fishing patterns with a view to presenting such data to WG-CEMP and WG-Krill (SC-CAMLR-XI, paragraphs 5.41 to 5.44). A Secretariat paper (WG-Krill-93/10) pertaining to this issue had been tabled.

5.3 WG-Krill-93/10 showed that during the 1992 season, 70% of the catches in Subarea 48.1 and 38% of those in Subarea 48.2 were taken in areas within 100 km from predator colonies. Dr Agnew stressed, however, that the lack of fine-scale data prevented more precise analyses, especially in view of the general lack of fine-scale data reported from Subarea 48.2.

5.4 WG-Krill-93/7, on the other hand, presented results from an analysis of Japanese very fine-scale data (10 n miles x 10 n miles) from Subarea 48.1 in relation to penguin distribution and food requirements. The paper showed that: (i) krill catches are concentrated near Livingston and Elephant Island in Subarea 48.1; (ii) the large penguin colonies in Subarea 48.1 are located on King George, Robert, Low and Nelson Islands; and (iii) subsequently the geographic overlap between the fishery and penguin foraging area during the critical period when animals are confined to their island breeding sites (December to March) is low.

5.5 Paper WG-Krill-93/7 also showed that current krill catches in Subarea 48.1 were low compared to the local krill biomass in that subarea and consequently suggested that the current fishery is very unlikely to have an adverse impact on the local krill biomass and hence on penguins.

5.6 Dr Marín commented that this study confirmed that there is no urgent need for additional precautionary measures in Subarea 48.1 to address fishery-predator concerns. Dr Hatanaka agreed with this opinion.

5.7 Dr Holt stated his belief that, since an allocation scheme may be necessary if fishing levels increase in the future, it is proper to study it now.

5.8 Dr J. Bengtson (USA) stated that WG-Krill-93/7 represented an important contribution to the evaluation of potential localised impacts of the krill fishery, and he welcomed the analyses provided by this paper. He noted, however, that the values for penguins' krill consumption used in the paper were provisional and the understanding of the specific nature of interactions between krill and its predators is still incomplete (e.g., how do krill distribution patterns affect the availability of krill biomass to predators, or how do krill move within the fishing grounds of Subarea 48.1). In addition, further work is needed to incorporate other krill predators such as fur seals, flighted seabirds, fish, and squid into austral summer krill consumption estimates. He noted that the paper, with its analyses of very fine-scale fishing data, offered a valuable foundation for continued research on these important topics.

5.9 Several Working Group members commented that WG-Krill-93/7 offered an important contribution to the continuing work of the Group and also served to emphasise the importance of reporting fine-scale catch data.

5.10 The Working Group specifically encouraged the development of analyses similar to those carried out in WG-Krill-93/7 in other subareas which fall outside Statistical Area 48.

Other Subareas

5.11 The Working Group acknowledged that the information presented on potential predator-krill-fishery interactions are only available for Subarea 48.1, and that there is general lack of such information for other subareas within Statistical Area 48 or for other areas. Consequently, similar analyses for other statistical areas and subareas were strongly encouraged.

Relation of Fishing to Krill Predators

Definition of Functional Relationships

5.12 WG-Krill-93/43 described an initial attempt to model the inter-relationships between krill, the fishery and dependent predators, following the framework developed by the Joint Meeting of WG-CEMP and WG-Krill in 1992 (SC-CAMLR-XI, Annex 8, Appendix 1).

5.13 The first requirement of the above model was to fix the parameters of the functional relationships relating predator survival rates to krill abundance. Members of WG-CEMP had provided information on the frequency of good, poor and bad years for adult predator survival and for the breeding success of four species of krill predator. This information was used to fix the levels of krill biomass, relative to the median level in the absence of exploitation, at which adult and juvenile survival rates (respectively) start to decline as krill biomass decreases. The adult survival rate estimates provided for the various predators were taken to represent the maximum value of this variable.

5.14 A “one-way” interaction model was developed, in which krill abundance fluctuations impact the predator population, but not *vice versa*. An immediate problem arose regarding the information supplied for two of the predator species: Adélie penguins and Antarctic fur seals. This information suggested that these two species would not be self-sustaining, even in the absence of a krill fishery, because the annual losses to natural mortality apparently exceed the maximum possible birth rate. WG-CEMP would be asked to examine whether there were perhaps biases in the estimates of population parameters provided, or errors in the manner in which they had been interpreted, which could explain this anomaly. Specific questions in this regard are detailed in paragraph 5.20.

5.15 The primary result of this modelling exercise was the indication that variability in the natural recruitment of krill results in predator populations being less resilient to krill fishing than deterministic evaluations would suggest. It was emphasised that it would be premature to attempt to draw quantitative conclusions about acceptable levels of krill fishing intensity at this initial stage of the exercise.

5.16 Some examinations of the sensitivity of the model developed relative to its assumptions were conducted. These indicated (*inter alia*) that predator populations were more resilient to krill fishing if the availability of other food sources for the predators were taken into account. A framework for developing a “two-way” interaction model, which accounts in addition for the effect of differing predator consumption levels on krill, was proposed. However, the Working Group considered that further work on this “two-way” model should first await clarification of questions concerning

parameter values for the population dynamics of the various species of predators considered, and investigation of the resultant implications for the “one-way” model.

5.17 In considering the next steps for refining the model, it was agreed that the sensitivity of results to the following modifications should be examined in greater detail:

- (i) different choices for S_J^M ;
- (ii) values of $S_J(B=0)$ and $S_M(B=0)$ which are greater than zero (to reflect the availability to the predator of food sources other than krill).

5.18 Dr Hatanaka commented that factors other than krill biomass might influence breeding success and should also be considered.

5.19 Dr Butterworth stated that the model should only be viewed as preliminary and as a first step in an attempt to define possible functional relationships between krill, krill predators and the fishery.

5.20 The Working Group therefore agreed that in the interests of refining the model further, WG-CEMP should be requested to answer the following questions:

- (i) What are the maximum rates of population increase which have been observed for closed populations (i.e., no immigration or emigration) of the predator species used in the model, as well as for other similar species?
- (ii) What is the average life span of such predators (also, are life table data available) [Note: average lifetime $\sim (1-S_A)^{-1}$, where S_A is the adult survival rate]?
- (iii) What were the proportions of “good”, “poor” and “bad” years for each predator species during the period for which adult survival rates were estimated?
- (iv) What are the maximum values of adult survival rates, as calculated from data in good years only (i.e., not including “poor” and “bad” years)?
- (v) Do the values for the given survival rates correspond to populations that are stable, are increasing, or declining (and if changing, what is the magnitude of these changes)?

- (vi) Are there identifiable biases in the population parameter estimates provided by WG-CEMP from the periods in which the estimates were derived (e.g., tag or band losses, sampling biases, etc.) and, if so, can these be quantified? and
- (vii) Are data of the type already provided available for other relevant predator populations?

5.21 The Working Group felt that WG-CEMP's considerations of these issues would help to improve development of the current model.

5.22 WG-Krill-93/15 addressed interactions between demersal fish and krill in Subarea 48.1. This showed that krill is an important prey item for demersal fish.

5.23 These results were discussed, especially in relation to their inferred implication that large benthopelagic populations of krill may be present in the area studied. The attention of the Scientific Committee is drawn to this conclusion and the Working Group encouraged the further development of studies to evaluate the extent of krill population at depths greater than 200 m.

5.24 Dr Everson commented that the study also indicated that squid may be an important by-catch in the krill fishery but that no information on the species concerned had been provided.

5.25 The Scientific Committee's attention was drawn to this matter and the Working Group encouraged further analysis of the squid component in this particular study.

Status and Role of CPUE Indices

5.26 In the light of the discussion under item 3, the view that CPUE was likely to be more easily interpreted in a local context than in a larger, subarea or area, context was again expressed.

5.27 The Working Group agreed that it was important to distinguish between the use of CPUE information for the purpose of the estimation of krill biomass and for other purposes, such as the application in WG-KRILL-93/14, where CPUE is used as a measure of localised density. It is therefore still necessary to collect and submit catch and effort data (SC-CAMLR-XI, Annex 4, Table 6).

5.28 CPUE indices were discussed in terms of their potential utility in improving current understanding of the relationship between local krill abundance and the fishery.

5.29 The initial CPUE studies conducted by Butterworth (1988)¹² and Mangel (1988)¹³ identified three basic parameters required for the construction of a CPUE index: searching time, towing time and total catch. One of the most difficult problems is the collection of search time data and this affects the practicality of this approach.

5.30 It was agreed that search time is a potentially important component of any CPUE index which attempts to relate krill distribution and abundance to fishery performance. Mr T. Ichii (Japan) indicated that in his experience efforts to collect search time information from the Japanese krill fishery had been futile given attendant difficulties in defining the exact characteristics of the krill fishing operation at any given time.

5.31 Both Drs Butterworth and de la Mare provided suggestions as to how search time could be estimated. The first approach involves estimating search time as a remainder component after subtraction from total time of the time spent on other activities (fishing time, processing time, etc.). The second would be to record a fishing vessel's activity at random instants.

5.32 The Working Group encouraged fishing nations to investigate the feasibility and cost of recording search time from the krill fishing operations along the lines outlined in paragraph 5.31 above. Such investigations should include an assessment of the cost-effectiveness of collecting the necessary data and submissions on the topic were encouraged. It was agreed that in all likelihood this evaluation could only really be achieved by the placement of Scientific Observers aboard fishing vessels.

Effects of Management Measures on Krill Fishing

5.33 At its 1992 meeting the Scientific Committee requested that the Secretariat design a simulation model to investigate the consequences of different extents and locations of closed areas on the krill fishery in Subarea 48.1 (SC-CAMLR-XI, paragraphs 5.41 and 5.42). A simple deterministic model of the fishery over the months December to March was described in WG-Krill-93/14. The model used CPUE data from the Chilean fishery to estimate the mean catch-per-fishing time in each of the fine-scale squares of Subarea 48.1 and the historical distribution of effort in the Chilean fishery to estimate a desirability function for each fine-scale square.

¹² Butterworth, D.S. 1988. A simulation study of krill fishing by an individual Japanese trawler. *Selected Scientific Papers, 1988 (SC-CAMLR-SSP/5)*, Part I. CCAMLR, Hobart, Australia: 1-108.

¹³ Mangel, M. 1988. Analysis and modelling of the Soviet Southern Ocean krill fleet. *Selected Scientific Papers, 1988 (SC-CAMLR-SSP/5)*, Part I. CCAMLR, Hobart, Australia: 127-235.

5.34 The model predicted a total catch of 9600 tonnes per vessel over a four-month period. This total, and the distribution of catches predicted by the model, agreed well with the general level and distribution of catches from other fishing nations in Subarea 48.1 reported to CCAMLR.

5.35 Several management scenarios were considered by the paper. Prohibiting catches within 50 km of the South Shetland Islands from December to March caused a 24% reduction in catch. Prohibiting catches within 100 km of Elephant Island caused a 15% reduction in catch, but the same restriction at Livingston Island led to an increase of 39% in catch. Closing the latter two zones in alternate years would maintain the catch at its original level, but would have the effect of concentrating all the catch in the area which was open.

5.36 The Working Group commended the Secretariat for the preparation of the document in such a timely manner. It was agreed that the model was a good first attempt and that it could serve as a basis for further developments.

5.37 It was noted that mean catch rates were substantially larger at Elephant Island than at Livingston Island. This suggests that krill fishermen should be more successful if they fished only at Elephant Island but in fact fishing occurs at both locations. Several reasons were suggested why both locations are fished:

- (i) fishermen may not maximise catch rates but catch only the amount that can be processed;
- (ii) actual catch rates in an area during a fishing season may vary substantially from the mean rate (i.e., krill abundance may be low in an area during part of the season); and
- (iii) other factors, such as the presence of salps or sea-ice, may constrain successful fishing.

5.38 Since actual CPUE rates in an area may differ substantially from the mean CPUE rate during the fishing season, it would be useful to have fine-scale data from vessels operating in different areas during the entire season to enable the model to be refined.

5.39 The Working Group noted that it would also be valuable if information were available from the fishery concerning specific effects likely to seriously impact on the fishery as a result of closing localised areas in Subarea 48.1. This information would include such factors as economic considerations, product quality, and constraints on fishing operations (e.g., induced by vessels having to move from ice-free to ice-bound areas).

5.40 Finally, the Working Group noted that management options considered to date have been based predominantly upon statistical area divisions. As indicated at previous meetings, it may be necessary to include consideration of krill “functional” ecological units (WG-Krill-93/37) in future investigations of management approaches to address the potential problem of overlap between the fishery and localised predators.

Liaison with WG-CEMP

5.41 At its 1992 meeting, the Scientific Committee recognised that a flexible scheme for designating specific management areas, fishing grounds or areas of specific ecological interest is required (SC-CAMLR-XI, paragraph 2.108). The Committee further directed that WG-Krill and WG-CEMP should continue their close liaison on the development of a feedback management procedure to take account of information on interactions among krill, krill predators, the fishery and the environment (SC-CAMLR-XI, paragraph 2.109).

5.42 The Working Group recognised the utility of information on investigating predator/prey interactions presented in several documents (WG-Krill-93/7, 14, 37, 43, 47 and WG-CEMP-93/4). The Working Group encouraged additional interaction between the two groups to further develop information (see below) for use in predator/prey interaction models.

5.43 In addition, little information is available concerning predator/prey interactions in other areas (e.g., Subareas 48.2, 48.3 and Statistical Area 58). Therefore, the Working Group suggested a high priority be placed upon obtaining this information.

5.44 Several specific areas where interaction between the two groups would benefit have already been identified elsewhere in this report (see paragraph 6.23).

5.45 The Scientific Committee had also encouraged Members to develop 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). No submissions on this topic had been received but it was pointed out that the continuing development of the potential yield and krill-predator interaction models will enable future progress on this matter.

Precautionary Limits on Krill Catches in Various Areas

Estimates of Potential Yield

6.1 The standard approach which has been adopted in the past by the Working Group for estimating the potential yield (Y) of krill in an area has been to multiply an estimate of krill biomass for the area (which is taken to reflect a pre-exploitation level B_0) by a factor γ i.e., $Y = \gamma B_0$. A model of krill population dynamics (discussed in paragraphs 4.55 to 4.64, above) is then used to predict the implications of different choices of γ for future krill spawning biomass levels.

6.2 It was noted that considerable progress had been made since the previous meeting in regard to the components of this formula. There was now agreement concerning the best estimate of B_0 for Subareas 48.1 + 48.2 + 48.3 obtainable from the FIBEX data (paragraph 4.27), and the formulae and associated computer code used to predict the consequences of alternative choices for the value of γ had been validated.

6.3 In discussions, two values of γ were suggested as appropriate for estimating potential yield: $\gamma = 0.1$ and $\gamma = 0.165$. The implications of these alternatives for future krill spawning biomass levels, expressed as proportions of median levels in the absence of exploitation, are as follows. (These results are taken from the calculations of WG-Krill-93/42, and apply to fishing conducted throughout the year; of the three fishing seasons examined in that paper, such whole-year fishing was considered to best reflect the current practice in the krill fishery.)

Statistic	$\gamma = 0.1$	$\gamma = 0.165$
Probability of biomass falling below 0.2 over 20-year harvest period	0.02	0.10
Biomass level at the end of 20 years:		
median	0.78	0.62
lower 5% -ile	0.41	0.24

WG-Krill-93/42 showed that results for values of γ in this range are relatively insensitive to alternative fishing seasons, and to a number of other variations of the krill population dynamics model.

6.4 The choice of $\gamma = 0.165$ is consistent with the criterion used previously by the Working Group for selection of this value: a 10% probability that the krill spawning biomass falls below 20% of its median pre-exploitation level over a 20-year period of harvesting.

6.5 Some account should also be taken of the Commission's agreed concepts (SC-CAMLR-IX, Annex 4, paragraph 61) in relation to operational definitions of Article II. The first of these concepts is that the aim should be to keep krill biomass at a level higher than if only single species harvesting considerations were of concern (which would typically be about 50% of the median pre-exploitation level). The second concept indicates that, given the fluctuations induced in the krill spawning biomass as a result of recruitment variability, the lower tail of this spawning biomass distribution needs to be taken into consideration as well. Accordingly, results for the median and lower 5% -ile of this distribution are given in the table in the preceding paragraph. It is to be noted that these calculations incorporate the consequences of survey sampling variance in the estimate of krill biomass B_0 .

6.6 A case can be made for the choice of $\gamma = 0.1$ at the present time, on the grounds that the associated spawning biomass distribution statistics reflected in the table in paragraph 6.3 would certainly seem consistent with the agreed concepts associated with Article II, as referenced in paragraph 6.5.

6.7 It was noted that a firmer choice of a value for γ in the context of Article II would be possible only after further development of the recently initiated krill-predator modelling studies (paragraphs 5.12 to 5.16). Values suggested at present for γ should certainly be reconsidered once such studies are sufficiently advanced.

6.8 Other factors to be taken into account in considering estimates of potential yield for krill at this time are that:

- (i) the estimates of B_0 from FIBEX are now some 12 years old;
- (ii) predictions of statistical distributions of krill biomass for different γ values remain based on educated guesses for ranges of certain biological parameters - data-based estimates for these parameters will be available for the 1994 meeting of the Working Group (see paragraphs 4.65 to 4.83); and
- (iii) it will be possible to take these estimates, together with other refinements of the krill population dynamics model (see Appendix E), into account in providing improved predictions for various choices of γ , at the 1994 meeting.

6.9 Taking cognisance of all these points, the Working Group believed that at this time a range of potential yield estimate (Y) should be provided for each Statistical Area, based upon the best estimate of B_0 for that area and the two values put forward for γ . The current best estimates of potential yield are therefore as follows, and are shown together with the preliminary catch levels reported for the 1992/93 season for comparative purposes:

Area/Division	B_0 (10^6 tonnes)	γ (10^6 tonnes)			1992/93 Catch (10^6 tonnes)
		$\gamma = 0.1$	-	$\gamma = 0.165$	
48.1 + 48.2 + 48.3	30.8	3.08	-	5.08	0.08
48.6	4.6	0.46	-	0.76	0
58.4.2	3.9	0.39	-	0.64	0

Immediate substantial increases in these present catch levels are not anticipated (see paragraphs 3.3 to 3.12).

6.10 Attention is drawn to the fact that fishing took place in Division 58.4.1 during the 1992/93 season, but that no range of potential yield estimates is provided for this division in the preceding table because of the absence of any survey in this division.

6.11 Priority should accordingly be given to planning a survey of Division 58.4.1. As this division is large, some subdivision may be necessary because of logistical constraints. Information (e.g., regarding the operational areas of the past and present fisheries in this Division) should be provided at the Working Group's next meeting to allow this matter to be addressed.

6.12 Revisions of the existing B_0 estimate for Division 58.4.2, together with another estimate from a subsequent survey in part of this Division, should be available for consideration at the Working Group's next meeting.

6.13 Modifications of Table 5 of the report of the Working Group's 1992 meeting, which presented various options for allocating a precautionary catch limit for this Statistical Area amongst its constituent subareas, were necessary due to the revisions of the FIBEX estimates of biomass in Statistical Area 48. These amendments are reflected in Table 5.

Possible Ecological Effects of Catch Limits

6.14 This matter is discussed in paragraphs 5.33 to 5.40 above.

Refining Operational Definitions of Article II

Formulation of Policy Questions to Commission

6.15 The Commission has already agreed to four concepts in this regard (SC-CAMLR-IX, Annex 4, paragraph 61). As indicated in paragraph 6.5 above, the present method used to provide estimates of the potential krill yield is already able to take some account of the first two of these concepts.

6.16 The process of moving from these concepts to operational definitions which relate directly to management advice, has started with the initiation of models of krill predator interactions (paragraph 5.12 to 5.16 above), but it will probably be some time yet before these models are sufficiently developed to be relied upon to provide the quantitative information required. The ultimate definitions themselves may be of a composite nature, including the satisfying of multiple criteria; for example, criteria for each of the three statistics reported in the table in paragraph 6.3, rather than a criterion in terms of one of these only.

6.17 It was considered that the best approach to seeking advice from the Commission on this matter would be to offer a specific range of alternatives, together with the anticipated consequences of each, and to ask the Commission to indicate its preference amongst these. Consideration should be given to the formulation of questions to the Commission in this manner at the next meeting of the Working Group.

6.18 The Commission's attention should also be drawn to the fact that advice from the Scientific Committee on best estimates of, say, the potential yield of krill will change from one year to the next as the basis for the scientific calculations improves with time. Thus, for example, the range of estimates for this yield (in 10^6 tonnes) for Subareas 48.1 + 48.2 + 48.3 has changed over the past three meetings from 1.40-2.11 in 1991, to 0.69-2.14 in 1992, to 3.08-5.08 this year. In the light of the level of variability which this indicates, the Commission may wish to consider the frequency (annual or less regularly) at which it might wish to adjust precautionary catch limits (up or down) in response to updated scientific assessments.

Other Possible Approaches and Their Development

6.19 Discussion in this regard in relation to the location, timing and intensity of krill fishing may be found in paragraphs 5.1 to 5.10.

Data Requirements

6.20 The Working Group discussed Table 6 from the report of the Group's 1992 meeting, which detailed these requirements at that time, in the light of subsequent developments reported at this meeting. The resultant modified list of requirements is appended as Table 6.

Future Work of WG-Krill

6.21 Points to be highlighted under this heading are further developments of the model used to assess the potential yield of krill, a workshop to evaluate krill flux in Statistical Area 48, the implementation of future surveys, and development of Operational Definitions of Article II in the course of a continuing dialogue with WG-CEMP. More details of these and other planned activities may be found in Table 7, which was developed by the Working Group by updating the corresponding table from the report of the previous meeting in the light of progress made through the year.

6.22 Three administrative points were also raised under this agenda item. First, in future, papers submitted to the Working Group must indicate on their cover page which agenda item they are intended to address, and how they relate to the plan for future work detailed in Table 7.

6.23 Secondly, a preliminary agenda for a Joint Meeting of WG-Krill and WG-CEMP to be held in 1994 (SC-CAMLR-XI, paragraph 6.15) will be drawn up by the Conveners in consultation with members of the groups. The Conveners would attempt to draw terms of reference for the meeting to be presented at SC-CAMLR-XII.

6.24 Thirdly, Members were asked to give consideration to the most appropriate format for future meetings of WG-Krill and WG-CEMP to facilitate discussion of this matter at the next Scientific Committee meeting. Given the convergent nature of many of the matters under consideration by these two groups, some form of combination of their annual meetings might be more appropriate. This exercise might profitably include a reconsideration of WG-Krill's present terms of reference.

OTHER BUSINESS

Exploratory Fisheries

7.1 At its 1992 meeting, the Commission had agreed that it would be useful to develop a procedure for evaluating fisheries during their exploratory phase, and had requested the Scientific Committee and its working groups to consider this matter during 1993 (CCAMLR-XI, paragraphs 4.32 and 4.33).

7.2 In response to the Scientific Committee's request that Members develop and submit papers outlining possible approaches to this issue (SC-CAMLR-XI, paragraph 3.51), a draft document has been prepared by the US Delegation (CCAMLR-XII/5). The authors indicated that this draft was being developed for submission to the Commission at its 1993 meeting, and was being made available now to allow review and comment by WG-Krill and WG-CEMP.

7.3 WG-Krill considered the draft document and agreed that it represented a useful start in responding to the requests of the Commission and Scientific Committee concerning exploratory fisheries. Suggestions for refining the definition of "exploratory fisheries" and for improving the clarity of other elements of the draft were made to the authors, who indicated their intention to submit a revised draft to WG-FSA, the Scientific Committee and Commission.

GLOBEC

7.4 Prof. J.-O. Strömberg (Sweden) reported on the progress within the International Global Ocean Ecosystem Dynamics (GLOBEC.INT) program. The program which started as a US initiative became international as the Scientific Committee on Oceanic Research (SCOR) in 1991 decided to accept it as one of its major activities. It is now co-sponsored by IOC, ICES and PICES and to its Southern Ocean component by SCAR. The scientific aim of GLOBEC.INT is "to understand the effects of physical processes on predator-prey interactions and population dynamics of zooplankton, and their relation to ocean ecosystems in the context of global climate system and anthropogenic change".

7.5 During the meeting of the Southern Ocean Working Group the key scientific questions to be addressed were formulated. These questions were formulated with regard to the ecology and dynamics of zooplankton, top predators and their interactions and are listed in Appendix F. Full details are given in the Report of GLOBEC.INT Southern Ocean Working Group.

7.6 The GLOBEC Southern Ocean Working Group suggested that many of the questions be examined within the context of a conceptual model that would be developed for the Southern Ocean prior to the development of a field program.

7.7 The GLOBEC Southern Ocean Working Group realised the considerable overlap with interests in other international scientific groups, among those, CCAMLR and its Working Groups on Krill and CEMP, and decided to assume close contacts with these. There is considerable overlap in membership between the GLOBEC Southern Ocean Working Group and WG-Krill. This should guarantee good liaison between the two groups and help ensure that duplication is avoided.

7.8 WG-Krill agreed that although the specific aims of CCAMLR and the GLOBEC program are very different there is a large area of common ground or common interest and there is a clear need for interaction between CCAMLR and the GLOBEC Southern Ocean program.

7.9 It was felt that a two-way process would be useful and that CCAMLR working groups should make GLOBEC working groups aware of their areas or topics of top priority. The Working Group also draws the Scientific Committee's attention to the fact that there are likely to be areas of overlap between the work of these groups, and that liaison between CCAMLR and GLOBEC would serve to reduce duplication and enhance the work of WG-Krill. Submission of papers describing the work of GLOBEC should be encouraged for consideration under specific agenda items of future meetings of WG-Krill.

7.10 The Working Group further recommended that the Scientific Committee should consider nominating an observer to the GLOBEC program. The work of WG-Krill would be greatly assisted if this observer could be present at the Working Group's meetings in addition to those of the Scientific Committee.

Bibliography of Antarctic Oceanography

7.11 The Working Group thanked the Secretariat for compiling this Bibliography (WG-Krill-93/11) and Members for supplying the data for it. It was noted that the bibliography would continue to be developed especially in regard to its initiative towards a workshop on krill flux (paragraph 4.10), which would attempt to synthesise much of the information contained in the papers listed in the bibliography.

7.12 The Working Group was informed that the Bibliography can be obtained from the Secretariat either in ASCII format or as a bibliographic database in "Endnote" format.

ADOPTION OF THE REPORT

8.1 The report of the meeting was adopted.

8.2 In closing the meeting the Convener thanked the rapporteurs, the various task group conveners and the Secretariat for their support and hard work during the meeting. He also thanked the participants for the large number of submitted papers, their input and good humour throughout the meeting. A substantive agenda had been addressed and the Convener indicated that many worthwhile initiatives were now under way within WG-Krill. This, in his opinion, is a strong indication of the prevailing spirit of cooperation and friendliness which has come to characterise the Working Group's meeting.

8.3 Finally, the Convener conveyed his, and the Working Group's thanks, to the local organisers (Dr Naganobu and Mr Uno), the Fisheries Agency of Japan and the Japan Deep Sea Trawlers Association, the Mariner's Court Hotel and the Japanese Government for their hospitality.

8.4 Dr K.-H. Kock (Germany), Chairman of the Scientific Committee, echoed the above sentiments, and expressed his thanks on behalf of the CCAMLR Scientific Committee.

8.5 Mr E. de Salas, Executive Secretary of CCAMLR, congratulated the Convener for conducting the meeting in an efficient and productive fashion.

Table 1: Summary of fine-scale data from the krill fishery.

Nationality	Subarea/ Division	Year	STATLANT Catch	Fine-scale Catch	%
CHL	48.1	1987	4 063	3 886	96
CHL	48.1	1988	5 938		0
CHL	48.1	1989	5 329	5 394	100
CHL	48.1	1990	4 501	4 501	100
CHL	48.1	1991	3 679	3 679	100
CHL	48.1	1992	6 066	6 066	100
CHL	48.2	1987	123	123	100
DDR	48.3	1990	396		0
ESP	48.1	1987	181	180	99
ESP	48.2	1987	198	199	100
JPN	48.1	1988	71 814	71 817	100
JPN	48.1	1989	75 912	75 912	100
JPN	48.1	1990	33 936	33 936	100
JPN	48.1	1991	54 720	54 720	100
JPN	48.1	1992	61 598	61 607	100
JPN	48.2	1986	16 929	16 929	100
JPN	48.2	1987	9 826	9 826	100
JPN	48.2	1988	1 298	1 298	100
JPN	48.2	1989	3 016	3 016	100
JPN	48.2	1990	1	0.22	22
JPN	48.2	1991	1 924	1 925	100
JPN	48.2	1992	272	263	97
JPN	48.3	1991	9 606	9 606	100
JPN	48.3	1992	12 405	12 405	100
KOR	48.1	1987	1 503	1 503	100
KOR	48.1	1988	1 111		0
KOR	48.1	1989	1 615	1 614	100
KOR	48.1	1990	4 040	4 040	100
KOR	48.1	1991	1 211	1 211	100
KOR	48.1	1992	519	519	100
KOR	48.2	1987	24	24	100
KOR	48.2	1988	414		0
KOR	48.2	1989	164	164	100
POL	48.1	1988	55	55	100
POL	48.1	1989	1 823	1 337	73
POL	48.1	1991	310	310	100
POL	48.1	1992	641	642	100
POL	48.2	1988	3 059	3 059	100
POL	48.2	1989	2 732	2 730	100
POL	48.2	1991	6 020	6 020	100
POL	48.2	1992	2 742	2 741	100
POL	48.3	1988	2 101	2 100	100
POL	48.3	1989	2 442	2 442	100
POL	48.3	1990	1 275	1 275	100
POL	48.3	1991	3 241	3 241	100
POL	48.3	1992	5 224	5 226	100

Table 1 (continued)

Nationality	Subarea/ Division	Year	STATLANT Catch	Fine-scale Catch	%
RUS	48.1	1992	8 925		0
RUS	48.2	1992	100 475		0
RUS	48.3	1992	42 295		0
SUN	48.1	1989	20 875	20 875	100
SUN	48.1	1991	4 721	4 721	100
SUN	48.2	1987	9 731	9 731	100
SUN	48.2	1988	89 888	89 888	100
SUN	48.2	1989	76 494	76 494	100
SUN	48.2	1990	220 517	220 517	100
SUN	48.2	1991	159 313	159 313	100
SUN	48.3	1988	188 391	189 432	100
SUN	48.3	1989	203 912	203 912	100
SUN	48.3	1990	79 698	79 698	100
SUN	48.3	1991	110 715	110 715	100
SUN	48.6	1988	104	104	100
SUN	58.4.1	1990	1 503	1 503	100
SUN	58.4.2	1988	6 490	6 490	100
UKR	48.1	1992	636	636	100
UKR	48.2	1992	19 697	19 064	97
UKR	48.3	1992	41 386	40 465	98

Table 2: Summary of historic Soviet/Russian krill data in Statistical Area 48.

[Total = tonnes caught as reported on STATLANT forms; fine = percent of catch reported as fine-scale data]

Year		48.?	48.1	48.2	48.3	48.4	48.5	48.6
1974	total				19 139			
	fine				0			
1975	total				41 352			
	fine				0			
1976	total	609						
	fine	0						
1977	total			68 301				
	fine			0				
1978	total	78 837						
	fine	0						
1979	total	266 386						
	fine	0						
1980	total		49 439	173 539	133 774			
	fine		0	0	0			
1981	total		89 108	60 540	135 252			217
	fine		0	0	0			0
1982	total		64 045	257 269	46 868			
	fine		0	0	0			
1983	total		39	116 497	11 480			735
	fine		0	0	0			0
1984	total			53 881	8 440			
	fine			0	0			
1985	total			101 520	45 335			
	fine			0	0			
1986	total			224 744	141 994			
	fine			0	0			
1987	total		319	9 731	254 480			
	fine		0	100	0			
1988	total			89 888	188 391			
	fine			100	101			
1989	total		20 875	76 494	203 912			
	fine		100	100	100			
1990	total			220 517	79 698			
	fine			100	100			
1991	total		4 721	159 313	110 715			
	fine		100	100	100			
1992	total		8 925	100 475	42 295	30		
	fine		0	0	0	0		

Data sources for potential fine-scale reporting:

1974 to 1977: summary reports, located at VNIRO and AtlantNIRO

1978 to 1983: 15-day reports, located at VNIRO, AtlantNIRO, and YugNIRO

1984 to 1992: magnetic tape, located at VNIRO

Table 3: Estimates of flow in Statistical Area 48.

Subarea	Location	Speed (cm/s)	Direction	Reference
48.1	Deep	5.5 - 10.9	East	SC-CAMLR-XI, Annex 4, Table 1
	Deep	3.4 - 5.1	East	SC-CAMLR-XI, Annex 4, Table 1
	Deep	30.0 - 40.0	East	SC-CAMLR-X, Annex 5, Table 1
	Deep	12.8-16.0	East	WG-Krill-93/38
	Coastal	0.8 - 1.6	East	SC-CAMLR-XI, Annex 4, Table 1
	Coastal	19.0	East	SC-CAMLR-X, Annex 5, Table 1
	Coastal	5.0 - 10.0	East	SC-CAMLR-X, Annex 5, Table 1
	Coastal	3.7	West	WG-Krill-93/38
	Bransfield Strait	26.0 - 64.0	East	SC-CAMLR-X, Annex 5, Table 1
	Bransfield Strait	19.9	East	WG-Krill-93/38
48.2	Deep	5.8 - 12.5	East	SC-CAMLR-XI, Annex 4, Table 1
	Coastal	0.8	East	SC-CAMLR-XI, Annex 4, Table 1
48.3	Deep	1.9 - 2.5	East	SC-CAMLR-XI, Annex 4, Table 1
	Deep	4.7 - 5.8	East	SC-CAMLR-XI, Annex 4, Table 1
	Deep	0.2	West	SC-CAMLR-XI, Annex 4, Table 1
	Deep	16.0	East	WG-Krill-93/38
	Deep	43 - 49	East	WG-Krill-93/35
	Coastal	4.2		WG-Krill-93/30
	Coastal	10.0		WG-CEMP-92/32

Deep = surface currents over deep water (open ocean)

Coastal = surface currents over the shelf

Table 4: Results of the recalculation of krill biomass from the FIBEX cruises.

	ρA (gm ⁻²)	Area ('000 km ²)	Coefficient of Variation	Biomass (thousand tonnes)
Details for Subarea 48.1				
<i>Professor Siedlecki</i> (Bransfield)	21.9	29.1	37.7	638
<i>Professor Siedlecki</i> (Drake)	1.5	160.1	31.1	240
Details for Subarea 48.2				
<i>Itzumi</i> (Bransfield)	159.6	26.5	19.7	4 229
<i>Itzumi</i> (E Drake)	66.9	8.3	65.0	555
<i>Itzumi</i> (W Drake)	91.9	4.7	43.1	432
<i>Walther Herwig</i> (SW)	94.2	89.4	38.0	8 420
Details for Subarea 48.2				
<i>Odissey</i> (Scotia A)	89.3	68.3	20.1	6 103
<i>Odissey</i> (Scotia B)	16.8	33.3	7.5	558
<i>Eduardo L. Holmberg</i>	82.8	83.8	34.9	6 937
<i>Walther Herwig</i> (E)	35.6	56.5	40.1	2 009
Combined results				
Area 41				
<i>Walther Herwig</i> (NW)	48.9	75	29.6	3 658
Subarea 48.1 (excluding <i>Professor Siedlecki</i>)	105.8	128.9	24.0	13 636
Subarea 48.2	64.5	241.9	18.1	15 606
Subarea 48.3	59.7	25.3	38.0	1 510
Subarea 48.1+2+3			14.3	30 752
Subarea 48.6				
<i>Agulhas</i>	8.0	576	23.0	4 608
Division 58.4.2				
<i>Nella Dan</i> + <i>Marion Dufresne</i> + <i>Kaiyo Maru</i>	2.3	1 711	32.0	3 935

Table 5: Re-calculation of the percentages used for allocation of a precautionary catch limit for krill in Statistical Area 48 among the various subareas.

	FIBEX Estimate	Historical Catch 1980-1992	Average of Columns 1 and 2 plus 5%
Krill-predator interactions considered?	N	N	N
Data availability?	Y	Y	Y
Provisional allocations:			
Antarctic Peninsula 48.1	39%	19%	34%
South Orkney Islands 48.2	44%	44%	49%
South Georgia 48.3	4%	37%	26%
S. Sandwich Islands 48.4		<0.01%	5%
Weddell Sea 48.5		<0.01%	5%
Bouvet Island region 48.6	13%	0.02%	12%

Table 6: Data requirements. This table lists the requests of WG-Krill-92, and adds additional requests of the Fifth Meeting of the Working Group.

Data Requested by WG-Krill-92	Data/Work Submitted	Data Requested by WG-Krill-93
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-93/40, 44	Continued requirement (Appendix E)
Influence of hydrography on krill distribution	WG-Krill-93/22, 26, 28, 30, 33, 39	Continued requirement for Workshop (paragraph 4.10 and Appendix D), and continued submission to the Bibliography requested (paragraph 7.11)
Length frequency data submission	Length frequency data from Chile and Japanese fishery	Now established; continuing
Haul-by-haul data	Chile only	Continued requirement
Finer scale data submission	Japanese 10 nm x 10 nm data reporting	Now established; continued requirement
Number and capacity of fishing vessels	-	-
Estimates of biomass for ISRs	Calculated at Workings Groups 1992 and 1993	Continued requirement
Monthly catch reporting	Proceeding	Now established
Data on amount and viability of krill passing through a net	1993/94	Validation of assumptions of WG-Krill-93/34 recommended and validation of code by Secretariat requested (paragraphs 3.36 and 3.38)
New data on krill flux	(see above)	-
Historical fine-scale catches	Information provided by Russia (paragraphs 3.16 to 3.21)	Progress on submission of historical fine-scale data encouraged (paragraph 3.20)
Secretariat requested to contact FAO concerning catches in Statistical Area 41	Done	-
Minimum data requirements from acoustic surveys required (SC-CAMLR-XI, Annex 4, Appendix H)	Partial compliance	Continued requirement
		Net haul density data should be submitted for calculation of ΔR (Appendix E)

Table 7: Future work requirements. This table lists the requests of WG-Krill-92, and adds additional requests of the Fifth Meeting of the Working Group.

Work Requested by WG-Krill-92	Data/Work Submitted	Future Work Requested by WG-Krill-93
Operational definitions of Article II	No progress	Continued requirement
Further analysis of net haul and acoustic data for FIBEX	WG-Krill-93/20, 31, Table 4	-
Models of functional relationships between krill, predators, and fishery	WG-Krill-93/43	Refinement of parameters and model of functional relationships (paragraph 5.17)
Validation of potential yield model	Done	-
Estimation of S_R and correlation of M and growth rate	WG-Krill-93/12, 13	Further validation of R/M model and input parameters (Appendix E)
Examination of effect of physical condition and orientation on krill target strength	WG-Krill-93/6, 21, 24	Further work, especially on upward-looking and multi-frequency transducers encouraged (paragraphs 4.17 and 4.20)
Survey designs	WG-Krill-93/5	An <i>ad hoc</i> group will correspond (organised by D. Miller) in the intersessional period to investigate the problems of survey design and sampling regimes for krill data (B_O , ΔR) required by WG-Krill (paragraphs 4.44 to 4.48)
Analysis of fine-scale fisheries data	WG-Krill-93/7, 10, 11	Further detailed quantitative analysis of overlap of predators and fishery in all CCAMLR areas requested of the Secretariat (paragraph 5.10)
Further consideration of the <i>Observers Manual</i>	No comments	Awaiting use in field
Evaluate Composite CPUE Index	Paragraph 3.39	Methods of estimating search time for use in the Composite CPUE Index should be investigated (paragraph 5.31) The Composite Index should be used in conjunction with size/maturity state information to infer within-season krill movement.

Table 7 (continued)

Work Requested by WG-Krill-92	Data/Work Submitted	Future work Requested by WG-Krill-93
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
Consideration of a near-synoptic survey of Statistical Area 48	Paragraphs 4.41 to 4.48	(above)
Subdivision of results from existing surveys in line with WG-Krill-92 (SC-CAMLR-XI, Annex 4, Appendix D)	-	Continued requirement
Clarification of noise margins and thresholds for Prydz Bay surveys	-	Continued requirement for reporting at the next meeting of WG-Krill
Modelling to evaluate feedback control management options and spatial effects related to localised predator aggregations	-	Continued requirement
Completion of precautionary catch limit allocation table	Done at Working Group (Table 5)	
		<p>Evaluate the statistical performance and cost-effectiveness of possible harvesting regimes (paragraph 5.45)</p> <p>A workshop on krill flux should be held in 1994 (paragraph 4.10)</p>

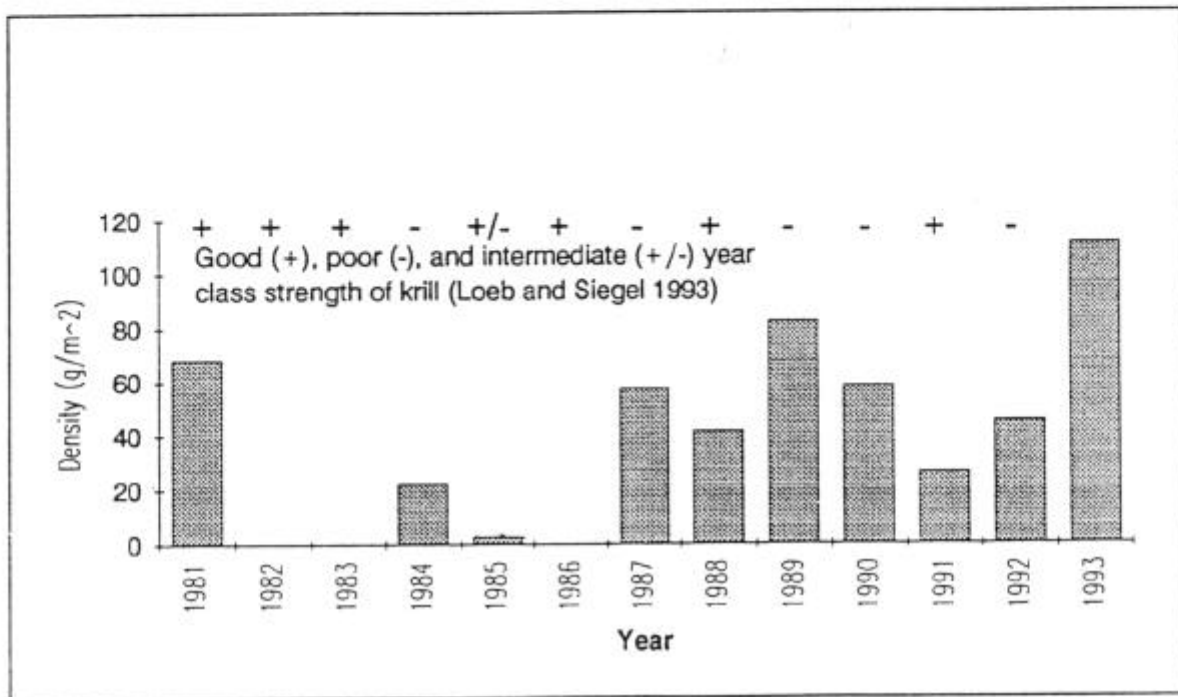


Figure 1: Average krill biomass density during January to March in the vicinity of Elephant Island appears to be variable and may reflect the effects of variations in year class strength according to Loeb and Siegel (1993).

AGENDA**Fifth Meeting of the Working Group on Krill
(Tokyo, Japan, 4 to 12 August 1993)**

1. Welcome
2. Introduction
 - (i) Review of the Meeting Objectives
 - (ii) Adoption of the Agenda
3. Review of Fisheries Activities
 - (i) Fisheries Information
 - (a) Data Submission (Fine-scale/Other)
 - (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) Immigration/Emigration Rates
 - (b) Residence Times
 - (c) Influence of Hydrography
 - (d) Effects on Estimates of Yield
 - (ii) Estimation of Effective Biomass
 - (a) Techniques
 - (i) KRAM Project
 - (ii) CPUE Indices
 - (b) Statistical Area 48

- (c) Other Areas
 - (d) Future Near-synoptic Survey(s) in Statistical Area 48
 - (e) Collection of Other Essential Data
 - (iii) Refinement of Yield Estimate Calculations
 - (a) Evaluation of Population Models
 - (b) Evaluation of Demographic Parameters
 - (iv) Review of Precautionary Catch Limits
 - (a) Statistical Area 48
 - (b) Other Statistical Areas
5. Ecological Implications of Krill Fishing
- (i) Location and Timing of the Fishery
 - (a) Statistical Subareas 48.1 and 48.2
 - (b) Other Subareas
 - (c) Relation of Fishing to Krill Predators
 - (i) Definition of Functional Relationships
 - (ii) Status and Role of CPUE Indices
 - (ii) Effects of Management Measures on Krill Fishing
 - (a) Krill Management Measures and Krill Predators
 - (b) Location, Timing and Intensity of Fishing
 - (iii) Liaison with WG-CEMP
 - (a) Future Development of Management Measures
 - (i) Role of Experimental Fishing
6. 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
 - (a) Formulation of Policy Questions to Commission
 - (iii) Other Possible Approaches and Their Development
 - (iv) Data Requirements
 - (v) Future Work of WG-Krill
7. Other Business
8. Adoption of the Report
9. Close of the Meeting.

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(Tokyo, Japan, 4 to 12 August 1993)

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LIST OF DOCUMENTS

Working Group on Krill
(Tokyo, Japan, 4 to 12 August 1993)

WG-KRILL-93/1	AGENDA
WG-KRILL-93/2	LIST OF PARTICIPANTS
WG-KRILL-93/3	LIST OF DOCUMENTS
WG-KRILL-93/4	GEOGRAPHIC ASPECTS OF <i>EUPHAUSIA SUPERBA</i> RESOURCES EXPLOITATION R.R. Makarov (Russia) (Submitted previously as WG-CEMP-92/31)
WG-KRILL-93/5	REQUIREMENTS TO KRILL ACOUSTIC SURVEYS W.D. Tesler (Russia)
WG-KRILL-93/5 Rev. 1	THE PREPARATION OF RECOMMENDATIONS AND STANDARD PROCEDURES FOR KRILL ACOUSTIC SURVEYS W.D. Tesler (Russia)
WG-KRILL-93/6	FURTHER ANALYSIS OF TARGET STRENGTH MEASUREMENTS OF ANTARCTIC KRILL AT 38 AND 120 KHZ: COMPARISON WITH DEFORMED CYLINDER MODEL AND INFERENCE OF ORIENTATION DISTRIBUTION Dezhang Chu (USA), Kenneth G. Foote (Norway), Timothy K. Stanton (USA)
WG-KRILL-93/7	AN ASSESSMENT OF THE IMPACT OF KRILL FISHERY ON PENGUINS IN THE SOUTH SHETLANDS T. Ichii, M. Naganobu and T. Ogishima (Japan)
WG-KRILL-93/8	STATUS OF THE KRILL STOCK AROUND ELEPHANT ISLAND IN 1991/92 AND 1992/93 V. Loeb (USA) and V. Siegel (Germany)
WG-KRILL-93/9	FINE-SCALE CATCHES OF KRILL IN AREA 48 REPORTED TO CCAMLR FOR THE 1991/92 FISHING SEASON Secretariat
WG-KRILL-93/10	KRILL CATCH DISTRIBUTION IN RELATION TO PREDATOR COLONIES 1987 TO 1992 Secretariat

- WG-KRILL-93/11 BIBLIOGRAPHY OF ANTARCTIC OCEANOGRAPHY, HYDROLOGY AND RELATED ASPECTS OF KRILL (*EUPHAUSIA SUPERBA*) DISTRIBUTION AND MIGRATION
Secretariat
- WG-KRILL-93/12 ESTIMATING KRILL RECRUITMENT AND ITS VARIABILITY
W. de la Mare (Australia)
- WG-KRILL-93/13 MODELLING KRILL RECRUITMENT
W. de la Mare (Australia)
- WG-KRILL-93/14 PRELIMINARY MODEL OF KRILL FISHERY BEHAVIOUR IN SUBAREA 48.1
D.J. Agnew (Secretariat)
- WG-KRILL-93/15 TROPHIC ECOLOGY OF DEMERSAL FISH COMMUNITIES IN WATERS TO THE SOUTH OF ELEPHANT ISLAND, NORTH OF LIVINGSTON ISLAND, NORTH OF ANTARCTIC PENINSULA AND EAST OF SMITH ISLAND, WITH NOTE ON THE ECOLOGICAL ROLE OF THE KRILL
Masanori Takahashi (Japan)
- WG-KRILL-93/16 A REVIEW ON THE FEEDING CONDITIONS OF THE BALEEN WHALES IN THE SOUTHERN OCEAN
Akito Kawamura (Japan)
- WG-KRILL-93/17 DISTRIBUTION OF SALPS NEAR THE SOUTH SHETLAND ISLANDS; THEIR ECOLOGICAL SIGNIFICANCE IN THE AREA
J. Nishikawa, M. Naganobu, T. Ichii and K. Kawaguchi (Japan)
- WG-KRILL-93/18 COMPARISON OF THE DISTRIBUTION OF PARTICULATE MATTERS AND THE COMPOSITION OF PARTICULATE ORGANIC MATTER IN SURFACE WATERS BETWEEN THE COASTAL AND OCEANIC AREAS OFF THE NORTHERN SOUTH SHETLAND ISLANDS IN SUMMER
Akihiro Shiimoto and Haruto Ishii (Japan)
- WG-KRILL-93/19 SOME IDEA OF NUMERICAL MODEL FOR ASSESSMENT OF *EUPHAUSIA SUPERBA* BIOMASS
Michio J. Kishi and Mikio Naganobu (Japan)
- WG-KRILL-93/20 REPORT OF AN EXAMINATION OF THE ACOUSTIC DATA FROM RV *EDUARDO L. HOLMBERG* COLLECTED DURING THE FIBEX STUDY
Inigo Everson (UK) and Adrian O. Madirolas (Argentina)
- WG-KRILL-93/21 PREDICTION OF KRILL TARGET STRENGTH BY LIQUID PROLATE SPHEROID MODEL
Masahiko Furusawa and Youichi Miyanoana (Japan)

- WG-KRILL-93/22 HYDROGRAPHIC FLUX IN STATISTICAL AREA 58 OF CCAMLR IN THE SOUTHERN OCEAN
Mikio Naganobu (Japan)
- WG-KRILL-93/23 CHLOROPHYLL DISTRIBUTIONS AROUND THE SOUTH SHETLAND ISLANDS
Haruto Ishii, Taro Ichii and Mikio Naganobu (Japan)
- WG-KRILL-93/24 ORIENTATION OF ANTARCTIC KRILL IN AN AQUARIUM
Yoshinari Endo (Japan)
- WG-KRILL-93/25 CPUES AND BODY LENGTH OF ANTARCTIC KRILL DURING 1991/92 SEASON IN THE FISHING GROUNDS NORTH OF LIVINGSTON ISLAND
T. Ichii (Japan)
- WG-KRILL-93/26 NOTE ON RELATIONSHIP BETWEEN THE ANTARCTIC KRILL AND ANNUAL VARIATION OF ICE EDGE DURING 1979 TO 1992
M. Naganobu and S. Kawaguchi (Japan)
- WG-KRILL-93/27 NOTE ON MATURITY OF KRILL IN RELATION TO INTERANNUAL FLUCTUATIONS OF FOOD ENVIRONMENT IN THE SEAS AROUND THE SOUTH SHETLAND ISLANDS
M. Naganobu and S. Kawaguchi (Japan)
- WG-KRILL-93/28 ESTIMATES OF PRIMARY PRODUCTION BY ICE ALGAE AND PHYTOPLANKTON IN THE COASTAL ICE-COVERED AREA NEAR SYOWA STATION, ANTARCTICA
Hiroo Satoh, Kentaro Watanabe and Takao Hoshiai (Japan)
- WG-KRILL-93/29 ENVIRONMENTAL GRADIENTS OF THE ANTARCTIC KRILL (*EUPHAUSIA SUPERBA* DANA) IN THE WHOLE OF THE ANTARCTIC OCEAN
Mikio Naganobu and Yuzo Komaki (Japan)
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Delegation of Russia

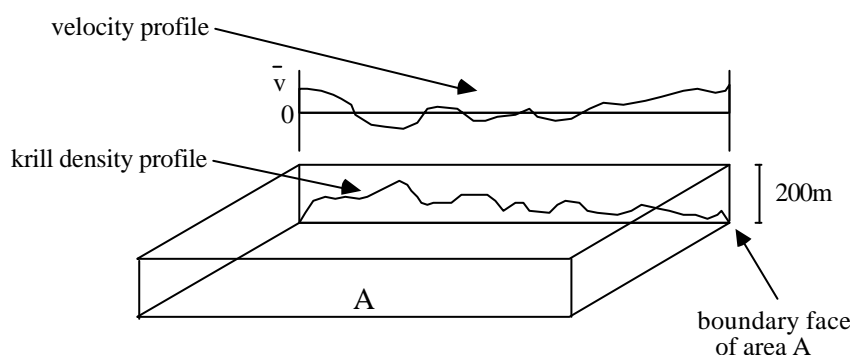
**TERMS OF REFERENCE FOR THE WORKSHOP
ON EVALUATING KRILL FLUX FACTORS**

The Terms of Reference for the Workshop on Evaluating Krill Flux Factors are as follows:

- (i) Determine the transport of water masses across boundaries of selected areas of ocean in terms of velocity profiles normal to the boundaries, integrated over the depth range 0 to 200 m.
- (ii) Determine krill density along each of the selected boundaries.
- (iii) Using information from (i) and (ii), calculate the passive krill fluxes across the boundaries.
- (iv) Determine the mean retention time of particles in selected small areas.
- (v) Propose methods for further studies on the question of krill fluxes.

CONCEPTUAL FRAMEWORK

2. A selected area consists of a slice of water 200 m deep.



For each boundary face a normal velocity profile needs to be calculated, integrated over the depth range 0 to 200 m. The convention will be: positive values into area, negative values - outwards. The velocity profile should ideally be given as an average value for each nautical mile of boundary.

3. A krill density profile for each boundary face should also be calculated, integrated over the same depth range, and at the same one nautical mile boundary resolution. If possible, these should be calculated for various times of the year.
4. The krill flux across each boundary is the product of the two profiles. It is not necessary or expected that the net inward krill flux is equal to the net outward krill flux over the time-scale of interest.
5. To investigate interannual variability in krill flux, both velocity and krill density profiles should be calculated for as many years as possible.
6. The subareas for which these calculations are to be carried out are 48.1, 48.2 and 48.3, and the smaller areas defined in Figure D.1. Velocity and krill density profiles are required along the boundaries for January to March in Subareas 48.1 and 48.2, and January to April, June and August in Subarea 48.3.

Velocity and krill density profiles and mean retention times are required for each 0.5° latitude 1° longitude rectangle in the hatched areas, for the same months as the subarea of which they form part.

7. Mean retention times of particles in the small areas designated in Figure D.1 should be calculated for as many years as possible.

Regional Definitions

Subarea 48.3 bounded by 50°S , 57°S , 30°W , 50°W

Subarea 48.2 bounded by 57°S , 64°S , 30°W , 50°W

Subarea 48.1 bounded by 60°S , 65°S and the northwest coast of the Antarctic Peninsula, 50°W , 70°W

Region A bounded by 52°S , 57°S , 30°W , 46°W

Region B covers the whole of Subarea 48.2

Region C bounded by 60°S , 64°S , 50°W , 70°W excluding the area northwest of a line between 62°S , 70°W ; 62°S , 66°W ; 61°S , 66°W ; 61°S , 63°W ; 60°S , 63°W .

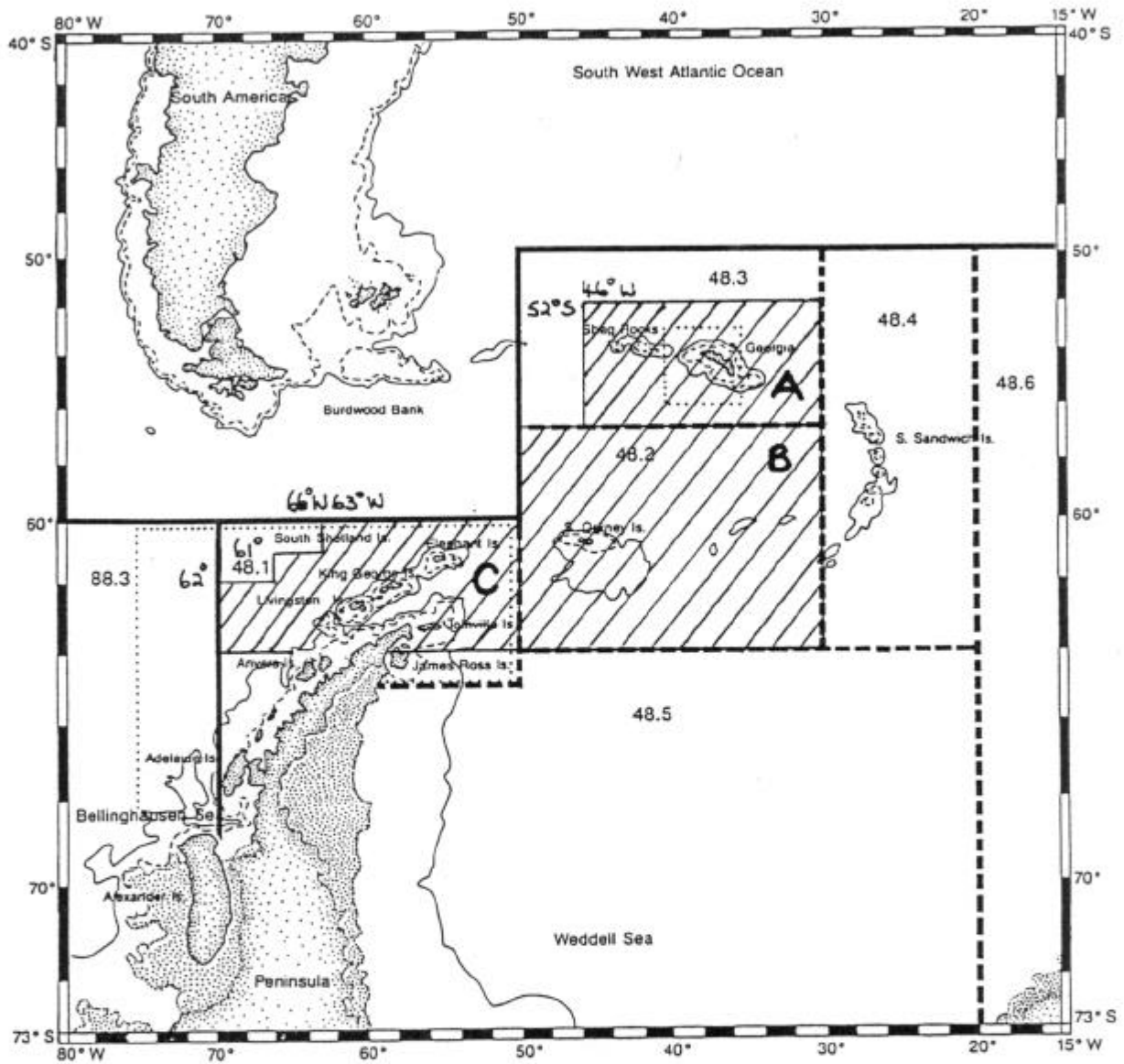


Figure D.1: Atlantic Antarctic area showing regions where velocity and krill density profiles are to be calculated.

**YET FURTHER REFINEMENTS OF THE CALCULATION OF THE FACTOR g
RELATING KRILL YIELD TO SURVEY BIOMASS ESTIMATES**

1. Updated Estimates for M and σ_R

Attempts will be made to obtain further datasets for krill trawl surveys to which the calculation methods developed in WG-Krill-93/12 can be applied. It was noted that the BIOMASS datasets had already been exhausted in this regard. The properties of each dataset to which the analysis is applied will be documented carefully, so that any censoring which may be necessary at the next WG-Krill meeting prior to the combination of results for different datasets, can be carried out on the basis of objectively pre-defined criteria. [Responsibility: D. Agnew]

Calculations will be carried out for any additional datasets obtained, and attempts will be made to investigate the quantitative consequences of any bias arising from net selectivity effects. [Responsibility: W. de la Mare]

2. Updated Estimates for l_r and l_m

Length frequency datasets from various national fisheries will be examined to obtain estimates of the parameters of the selectivity functions for each. Analyses of maturity data will be examined in the same way to provide estimates of the parameters of the maturity function. [Responsibility: D. Agnew]

Model calculations will be repeated for the revised estimates. [Responsibility: D. Butterworth]

3. Sex Differentiation

To allow for deliberate avoidance of gravid females by the fishery, the model will be sex-disaggregated. During the months of summer fishing (December to February), 20% by number of mature females present at the start of December will remain unavailable to the fishery. While in standard calculations, spawning biomass will be calculated in terms of the maturity vs length function

for females, in this case results will be reported separately for males and females, taking account of the difference in maturity-at-length functions for the two sexes. [Responsibility: D. Butterworth]

4. Age Dependence of M

Calculations will be repeated under the assumption that M for ages 0, 1 and 2 is double that for older ages. (This does not require modifications of the methods developed in WG-Krill-93/13.) [Responsibility: D. Butterworth, W. de la Mare]

5. Growth Rate - Natural Mortality Correlation

A number (10 to 20) of species - preferably ones closely related to krill -for which both M and the von Bertalanffy growth rate parameter κ are reasonably well determined will be selected to allow estimation of the distribution of the κ/M ratio. This approach will be used, given estimates of M provided under 1 above, to generate associated values for the von Bertalanffy growth parameter β used in the krill model. [Responsibility: M. Basson, D. Butterworth]

6. Validation

The algebra and associated computer code for the methods developed in WG-Krill-93/12 and 13 will be checked. The methods will also be tested by application to a few simulated datasets. [Responsibility: D. Agnew, K. Hiramatsu]

7. Miscellaneous Aspects and Tests

Results for different γ values for the new estimation technique [1 above] for which M and σ_R are correlated, are to be compared with those from the existing method based on uncorrelated values generated from uniform distributions. [Responsibility: W. de la Mare]

Unless specifically necessary, all calculations need be carried out for the summer (December to February) fishing season option only.

All parties contributing to work on these further refinements are to report on progress in February 1994. [Responsibility: All]

All the computer programs required for these calculations are to be prepared so that they may be run for updated estimates during the 1994 meeting of the Working Group. [Responsibility: D. Agnew, D. Butterworth, W. de la Mare]

The code for the computer programs will be cleared of extraneous comments, and appropriately documented, after the 1994 meeting. [Responsibility: D. Agnew]

Adjunct

The following data are required to calculate krill length density distribution for determining recruitment proportions:

1. Survey design [station list, haul type (oblique, horizontal, etc.), time of day].
2. Gear type, mesh size, etc.
- 3a. Krill density in each haul by 2 mm length class (hauls with no krill must be included in the data).

OR

- 3b. The data needed to calculate the density:
 - time the net was fishing, flow meter readings, OR volume filtered;
 - mouth area of net;
 - total weight of krill in the haul; and
 - length frequency distribution of a sample and the weight of the length frequency sample, OR total numbers at length in the haul.

**INTERNATIONAL GLOBAL OCEAN ECOSYSTEM DYNAMICS
(GLOBEC.INT) PROGRAM**

GLOBEC.INT Scientific Steering Committee will set up the following Working Groups (WG):

- (i) WG on Population Dynamics and Physical Variability (Dr D.H. Cushing, Chair);
- (ii) WG on Sampling and Observation Systems (Prof. T. Dickey, Chair);
- (iii) WG on Numerical Modelling (Prof. A. Robinson, Chair);
- (iv) WG on PRUDENCE (dealing with old data);
- (v) WG for GLOBEC-Southern Ocean Program (Prof. J.-O. Strömberg, Chair);
- (vi) WG for ICES/GLOBEC Cod and Climate Program (Dr K. Brander, Chair); and
- (vii) WG for PICES/GLOBEC Subarctic Pacific Program (Dr D. Ware, Chair).

2. The matters to be considered by Southern Ocean GLOBEC with regard to zooplankton (including krill) are:

- zooplankton overwintering strategies;
- seasonal and geographical variations in the distribution of Southern Ocean key zooplankton species, especially in relation to the physics of the environment;
- factors affecting successful reproduction;
- factors relating to larval survival and recruitment to the adult population;
- the distribution of Southern Ocean zooplankton in relation to the distribution of food biomass and reproduction;

and for predators:

- effects of variability in the physical and biological environments on predator population dynamics;
- the role of ice in affecting foraging performance, reproductive success and survival of top predators;
- krill variability and its allocation between several top predator species;
- the effect of predator foraging activities on altering the distribution and abundance of krill; and
- the nature of the functional relationships between krill availability and performance and survival of its predators.

**REPORT OF THE WORKING GROUP
ON FISH STOCK ASSESSMENT**
(Hobart, Australia, 12 to 19 October 1993)

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REPORT OF THE WORKING GROUP ON FISH STOCK ASSESSMENT

(Hobart, Australia, 12 to 19 October 1993)

INTRODUCTION

1.1 The meeting of the Working Group on Fish Stock Assessment (WG-FSA) was held at the CCAMLR Headquarters, Hobart, Australia from 12 to 19 October, 1993. The Convener, Dr I. Everson (UK), chaired the meeting.

1.2 The Convener welcomed participants to the meeting.

ORGANISATION OF THE MEETING

2.1 As in the past, the Convener suggested that the required assessments be undertaken in small task groups with periodic review, in the plenary, of the datasets and assessment and management advice as they are developed by the task groups. The Working Group agreed with this suggestion.

2.2 In accordance with established practice, all papers submitted to WG-FSA prior to the start of the meeting were accepted for consideration.

2.3 The report was prepared by Drs A. Constable and W. de la Mare (Australia), Mr D. Miller (South Africa), Drs C. Moreno (Chile), G. Parkes (UK), K. Sullivan (New Zealand), D. Agnew and E. Sabourenkov (Secretariat), and members of the various assessment subgroups.

ADOPTION OF THE AGENDA

3.1 The Provisional Agenda was circulated prior to the meeting. The Agenda was adopted with one amendment, the addition of sub-item "General Advice" to Agenda Item 6 "Assessment Work and Management Advice". This was included to allow for discussion of various management issues of a general nature and, in particular, high seas fisheries and straddling stocks, a topic to be considered by the Scientific Committee under its agenda item on the United Nations Conference on Straddling Fish Stocks and Highly Migratory Species.

3.2 The adopted 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.

OBSERVATION AND INSPECTION

4.1 The Scheme of International Scientific Observation was adopted last year by the Commission. The pilot edition of the *Scientific Observers Manual* had been published and distributed to Members. The Scientific Committee had decided, that on implementation of the Scheme, the pilot edition of the Manual should be tested in the field as soon as possible and be reviewed or updated whenever necessary.

4.2 The first, and currently only, observation under this Scheme was conducted in the 1992/93 season in accordance with an agreement between Chile and the UK (SC-CAMLR-XII/BG/4). Under this agreement, a Scientific Observer nominated by the UK together with an observer nominated by Chile, undertook scientific observations on board the Chilean longliner, *Frio Sur V*, fishing for *Dissostichus eleginoides* in Subarea 48.4 (South Sandwich Islands).

4.3 Dr Moreno reported that the observers found the text of the Manual to be useful and easy to follow. However, they also found that the formats for collecting data given in the Manual were difficult to use in the confined space and often short time available for making observations. They also had several specific comments on Format 1B. The observers had, in fact, used a simplified form developed on board to record a subset of the recommended information.

4.4 In this context, the Working Group recommended that a short introduction should be added to a list of research priorities identified by the Scientific Committee for scientific observations on commercial vessels and included in the next edition of the Manual. This introduction should explain that observers are not required to conduct a full set of identified research tasks. The actual list of tasks undertaken by an observer would depend on the type of vessel, the number of observers involved and their professional skills.

4.5 The Working Group commended the observers for their efforts in implementing the Observation Scheme.

4.6 In conclusion, the Working Group recommended that in light of the limited experience acquired so far in using the Manual, the formats should not be changed at this stage. A new edition of the Manual should be considered only after more information about its use in the field becomes available.

REVIEW OF MATERIAL FOR THE MEETING

DATA REQUIREMENTS ENDORSED BY THE COMMISSION IN 1992

5.1 Various data were specifically requested by the Working Group in 1992 (SC-CAMLR-XI, Annex 5, Appendix D). Data submitted to the Secretariat in response to this request are listed in Appendix D.

5.2 Catch and biological information had been submitted from the two current fisheries for *D. eleginoides* at South Georgia and the Kerguelen Islands. Fine-scale data and length frequency information from the 1992 crab fishery in Subarea 48.3 had also been submitted. However, overall the submission of data requested by the Working Group from previous fishing seasons was disappointing.

CATCH AND EFFORT STATISTICS

5.3 The Secretariat has experienced problems in adequately preparing STATLANT data submitted by the 30 September deadline in time for WG-FSA's consideration. Members had therefore been requested to consider the implications of changing this deadline for the submission of STATLANT forms to 31 August (COMM CIRC 93/38 dated 2 August 1993). The Working Group agreed that bringing the deadline forward should serve to improve availability of data from the most recent fishing season for assessment purposes. Furthermore, no Members have objected to the suggested change in dates. Consequently, WG-FSA recommended that the annual submission date for STATLANT forms should be changed to 31 August.

5.4 Fishing for *D. eleginoides* in Subarea 48.3 was undertaken by longline vessels from Chile, Russia, Ukraine and Bulgaria. Data were reported to CCAMLR as part of the requirements of Conservation Measure 56/XI by all participants in the fishery.

5.5 The Working Group discussed the fishery for the straddling stock of *D. eleginoides* which was conducted in international waters by Chilean vessels. WG-FSA-93/21 provides a breakdown of catches in Chilean and international waters (as well as within Subarea 48.3) with reported positions of longline hauls. A large number of reported longline catches came from areas immediately adjacent to the boundaries of Subarea 48.3. It is presently not known whether vessels other than those from Chile undertake fishing for *D. eleginoides* in waters adjacent to the CCAMLR Convention Area.

5.6 The Working Group considers that as assessment and management of the whole stock is required, the question of straddling stocks fished within CCAMLR waters needs to be addressed urgently.

5.7 Given the proximity of the fisheries in international waters (FAO Statistical Divisions 41.3.2 and 41.3.3) to Subarea 48.3, the Working Group also requested the Scientific Committee to consider the consequences of misreporting of catch information, both with regard to the risk to fish stocks in CCAMLR waters and to the credibility of stock assessment and management by the Commission.

5.8 A TAC of 3 350 tonnes was set for *D. eleginoides* at the 1992 Commission meeting. The fishery was closed on 5 February 1993 when 2 886 tonnes had been reported caught; this resulted in the total catch falling short of the TAC for the season. As no report was received from the Ukrainian fishing vessel(s) at this point for the previous five-day period, a catch was assumed when in fact none had been taken, triggering the closure of the fishery. The final fine-scale reports which are assumed to be more accurate showed an additional 104 tonnes above the catch reported in the five-day periods, making a total reported catch of 2 990 tonnes.

5.9 Catch statistics were also reported from Division 58.5.1 (Kerguelen), 2 722 tonnes of *D. eleginoides* taken by the trawl fishery (see paragraph 6.109).

5.10 The only other reports of finfish catches in CCAMLR waters came from a Chilean exploratory fishing expedition in Subarea 48.4 (SC-CAMLR-XII/BG/4) and some Bulgarian longlining. All positions of longline hauls within Subareas 48.3 and 48.4 had been reported and were presented in WG-FSA-93/27.

EXPERIMENTS AFFECTING CATCHABILITY

5.11 A Polish paper on water flow through trawl codends was discussed (WG-FSA-93/11). This paper had previously been presented to ICES. The study shows that the design of meshes in the codend could be improved on theoretical grounds to ensure greater mesh opening efficiency and better selectivity of the codend. The new design had not yet been rigged and tested. The Working Group considered that this was one of a number of possible solutions to the problem of mesh selectivity, however, future tank and sea trials will be needed to evaluate the method further.

OTHER DOCUMENTS

5.12 The Working Group considered 29 documents submitted to the meeting and 10 other background papers. Those papers not reviewed in other sections of the report are briefly summarised here.

Feeding

5.13 WG-FSA-93/24 compared the diet and feeding intensity of *Champsocephalus gunnari* in Subarea 48.3 from a number of years. Although the preferred diet is likely to be krill, low abundance of krill in this area in 1991 may have led to replacement in the diet by the hyperiid *Themisto gaudichaudii*. Evidence was presented that the shortage of krill in 1991 may have resulted in poor gonad development of the fish in that spawning season.

Growth

5.14 The Working Group noted the importance of improving age determination methods for Antarctic fish. WG-FSA-93/6 described a validation study of the timing of annulus formation in *Notothenia coriiceps*¹ by scanning electron microscopy (SEM) and light microscopy techniques. The SEM was preferred to the other method. WG-FSA-93/7 described the use of the Bedford method for preparing large numbers of otolith sections embedded in resin blocks, followed by etching of the polished surface for SEM viewing (Bedford, 1983²).

5.15 WG-FSA-93/14 reviewed the early life history of *D. eleginoides* and compared the onset of scale formation and early growth throughout the Convention Area.

Maturity

5.16 WG-FSA-93/26 described ovarian maturation in *N. coriiceps* and found that the adolescent phase lasts for about four years. It was noted that if such a pattern was present in exploited species it would have implications in determining age at first spawning.

¹ Formerly *N. neglecta*

² Bedford, B.C. 1983. A method for preparing sections of large numbers of otoliths embedded in black polyester resin. *J. Cons. int. Explor. Mer.*, 41: 4-12.

5.17 WG-FSA-93/19 covered the distribution and interannual variation in larval fish assemblages in Subarea 48.3 sampled off South Georgia by the British Antarctic Survey. It was noted that such studies would provide useful information on the distribution of larval fish for consideration with respect to the impact of krill fishing on fish stocks.

Taxonomy

5.18 WG-FSA-93/25 presented evidence that *Lepidonotothen squamifrons*, *L. kemp* and *L. macrophthalma* are in fact one species (*L. squamifrons*).

Recruitment Variability

5.19 WG-FSA-93/13 described the variability in abundance and size of juvenile *Notothenia rossii* in relation to the not commercially fished species *N. coriiceps* at Potter Cove, South Shetland Islands from 1983 to 1992, sampled by trammel nets.

Biology of *Electrona carlsbergi*

5.20 WG-FSA-93/17 detailed the trophic status of myctophids in the Southern Ocean ecosystem and provided a preliminary estimate of the yearly consumption of zooplankton by *E. carlsbergi*. WG-FSA-93/18 discussed the distribution of *E. carlsbergi* in Antarctic waters and the processes which possibly control the migration of immature and mature fish. The Working Group considered that full English translations of both of these papers would be useful.

ESTIMATES OF SEABED AREAS WITHIN SELECTED DEPTH RANGES

5.21 Last year the Working Group had requested the Secretariat to refine previous estimates of seabed areas of Statistical Area 48 (SC-CAMLR-XI, Annex 5, Appendix H) and to extend these estimates to 2 500 m depth. In the past, such estimates have been calculated by manually drawing contours on charts containing all available soundings and then tracing or digitising these contours to estimate areas. This method was found to be extremely laborious, prone to operator error and somewhat subjective. The estimates which can be made from these calculations are also constrained by the initial choice of depth ranges.

5.22 The Secretariat looked into alternative data sources available in a digital form (WG-FSA-93/19). The use of digital data should avoid most of the problems indicated above: once written, the code is applicable to many different areas and depth intervals and the methodology is objective. The Secretariat has conducted a pilot study using the digitised data set of the World Ocean bathymetry (ETOP05) published on CD-ROM by NOAA/NGDC. A set of seabed estimates was calculated for a section of the South Georgia area.

5.23 The pilot study has established that unless more information on the precise data sources used for the ETOP05 data set becomes available, it would be difficult to validate the estimates obtained.

5.24 The Working Group decided that, at present, estimates of seabed areas obtained from the digital database, for depths greater than 500 m would be of sufficient accuracy for fish stock assessment purposes. These estimates will complement the existing estimates for depths less than 500 m. The Secretariat was asked, during the intersessional period, to revise estimates published in 1992 (SC-CAMLR-XI, Annex 5, Appendix H) by adding estimates for depth ranges between 500 and 2 500 m.

ASSESSMENT WORK AND MANAGEMENT ADVICE

NEW FISHERIES

6.1 In 1992, Chile notified the Commission of its intention to investigate a new fishery for *D. eleginoides* in the South Sandwich Islands (Subarea 48.4). The Commission adopted Conservation Measure 44/XI which would enable one Chilean vessel to conduct exploratory fishing in this region, with a catch limit of 240 tonnes. However, a fishing vessel from a non-member state (Bulgaria) conducted a longline fishery in the South Sandwich Islands from 18 November to 4 December 1992, prior to the opening of the fishery in Subarea 48.3, taking a total catch of 39 tonnes of *D. eleginoides*. Bulgaria forwarded haul-by-haul catch and effort data from this vessel to CCAMLR.

6.2 A Chilean longline vessel attempted to carry out the planned exploratory fishery in February and March 1993, but the effort was abandoned after only a week, when it became obvious that no commercial concentrations of fish were available. Only 395 kg of the target species of fish were taken in seven hauls. The catch rate of 5.4 g/hook was less than 1% of that found in the fishery around South Georgia. A detailed report, based on data collected by Scientific Observers from Chile and the UK on board the fishing vessel, was available to WG-FSA (SC-CAMLR-XII/BG/4). Haul-by-haul catch and effort and biological data from the catches have been forwarded to CCAMLR.

6.3 The available catch and effort data were used to estimate local density using the Leslie method (Seber, 1985³). The locations of hauls and the region of the shelf area considered to contain the fishable stock of *D. eleginoides* in Subarea 48.4 is shown in Figure 1. The results in terms of density and biomass are given in Table 1 below. About 70% of the fishable area of 2 150 n miles² was fished by Chilean and Bulgarian vessels in 1992/93. Using the yield-per-recruit analyses reported in SC-CAMLR-XI (Annex 5, paragraph 6.171) for *D. eleginoides* in Subarea 48.3, gave an estimated yield of 28 tonnes for Subarea 48.4.

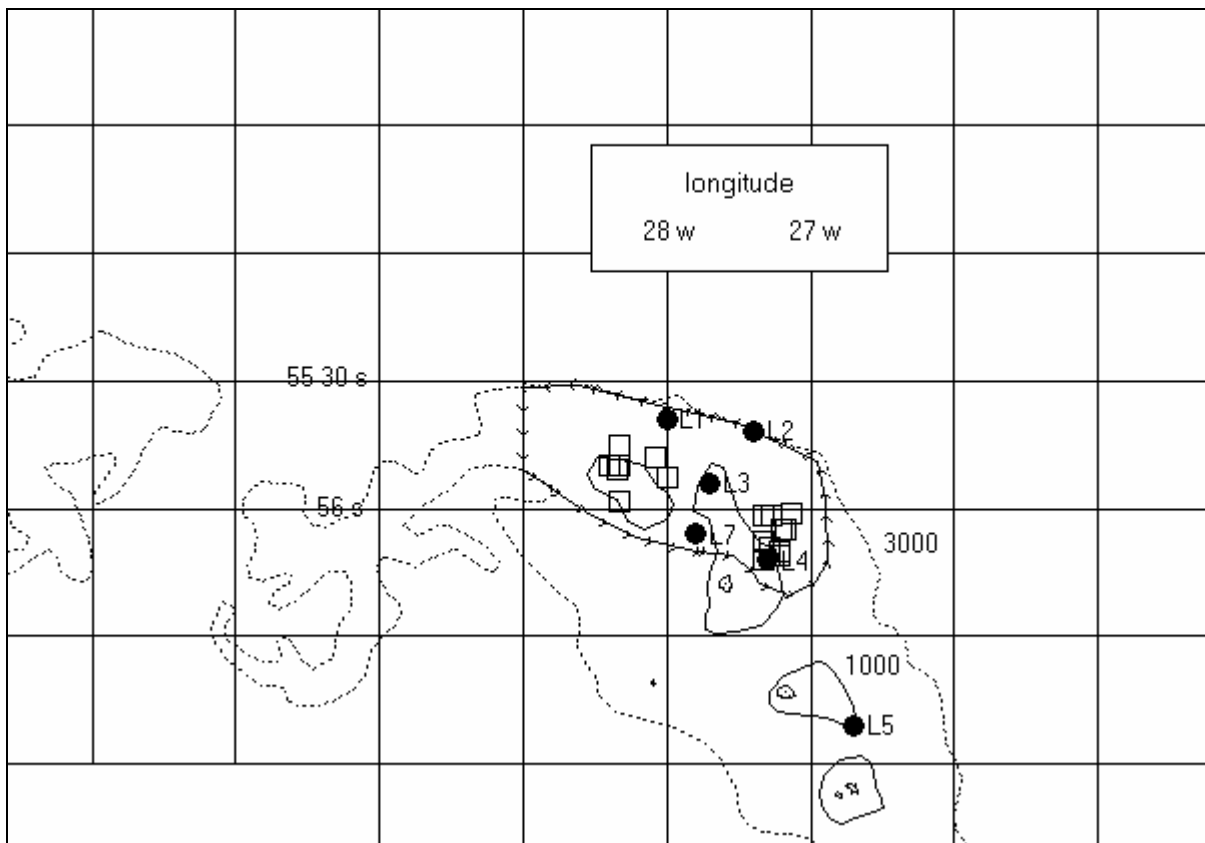


Figure 1: Position of catches by Bulgaria (□) and experimental hauls by Chile (?) in Subarea 48.4. ->->-> represents the estimated extent of the fishable shelf area. 3 000 and 1 000 m depth contours are shown.

³ Seber, G.A.F. 1985. *The Estimation of Animal Abundance and Related Parameters*. Second Edition. Charles Griffin & Co. Ltd., London: 654 pp.

Table 1: Assessment summary for *D. eleginoides* in Subarea 48.4 (South Sandwich Islands).

	Biomass (tonnes)	Area (n miles ²)	Density (tonnes/n mile ²)
Small area 1 (Bulgarian CPUE)	37.0	178	0.21
Small area 2 (Bulgarian CPUE)	52.0	434	0.12
Small area 3 (Chilean CPUE)	0.4	908	0.0004
Mean density on fishing grounds	= 0.11 tonnes/n mile ²		
Total area of fishable ground	= 2 150 n miles ²		
Stock estimate at start of season	= 235 tonnes		
F _{0.1}	= 0.12		
TAC	= 28 tonnes		

Management Advice

6.4 The fishing grounds for *D. eleginoides* in Subarea 48.4 are around three of the South Sandwich Islands, which lie on a narrow ridge which falls steeply into deep waters. Consequently, the area of bottom suitable for fishing is limited, being confined mostly to a small plateau at the northern end of the island chain. The islands are not generally considered to be in a region of high marine productivity. They are also considered to be at the extreme southern end of the range of *D. eleginoides*. Consequently, the Working Group agreed that the prospects for developing a commercial fishery for *D. eleginoides* in the region are very poor. In case there is any further interest in exploratory fishing in the area, the Working Group recommends a TAC of 28 tonnes for *D. eleginoides* in the South Sandwich Islands.

SOUTH GEORGIA (SUBAREA 48.3) - FINFISH

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

Reported Catches

6.6 The catch history for Subarea 48.3 is shown in Table 2. The only finfish to be taken in this Subarea in the 1992/93 season was *D. eleginoides*, although other fisheries were open and TACs had been set for *E. carlsbergi* (245 000 tonnes), and the midwater trawl fishery for *C. gunnari* (9 200 tonnes). All other directed fisheries were closed.

6.7 The longline fishery for *D. eleginoides* (3 350 tonnes TAC) was open from 6 December 1992 to 5 February 1993 and took 2 990 tonnes in this time. A further 59 tonnes which appears in Table 2 was taken in July 1992 as part of a Russian research cruise.

Table 2 : 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 ^e	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 ^a	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 ^b	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 ^c	9167
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 ^d	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 ^f	3	1	0	0	1	82423
1992	0	2	5	2	46960	3703 ^g	4	1	0	0	1	50678
1993	299	0	0	0	0	3049 ^h	0	0	0	0	0	3348

^a Includes 13 724 tonnes of unspecified fish caught by the Soviet Union

^b Includes 2 387 tonnes of unspecified Nototheniidae caught by Bulgaria

^c Includes 4 554 tonnes of unspecified Channichthyidae caught by the GDR

^d Includes 11 753 tonnes of unspecified fish caught by the Soviet Union

^e Before 1988, it is not confirmed that these were *E. carlsbergi*

^f Includes 1 440 tonnes taken before 2 November 1990

^g Includes 1 tonne taken as research catch by the UK, 132 tonnes taken as research catch by Russia before 30 June

^h 59 tonnes taken by Russian research cruise July 1992, 2 990 tonnes by the longline fishery December 1992 to February 1993.

Dissostichus eleginoides (Subarea 48.3)

6.8 The total catch of *D. eleginoides* for the period 6 December 1992 to 5 February 1993 was 2 990 tonnes, which was less than the TAC of 3 350 tonnes specified in Conservation Measure 55/XI. The reason for this shortfall is due to a problem of projecting the closure date, described in paragraph 5.8. Conservation Measures 56/XI and 51/XI, relating to the reporting of catch, effort and biological data, were also in force.

6.9 The 1992/1993 fishing season for *D. eleginoides* was shorter than the previous one, not only because of the problem with projecting the closure date, but also because the efficiency of the different fleets improved, with the CPUE increasing, especially for Chilean and Russian vessels (Figure 2).

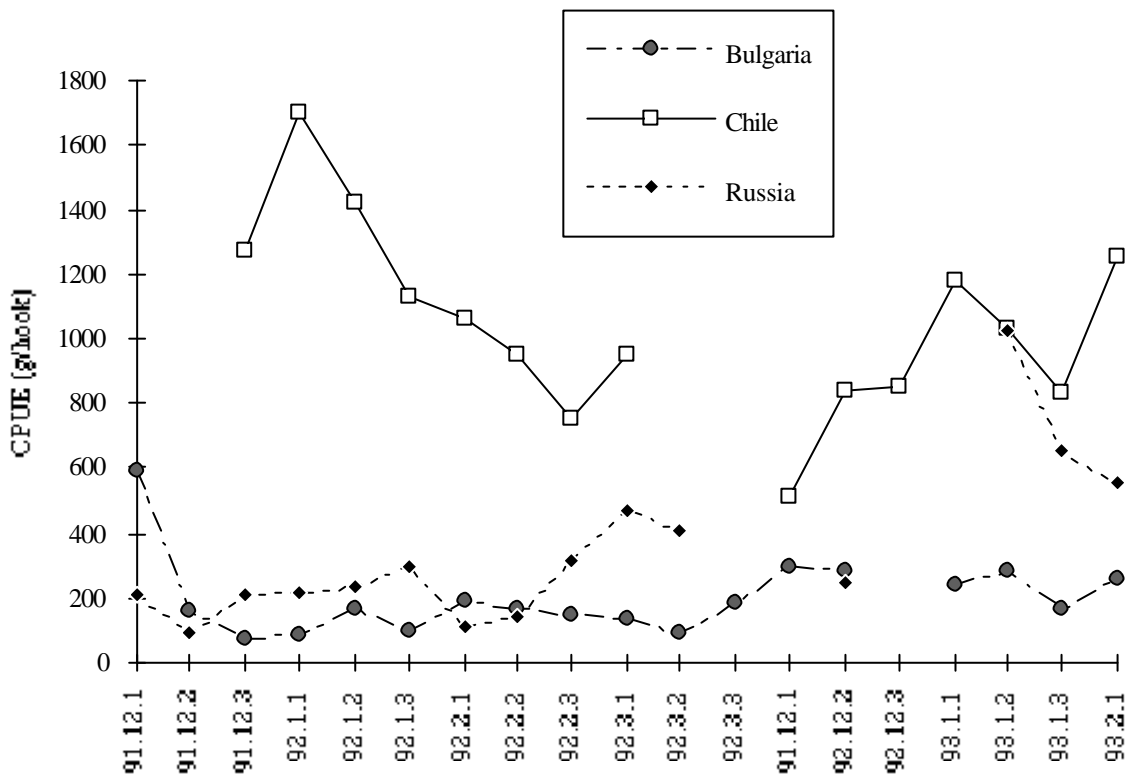


Figure 2: CPUE for the *D. eleginoides* fishery in Subarea 48.3 by 10-day periods (e.g., 91.12.2 = second 10-day period [11-20] of December 1991).

6.10 The total effort during the season comprised one Bulgarian, two Ukrainian, two Russian and between three and nine Chilean vessels, fishing for different periods as shown in Figure 3. The total effort was similar to the 1991/1992 season (in accordance with Conservation Measure 55/XI).

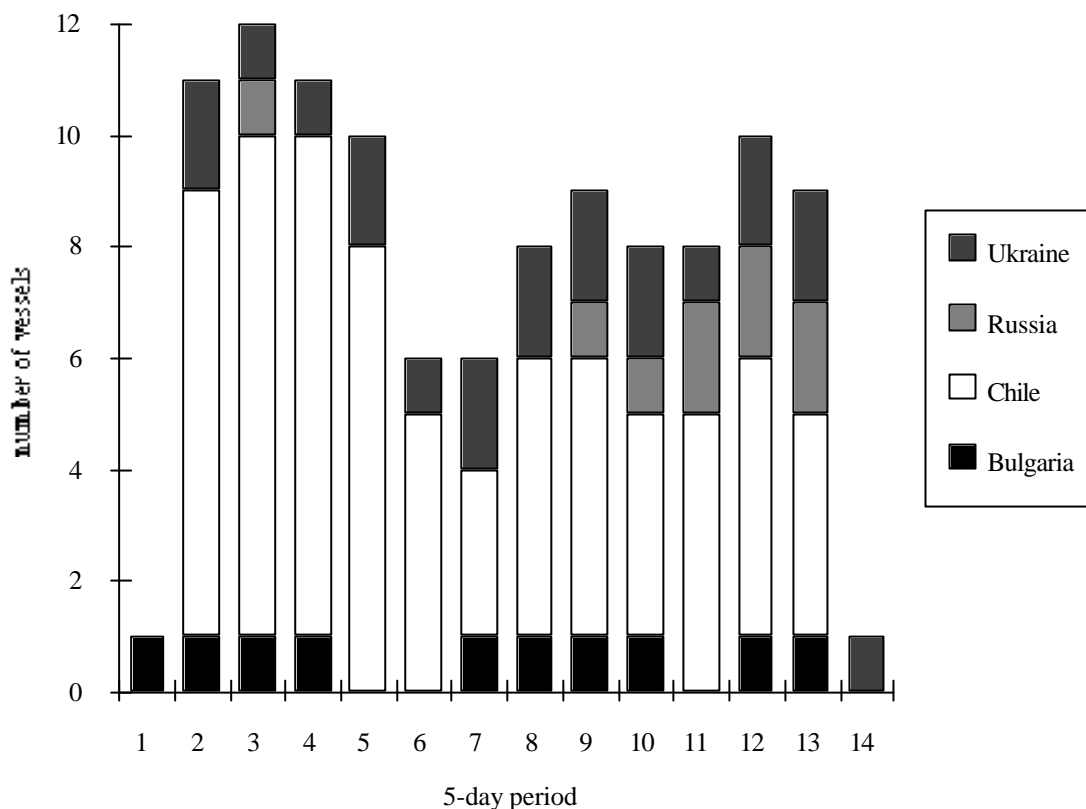


Figure 3: Number of vessels involved in *D. eleginoides* fishing in the 1992/93 season, Subarea 48.3.

Review of Catch and Effort Data

Catch Location from Fine-scale Data

6.11 The position of all catches by Russia, Chile, Ukraine and Bulgaria is shown in Figure 4. The fishery took place around Shag Rocks and South Georgia, as was the case in the 1991/92 season. The depth of fishing was also similar to the last season, ranging from 500 to 2 000 m with highest effort between 1 300 and 1 400 m depth.

6.12 In addition, two fishing sites located in the high seas adjacent to Subarea 48.3 were exploited by the Chilean fleet. Data relating to these fishing grounds were reported in WG-FSA-93/21. In the northern bank the total catch was 1 958 tonnes and in the western Rhine Bank the catch was 2 036 tonnes. Since these two fishing grounds are contiguous with Subarea 48.3, it was suggested that the fish taken on these grounds belong to the same stock as that found within Subarea 48.3.

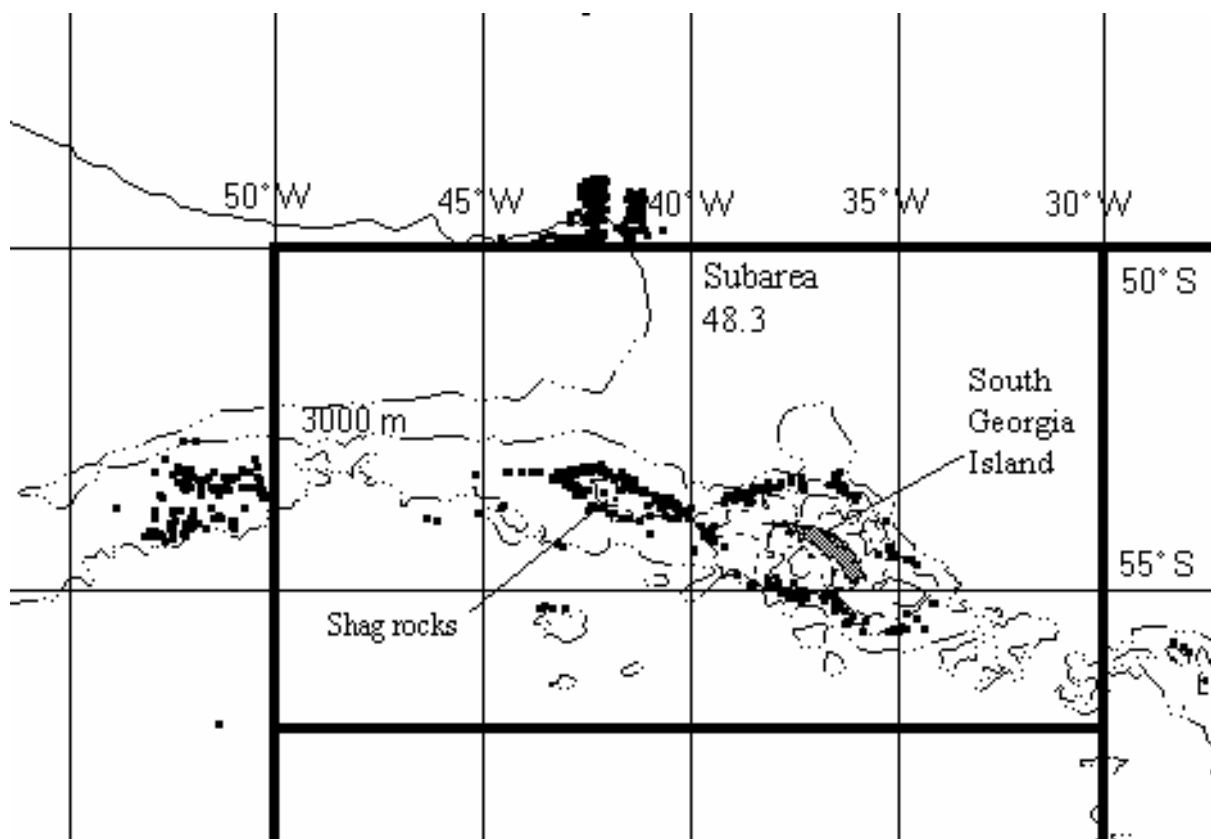


Figure 4: Position of catches of *D. eleginoides* by Chile, Russia, Bulgaria and Ukraine in Subarea 48.3 and adjacent waters ().

Review of Other Data

6.13 A substantial review of biological information was undertaken in last year's assessment. No new estimates of biological parameters for *D. eleginoides* were received, and the values accepted by the Working Group last year were used in the assessments.

Assessment Work

6.14 The data over several years, plotted in Figure 2, indicate some decline in CPUE, although there are also indications of increasing efficiency, particularly in the last season, and particularly for the Russian fleet. An examination of the total CPUE data for the most recent season did not show any declining trend within the season. However, this is not unexpected, because the likely effect of pooling different vessels, possibly using different hook types, and operating on different fishing grounds, is to obscure trends in CPUE. Moreover, the usual fishing pattern is for vessels to make a

number of hauls in the same vicinity, which often results in declining catch rates, and then move to another location which results in a sharp recovery in catch rate.

6.15 Estimates of abundance were calculated using the procedure adopted last year (see SC-CAMLR-XI, Annex 5, paragraphs 6.143 to 6.158 for a detailed description of the method and its underlying assumptions) in which local densities were estimated from the change in CPUE for a number of single fishing vessels fishing in a small area over a limited period of time. A simple regression of CPUE against cumulative catch is used to estimate the biomass in the small area at the start of fishing (modified Leslie's method - Ricker, 1975⁴). Identifying data suitable for this method of analysis involves a detailed examination of the large volume of haul-by-haul data. As a result, only the Chilean data could be analysed in the time available during the meeting. Since the Chilean fleet is the largest, and has not increased its efficiency to a substantial extent (unlike the large increase in efficiency since last season observed for the Russian vessels), it is likely that the Chilean data will be representative for the stock on the fishing grounds. The catch rates for the Bulgarian vessel are much lower than the Chilean vessels, and so it is less likely that this vessel will fish down the local stock to the extent required for reliable density estimation.

6.16 The area fished was calculated as that lying within a boundary which enclosed the reported positions of the group of hauls. However, in some cases the reported positions fell within a very small area, and in such cases the area was calculated as the area of a circle with a diameter of the length of a longline plus one nautical mile (to allow for an end-effect). The particular end-effect distance was selected because of the correspondence between the local density estimates obtained last year by the area enclosure method with those obtained using an assumed effective fishing width for longlines of one nautical mile (see SC-CAMLR-XI, Annex 5, Table 11). Vessels from the Chilean fleet use a longline of approximately 22 km in length, which results in a minimum area fished of 133 n miles² per location. This is less than the arbitrary lower bound used in last year's analysis of 200 n miles². Consequently, this year's abundance estimates will be slightly higher than they would be if calculated using last year's lower bound. Improved estimates of the area fished would be obtained if the bearing of the longline, or the positions of both ends of line were to be reported.

6.17 Three major fishing grounds within Subarea 48.3 were identified last year; one to the north of South Georgia (SGN), one to the south (SGS), and another around Shag Rocks (SHG) (see Figure 4). The 1992/93 estimates of the local density for each of these fishing grounds are given in Table 3, along with the extrapolated biomass for each fishing ground. These density estimates are similar to those estimated last year of 0.43 to 1.5 tonnes/n mile² (SC-CAMLR-XI, Annex 5, paragraph 6.161 and Table 11), using the same basic methods.

⁴ Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Board of Canada*, 191: 149-161.

Table 3: Local density estimates for the three fishing grounds around South Georgia and Shag Rocks, estimated using Leslie's method with the local change in CPUE for individual fishing vessels.

Number of Hauls	Fishing Ground	Area Fished (nm ²)	Biomass (tonnes)	Density (t/nm ²)	Mean Density (t/nm ²)	SD	CV	Seabed Area (nm ²)	Biomass (tonnes)
5	SGN	133.0	96.89	0.73	1.22	0.49	40.14	2374.9	2890.34
5	SGN	133.0	226.84	1.71					
9	SGS	133.0	325.90	2.45	2.00	0.97	48.40	3244.8	6476.17
7	SGS	133.0	487.76	3.67					
6	SGS	133.0	139.96	1.05					
5	SGS	136.5	164.98	1.21					
4	SGS	245.7	393.27	1.60					
6	SHG	1661.1	57.40	0.03	0.40	0.44	110.34	3380.7	1359.53
4	SHG	270.5	13.66	0.05					
5	SHG	2843.8	98.53	0.03					
5	SHG	133.0	126.40	0.95					
9	SHG	164.6	154.87	0.94					

6.18 The mean density for the fishable ground in the whole of the subarea is assumed to be estimated by the mean of the local density estimates on the recognised fishing grounds. The total biomass for the subarea is obtained by extrapolation to the whole of the seabed area in the depth range 500 m to 2 000 m in Subarea 48.3. The total exploitable biomass estimate for the beginning of the 1992/93 season is 10 700 tonnes. Given that this extrapolation assumes that the density of fish outside the currently recognised fishing grounds is the same as that within them, the biomass estimates may tend to be biased upwards.

6.19 Similar calculations were made for the two fishing grounds outside the CCAMLR boundary but immediately adjacent to Subarea 48.3. These results are given in Table 4 for the northern bank, and Table 5 for the Rhine (western) Bank. If it is assumed that the fish on these banks are part of the same stock found in Subarea 48.3, then the estimated exploitable biomass for the total stock is 17 450 tonnes at the start of the 1992/93 season.

Table 4: Local density estimates for the adjacent fishing grounds to the north of Subarea 48.3, estimated using Leslie's method with the local change in CPUE for individual fishing vessels.

Number of Hauls	Biomass (tonnes)	Area fished (n miles ²)	Density (tonnes/n mile ²)
8	35.3	133	0.27
5	4.2	133	0.03
5	97.5	133	0.73
6	175.7	1 436	0.12
6	868.4	133	6.54
Mean density		=	1.54 tonnes/n mile ²
Standard error		=	1.12
Area of fishing ground		=	2 758 n miles ²
Total biomass (1992/93)		=	4 250 tonnes
Yield for $F_{0.1}=0.12$		=	510 tonnes

Table 5: Local density estimates for the adjacent fishing grounds to the west of Subarea 48.3 (Rhine Bank), estimated using Leslie's method with the local change in CPUE for individual fishing vessels.

Number of Hauls	Biomass (tonnes)	Area fished (n miles ²)	Density (tonnes/n mile ²)
6	544.8	1797	0.30
10	533.9	945	0.56
5	693.4	133	5.21
5	290.1	1256	0.23
5	180.0	133	1.35
3	225.2	133	1.69
4	200.0	133	1.51
5	472.0	133	3.55
Mean density		=	1.80 tonnes/n mile ²
Standard error		=	0.57
Area of fishing ground		=	1 387 n miles ²
Total biomass (1992/93)		=	2 500 tonnes
Yield for $F_{0.1}=0.12$		=	300 tonnes

Population Projections

6.20 In order to calculate the approximate ratio of the current stock biomass relative to the unexploited stock level, a simple, deterministic biomass projection model based on the following difference equation was used:

$$B_{t+1} = \gamma(B_t - C_t) \cdot e^{-M} + \alpha B_0(1 - e^{-M})$$

where B_t is the biomass at the beginning of season t , C_t is the catch in season t , M is the natural mortality (0.13), γ is the proportional increase in biomass of the survivors from fishing and natural mortality through growth to the start of the following season, and α is the proportion of annual increment in biomass in the unfished stock which is due to recruitment. Thus, the second term in the equation represents a constant level of recruitment. The value of γ is determined so that the population has an equilibrium biomass B_0 in the absence of fishing.

6.21 Values of B_0 and α were found such that the biomass trajectory would pass through the 1992/93 biomass estimate, and give a rate of increase in biomass in the absence of fishing in the following year equal to the $F_{0.1}$ exploitation rate of 0.12. This leads to an approximate estimate of the stock depletion relative to the unfished stock level B_0 , and a projected biomass at the start of the next fishing season, which is required to calculate the TAC.

6.22 Two projections were calculated, one using the estimated biomass for Subarea 48.3 without considering the possible component of the stock in the immediately adjacent fishing grounds, and one in which the stock's range includes these two areas. The results of both projections, with corresponding yields, for the range of $F_{0.1}$ values given in Table 13 of WG-FSA-92 (SC-CAMLR-XI, Annex 5), are shown in Table 6. The calculations show that the stock is projected to have a current biomass at roughly 30% of the unexploited level. This result is not sensitive to the choice of whether or not to include the biomass and catches from the adjacent fishing grounds. The yield, however, is sensitive to the value of M used in calculating $F_{0.1}$ (see SC-CAMLR-XI, Annex 5, Table 13). The range of yields is 900 to 1 700 tonnes.

Table 6: Assessment based on the deterministic population projection passing through the biomass estimate at the start of the 1992/93 season.

	Subarea 48.3 Data Only	Including Adjacent Fishing Grounds
Initial biomass (1976/77)	31 600 tonnes	37 450 tonnes
Biomass start of 1992/93 season	10 700 tonnes	17 450 tonnes
Projected biomass 1993/94 season	8 980 tonnes	12 140 tonnes
α	0.45	0.54
γ	1.076	1.064
1993/94 biomass \div 1976/77 biomass	28.4%	32.4%
Yield using $F_{0.1} = 0.10$	900 tonnes	1 210 tonnes
Yield using $F_{0.1} = 0.12$	1 080 tonnes	1 460 tonnes
Yield using $F_{0.1} = 0.14$	1 260 tonnes	1 700 tonnes

6.23 The Working Group recalled the concerns expressed last year about assessments obtained using local density estimates on the fishing grounds to extrapolate a biomass estimate for the whole subarea. It also recalled its concerns about the other assumptions relating to the nature of the CPUE data, described in detail in WG-FSA-92. Nonetheless, the Working Group agreed that the assessment presented here was the best scientific advice that it could offer at this time on yields and the status of the stock.

Management Advice

6.24 The Working Group noted that the stock projections indicate that the stock may have been depleted to around 30% of its unfished abundance. This is below the level which would be attained when the stock is fished at $F_{0.1}$, and is approaching the level of depletion where the probability of recruitment failure increases. The Working Group recommends that a substantial reduction in catch is required to allow the stock to begin to rebuild. The Working Group noted that the spawning stock biomass depletion obtained when fishing at $F_{0.1}$ is around 40%. Fishing at $F_{0.1}$ should allow a slow recovery in the stock towards this level.

6.25 Advice on possible TACs is complicated by the fact that the stock may be vulnerable to fishing outside the CCAMLR Convention Area. If the stock is considered only to be that found in Subarea 48.3, a TAC in the range 900 to 1 260 tonnes is indicated. In this case, catch levels of about 500 and 300 tonnes would be indicated for the stocks on northern and western fishing grounds adjacent to Subarea 48.3 respectively. If the fish on the adjacent fishing grounds belong to the stock found in Subarea 48.3 then a higher TAC in the range 1 210 to 1 700 tonnes could be

contemplated, but a difficulty could arise in ensuring that the TAC would not be exceeded due to fishing on the adjacent fishing grounds outside the CCAMLR Convention Area.

6.26 The Working Group noted last year that the TAC in 1991/92 was reached early in the fishing season, and agreed then that further expansion in the number of vessels taking part in the fishery would not be appropriate. This year, although the number of participating vessels remained similar to the number in 1991/92, the TAC was reached even earlier in the season due to increasing efficiency. If there is a substantial reduction in the TAC, and there is no corresponding reduction in vessel numbers, the TAC will be reached during a very short fishing season, which could introduce complications into the CPUE and other fine-scale data, with consequent deleterious effects on the assessments. The Working Group noted that to avoid such problems any reduction in TAC should also lead to a reconsideration of the number of vessels operating in the fishery at any one time.

Chamsocephalus gunnari (Subarea 48.3)

Commercial Catch

6.27 The TAC of *C. gunnari* in Subarea 48.3 for the 1992/93 season was set at 9 200 tonnes (Conservation Measure 49/XI). There was, however, no reported catch of *C. gunnari* in Subarea 48.3 during the season. The fishery was closed on 1 April 1993 until the end of the Commission meeting on 5 November 1993 in accordance with Conservation Measure 49/XI. There has therefore been no significant commercial catch of *C. gunnari* since the 1989/90 season, during which 8 027 tonnes were taken.

Research Surveys

6.28 The Working Group received no reports of any research surveys designed to assess the status of the *C. gunnari* stock in Subarea 48.3 during the 1992/93 season. The Working Group therefore had no new information from the 1992/93 season with which to update the assessment undertaken at last year's meeting.

Background Documents

6.29 WG-FSA-93/29 presented a revision of the catch-at-age of *C. gunnari* in Subarea 48.3 between 1976/77 and 1991/92. This revision was based on a more statistically reliable method for

calculating age distributions than has been used previously. The catch-at-age presented in WG-FSA-89/8 and used subsequently by the Working Group was calculated by applying only two age/length keys to length distributions over the period 1971/72 to 1988/89. An age distribution calculated from a length distribution and an age/length key derived from samples taken at different times can be a biased representation of the true age distribution of the catch. Iterative application of the age/length key as described by Kimura and Chikuni (1987)⁵ corrects this problem and provides unique maximum likelihood estimates of age distributions. The Working Group suggested that the revised catch-at-age presented in WG-FSA-93/29 be used for future assessment of the *C. gunnari* fishery in Subarea 48.3 using VPA.

Stock Assessment

6.30 Assessment of the *C. gunnari* fishery in Subarea 48.3 was attempted at last year's meeting using VPA. The results of the VPA were not considered to provide a reliable representation of the status of the *C. gunnari* stock in the most recent years and were not used for estimating the level of TAC for the 1992/93 season. The VPA predicted a large proportion of 4 and 5 year olds in the population in 1991/92. These cohorts were not detected in abundance during the 1991/92 survey by the UK. The problems with the VPA arose from two sources; the assumption of constant M over the period 1989/90 to 1990/91 when research surveys indicated a substantial drop in biomass in the absence of substantial F, and contradictions between the year class strength in the commercial catch-at-age and that of the survey series used for tuning. The Working Group had insufficient time to investigate these problems in detail at its 1992 meeting and resorted to using the results of the 1991/92 survey as a basis for projecting population size and potential catch in 1992/93.

6.31 With no commercial catch and no survey in 1992/93 the Working Group was unable to extend the time-scale of the VPA beyond that at last year's meeting (i.e., terminating in 1990/91). The UK survey in January 1992 provides the most recent information on the status of the population. This results in there being a high degree of uncertainty associated with any assessment of the population size and potential commercial catch in 1993/94.

6.32 In order to provide guidance for an appropriate level of TAC in 1993/94 the Working Group decided to extend the projection made at last year's meeting by an extra year, incorporating simulated recruitment levels to indicate the uncertainty in the assessment of population size.

⁵ Kimura, D.K. and S. Chikuni. 1987. Mixtures of empirical distributions: an iterative application of the age/length key. *Biometrics*, 43: 23-35.

6.33 In addition it was decided to re-run the VPA with the revised catch-at-age presented in WG-FSA-93/29, tuned to a survey series re-calculated using the method described in WG-FSA-93/20. This would provide an indication of the potential for improvement in the performance of the VPA resulting from the revision of some of the data inputs.

Survey Estimates

6.34 Biomass estimates from a series of bottom trawl surveys (see Table 7) had been used to tune the VPA at last year's meeting. For reasons discussed at previous Working Group meetings (e.g., SC-CAMLR-X, Annex 6, paragraph 7.46) abundance estimates for South Georgia only (excluding Shag Rocks) have been used. These biomass estimates were recalculated according to the method provided in WG-FSA-93/20. The results are presented in Table 7.

Table 7: *C. gunnari* survey biomass estimates - UK surveys 1989 to 1992, South Georgia only.

Estimator:	Sample Mean		MVUE*		Lower CI	Upper CI
	Estimate	CV(%)	Estimate	CV(%)		
<i>1988/89 survey - Professor Siedlecki</i>						
50-150 m	3 384	75.6	1 976		804	10 065
150-250 m	27 879	49.7	21 900		10 101	73 485
250-500 m	423	69.4	364		91	5 407
Total	31 700	44.5	24 241	38.1	12 177	75 849
<i>1989/90 survey - Hill Cove</i>						
50-150 m	1 235	49.7	2 482		392	175 652
150-250 m	93 533	64.2	68 103		15 620	702 185
250-500 m	667	30.4	1 504		368	24 929
Total	95 435	62.9	72 090	65.2	18 951	576 718
<i>1990/91 survey - Falklands Protector</i>						
50-150 m	5 392	49.0	4 294		2 518	533
150-250 m	15 126	15.2	21 522		12 052	49 837
250-500 m	1 569	58.3	1 295		566	5 008
Total	22 089	16.4	27 111	25.9	17 163	55 506
<i>1991/92 survey - Falklands Protector</i>						
50-150 m	2 359	29.4	4 276		1 528	26 776
150-250 m	30 522	20.9	33 096		21 417	60 472
250-500 m	4 430	53.5	6 392		1 638	86 930
Total	37 311	18.3	43 763	21.4	28 997	124 747

* MVUE = Minimum Variance Unbiased Estimate

6.35 The alternative abundance estimates are of a similar magnitude to those presented previously, however, those derived from surveys with patchy distributions (1988/89 and 1989/90) are about 24% lower, whilst those from surveys with more even distributions of fish (1990/91 and 1991/92) are about 17 and 23% higher respectively. The decline in abundance between surveys in 1989/90 and 1990/91 was therefore less when estimated by this method, but was still of the order of 60%.

VPA

6.36 Six VPAs were run with the revised catch-at-age in WG-FSA-93/29, using the version of the ADAPT program used by CCAMLR (FADAPT8). The details of the inputs to these runs are provided in Table 8. The first three runs were equivalent to the first three runs at last year's meeting (SC-CAMLR-XI, Annex 5, Table 5). Runs 4, 5 and 6 were tuned to a survey series, calculated using abundance estimates for 1989 to 1991 as in Table 7. The catch-at-age for Run 6 was a combination of the revised version in WG-FSA-93/29 and that provided in WG-FSA-91/27 for the period 1982/83 to 1985/86.

Table 8: VPA runs for *C. gunnari* at WG-FSA-93 using revised catch-at-age (WG-FSA-93/29).

Run Number	Period	Catch-at-age	M	Tuning Index	Treatment
1	1977 - 1991	WG-FSA-93/29, Table 2b	0.48	Surveys 1987-1991 Sample mean	Unweighted
2	1977 - 1991	WG-FSA-93/29, Table 2b	0.48	Surveys 1987 -1991 Sample mean	Inverse variance weighting
3	1977 - 1990	WG-FSA-93/29, Table 2b	0.48	Commercial CPUE 1983-1990 (WG-FSA-91/27)	Unweighted
4	1977 - 1991	WG-FSA-93/29, Table 2b	0.48	Surveys 1987-1991 MVUE (1989-1991)	Unweighted
5	1977 - 1991	WG-FSA-93/29, Table 2b	0.48	Surveys 1987 - 1991 MVUE (1989-1991)	Unweighted Standardised to 1 July
6	1977 - 1991	WG-FSA-93/29, Hybrid	0.48	Surveys 1987-1991 MVUE (1989-1991)	Unweighted

6.37 The surveys used to generate the index for tuning are listed in Table 9.

Table 9: Source of survey data.

Season	Vessel	Reference
1986/87	<i>Professor Siedlecki</i>	SC-CAMLR-VI/BG/12
1987/88	<i>Professor Siedlecki</i>	SC-CAMLR-VII/BG/23
1988/89	<i>Professor Siedlecki</i>	Parkes, 1993*
1989/90	<i>Hill Cove</i>	WG-FSA-90/11
1990/91	<i>Falklands Protector</i>	WG-FSA-91/14
1991/92	<i>Falklands Protector</i>	WG-FSA-92/17

* Parkes, G.B. 1993. The fishery for Antarctic icefish *Champscephalus gunnari* around South Georgia. Ph. D. Thesis. Imperial College of Science Technology and Medicine, London University: 465 pp.

6.38 The methods and sampling equipment used during these surveys were similar and have been discussed at previous meetings (e.g., SC-CAMLR-X, Annex 6, paragraph 7.46). Despite changes in the survey vessel between years, Table 9 was considered by the Working Group to represent the most consistent available series of surveys from which to generate an index of abundance for tuning the VPA.

6.39 No satisfactory results were obtained from runs tuned to survey and CPUE indices together because the indices are incompatible.

6.40 Total abundance of fish age ≥ 2 years over the period 1976/77 to 1990/91 is illustrated in Figure 5. Runs 1 to 5 show similar patterns of abundance over time up to 1987/88. The CPUE tuned run (Run 3) then indicates a slight increase, while the survey tuned runs all show a continued drop in abundance. The survey-tuned runs indicate total biomass of fish ≥ 2 years old in 1990/91 to be in the range 40 000 to 67 000 tonnes.

6.41 Run 6 indicates much higher abundance than the other runs over the period 1977/78 to 1982/83. This run used a hybrid catch-at-age as described in paragraph 6.36. The catch-at-age from WG-FSA-91/27 over the period 1982/83 to 1985/86 indicated substantially higher numbers of older fish in the catch than estimated in the revised version (WG-FSA-93/29), particularly with regard to 3 year olds in 1983/84. The Working Group was unable to determine which of these was the most accurate over this period.

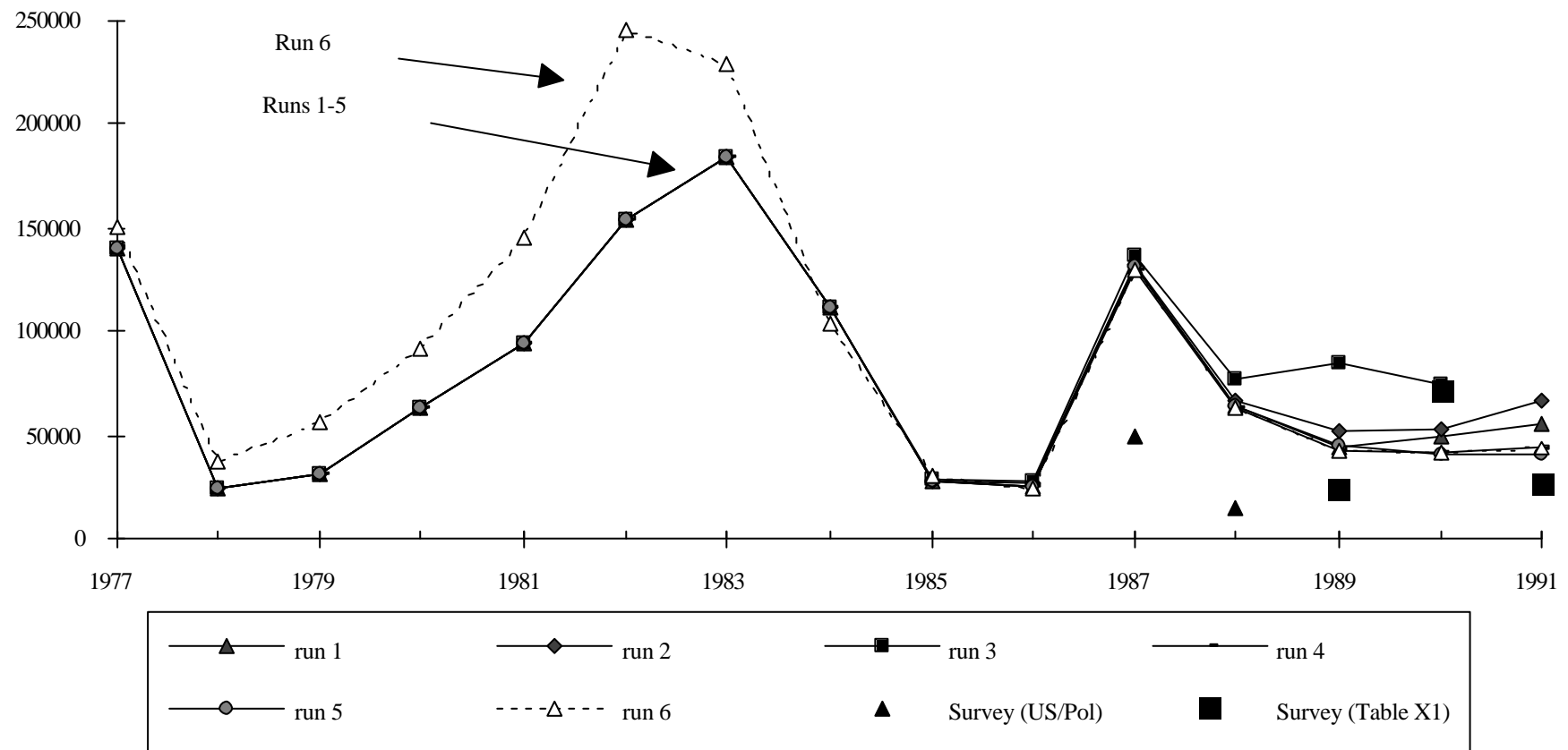


Figure 5: Results of VPA runs for *C. gunnari* in Subarea 48.3.

6.42 Run 1 (survey tuned) is compared to its equivalent VPA run made at last year's meeting (SC-CAMLR-XI, Annex 5, Table 5, Run 1) in Figure 6. The abundance over time estimated by the revised VPA was generally lower than previously estimated. The pattern of change in total abundance over time was, however, broadly similar to those shown at last year's meeting with marked peaks in biomass in 1982/83 and 1986/87. Minor differences were noted, such as the lower biomass in 1986, which is consistent with the low commercial catch in that year (11 107 tonnes).

6.43 The recruitment of 1 year olds over the period of the VPA is illustrated in Figure 7. The big 1987 year class (1 year olds in 1987/88) shown by previous VPA does not appear (e.g., SC-CAMLR-X, Annex 6, Figure 4). The current VPA indicates that the year class spawned in 1984/85 has been the strongest cohort in recent years. This appeared strongly in both the commercial catches (2 year olds in 1986/87 and 3 year olds in 1987/88) and in the survey index (2 year olds in 1986/87). Run 6 again showed very different results to the other runs due to differences in the catch-at-age between 1982/83 and 1985/86.

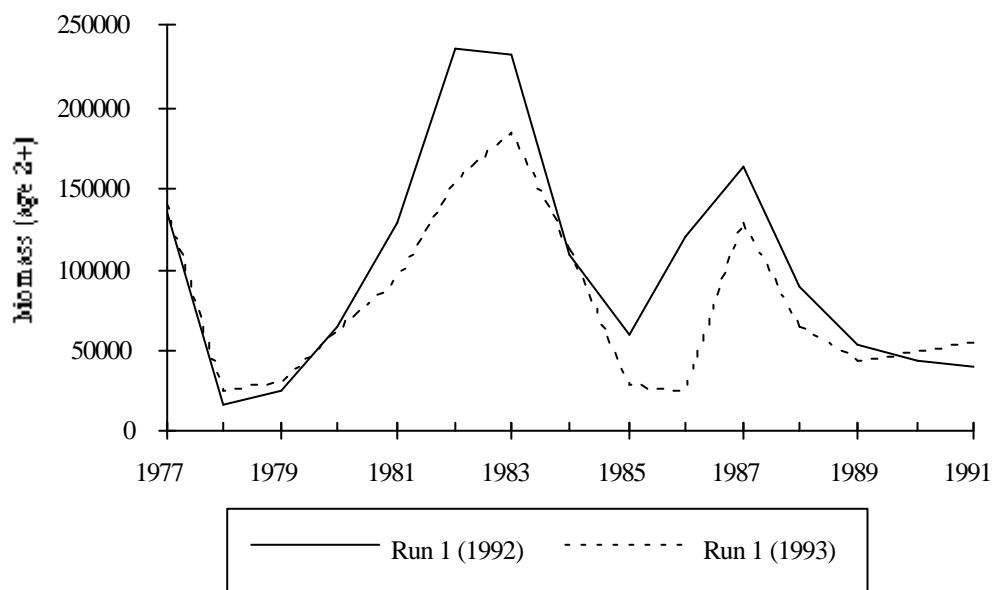


Figure 6: Run 1 of the VPA for *C. gunnari* in Subarea 48.3: results obtained in 1992 are compared with the results obtained at this year's meeting (1993).

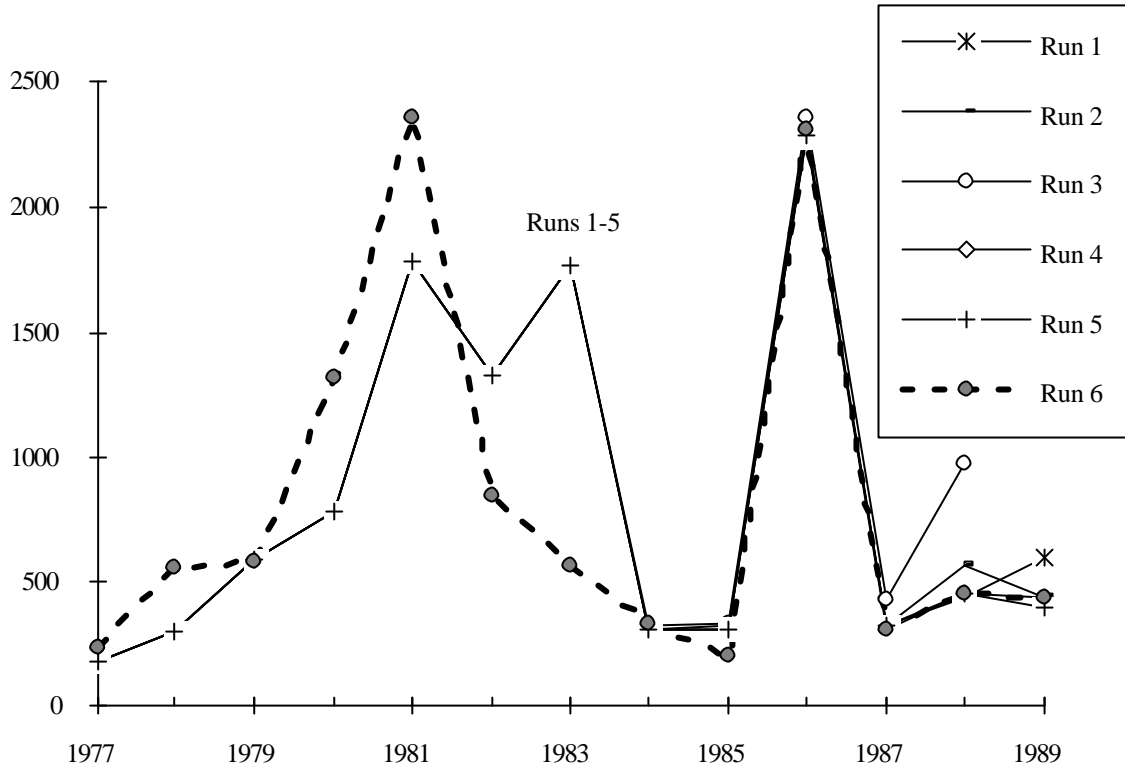


Figure 7: Recruitment of *C. gunnari* (1 year olds) from VPA runs.

Proportionality Coefficient (q) from the Surveys

6.44 There has been discussion at previous Working Group meetings suggesting that the q (the constant of proportionality between the index and absolute abundances⁶) of biomass estimates of *C. gunnari* from bottom trawl surveys is likely to be less than 1 (e.g., SC-CAMLR-IX, Annex 5, paragraphs 114 to 116). Average values of q by age varied between survey tuned VPA runs as indicated in Table 10.

Table 10: Average values of q by age for VPA runs on *C. gunnari*, Subarea 48.3.

Age	Run 1	Run 2	Run 4	Run 5	Run 6
2	0.42	0.21	0.46	1.0	0.46
3	0.85	0.28	0.84	1.35	0.84
4	0.61	0.29	0.61	0.82	0.61
5	0.37	0.24	0.51	0.38	0.51

⁶ Index = $q \cdot$ absolute abundance

6.45 Weighting the survey index by the inverse of the variance of the survey biomass estimate (Run 2) resulted in lower q s compared to unweighted runs, due to the severe down weighting of the large 1989/90 survey estimate. The effect of this down-weighting was therefore to increase estimated abundance in recent years compared to other survey tuned runs (Figure 5). Run 5 produced the highest estimates of q , with values ranging from 0.38 (age 5) to 1.35 (age 3). For Run 5 the survey index was standardised to 1 July to account for between-year differences in the size of the reported commercial catch taken between the start of the split-year and the time of the survey. These differences have been substantial: 10 500 tonnes, 19 900 tonnes and 21 356 tonnes in 1986/87, 1987/88 and 1988/89 respectively, but negligible in 1989/90 and 1990/91 (Parkes, 1992⁷). The Working Group therefore considered that the standardised index used in VPA Run 5 was the most realistic basis for tuning the analysis.

6.46 The precision of the estimates of q and F estimated by the VPA as indicated by the CV was of the order of 20 to 30% for the former and 40 to 50% for the latter. These figures were generally much lower than those from VPAs run at last year's meeting.

Stock Projections

6.47 The VPA terminated in 1990/91. Stock size for years beyond this must be projected by accounting for M , F and recruitment. The survey in January 1992 provides an independent estimate of relative stock size for the 1991/92 season (this was not used for tuning the VPA). The projection from the VPA (Run 5) was compared to this survey estimate, using the q from the VPA to adjust the latter to provide an estimate of absolute abundance. Recruitment for this projection was fixed as the mean from VPA Run 5 over the period 1976/77 to 1988/89. The total biomass of fish ≥ 2 years old from the adjusted survey was 51 000 tonnes and that from the VPA projection was 72 000 tonnes.

6.48 Figure 8 compares the age distribution of the VPA projection and the survey in 1991/92. The survey result is plotted both with and without the q adjustment. A similar figure was presented in last year's Working Group report (SC-CAMLR-XI, Annex 5, Figure 2). Concern was expressed at that meeting that the VPA was predicting a significantly greater proportion of 4 and 5 year old fish than was observed during the 1992 survey. The prediction from the revised VPA at this year's meeting was more in line with the 1992 survey, however, there is still a much larger proportion of 4 year olds in the VPA prediction than in the survey samples.

⁷ Parkes, G.B. 1992. Notes on the use of virtual population analysis for stock assessment of the mackerel icefish, *Champsocephalus gunnari* (Lönnerberg, 1906) in Subarea 48.3 for the 1990/91 and 1991/92 seasons. In: *Selected Scientific Papers, 1992 (SC-CAMLR-SSP/9)*. CCAMLR, Hobart, Australia: 49-79.

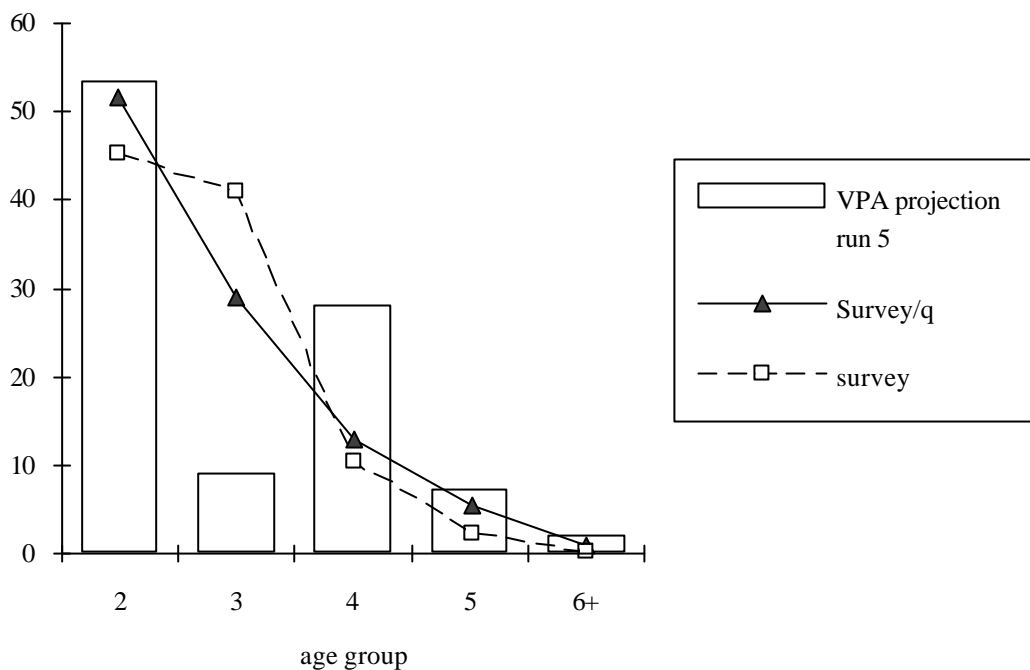


Figure 8: Comparison of age distributions of *C. gunnari* in 1992 derived from VPA projections and the 1991/92 survey.

6.49 The Working Group considered that the VPA based on the revised catch-at-age provides a more consistent picture than previous analyses, but there remained some problems in recent years, arising from the marked decline in abundance shown by the research survey in 1992 (SC-CAMLR-XI, paragraph 3.56), which was not explicitly taken into account by the VPA.

6.50 The VPA terminated in 1990/91, leaving three years between the most recent estimates from this source and the season for which an assessment is required (1993/94). The Working Group considered that using the VPA results for projecting forwards in time would be a risky method of estimating population status in 1993/94 because of the discrepancy indicated in Figure 8 and also the extra year required in the projection, which would increase the level of uncertainty (SC-CAMLR-XI, paragraph 3.59).

6.51 The results from the survey in January 1992 were used to provide a starting point for projections of population size to estimate an appropriate level of TAC in 1993/94. Two starting points were considered by the Working Group: the mean alternative survey biomass estimate (Table 7) adjusted using q at age from VPA Run 5 (Projection 1) and the lower confidence interval of this survey estimate, without the q adjustment (Projection 2).

6.52 The starting point for Projection 2 only used the survey biomass estimate from South Georgia and was not adjusted using the q from the VPA. The fishery, however, has operated in the past at both South Georgia and Shag Rocks. The biomass at Shag Rocks estimated from the survey in 1991/92 was of the order of 7% of the total for Subarea 48.3. This starting point therefore represents a slight underestimate of the biomass from the survey in 1991/92. The projection to 1993/94, however, includes two years of simulated recruitment. The Working Group did not feel that this had given rise to a significant underestimation of the TAC based on $F_{0.1}$ in Projection 2.

6.53 Recruitment was simulated according to the method used at last year's meeting (SC-CAMLR-XI, Annex 5, paragraph 6.59), using the mean and variance of \ln recruitment from VPA run 5 (850×10^6 individuals and 0.61 respectively). Confidence limits based solely on recruitment variability were estimated from 500 runs (a parametric bootstrap technique).

6.54 The results of these projections are presented in Table 11 and illustrated in Figure 9. The catch equivalent to $F_{0.1}$ (0.39, assuming $t_c=2$ years) in 1993/94 is estimated to be 35 000 tonnes in Projection 1 and 27 000 tonnes in Projection 2. There is considerable uncertainty around these estimates arising from recruitment variability, as indicated by the 95% confidence limits. In accordance with the approach adopted at last year's meeting the Working Group considered that the lower 95% confidence limits (20 800 and 13 200 for Projections 1 and 2 respectively) provided a range of possible TACs for the 1993/94 season.

Table 11: Biomass and yield projections for *C. gunnari*, Subarea 48.3.

	1991/92 Survey Back-calculated to 1 July	1992/93 Biomass	1993/94 Biomass	$F_{0.1}$ Yield	1994/95 Biomass
Projection 1:					
Upper 95% CL		20 3967	396 239	103 208	435 073
Median	63 327	97 243	133 157	34 683	124 185
Lower 95% CL		74 157	80 047	20 850	57 880
Projection 2:					
Upper 95% CL		174 573	370 496	96 503	434 498
Median	34 651	68 647	102 083	26 590	111 547
Lower 95% CL		44 500	50 713	13 209	40 753

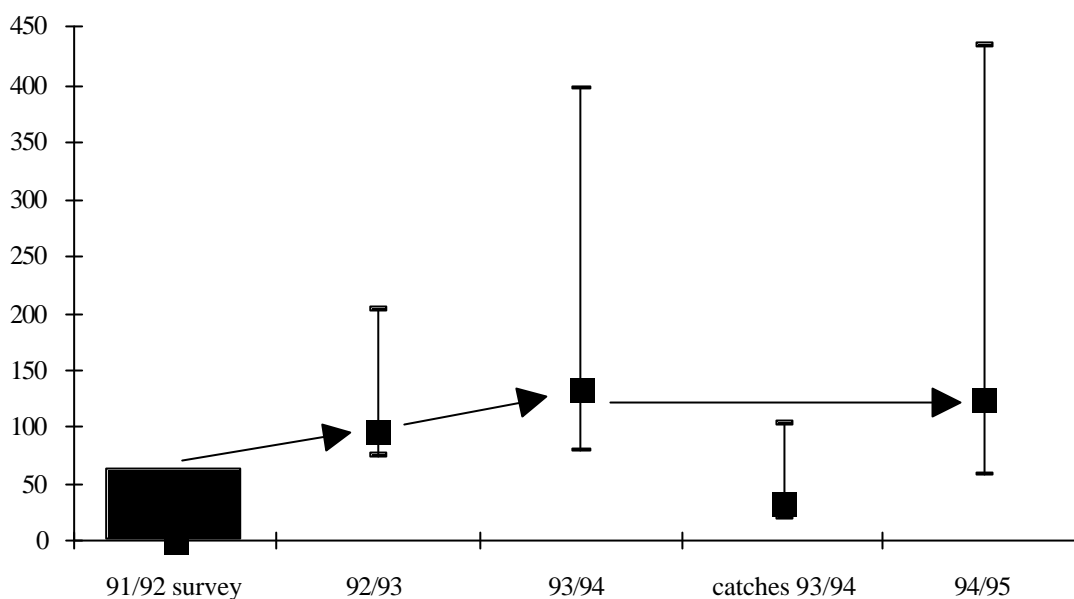


Figure 9: Biomass and yield projection for *C. gunnari* starting with the 1991/92 UK survey. Projection 1 from Table 11 is plotted.

By-catch Consideration

6.55 The by-catch of other finfish species in a fishery targeting *C. gunnari* was discussed at last year's meeting (SC-CAMLR-XI, Annex 5, paragraphs 6.66 to 6.74). The TAC of *C. gunnari* in Subarea 48.3 in 1992/93 was set on the basis of a simple multiple of the potential MSY of *Notothenia gibberifrons*, assuming a by-catch proportion of 16% in pelagic trawls targeting *C. gunnari*. The potential ceiling on the TAC of *C. gunnari* based on the by-catch of *N. gibberifrons* could remain the same as last year, as indicated in Table 12.

Table 12: Potential catch of *C. gunnari* where the by-catch of *N. gibberifrons* is limited to 1 470 tonnes.

Fishery	By-catch Percentage by Weight	By-catch Limit	Potential Ceiling of <i>C. gunnari</i> catch
Bottom trawl fishery	16.7	1 470	8 800
Pelagic trawl fishery	16	1 470	9 200
Pelagic trawl fishery	3	1 470	49 000

Management Advice

6.56 Given the uncertainty surrounding the current status of the exploitable stock of *C. gunnari* in Subarea 48.3, the Working Group considered that a conservative approach to management is appropriate in the immediate future.

6.57 The Working Group recommended that a scientific survey to estimate the abundance of *C. gunnari* and other species be carried out during the 1993/94 season.

6.58 The Working Group considered a number of possible TAC levels (Table 13) and recommended two options for possible levels of TAC for the 1993/94 season.

- (i) The TAC for *C. gunnari* should remain at the same level as last year (i.e., 9 200 tonnes), because no new information on the by-catch of *N. gibberifrons*, *Chaenocephalus aceratus* and *Pseudochaenichthys georgianus* in pelagic trawls targeting *C. gunnari* was available to the Working Group to revise the by-catch figures estimated at last year's meeting (SC-CAMLR-XI, Annex 5, paragraphs 6.66 to 6.74).
- (ii) Provided it would be possible to monitor continuously the by-catch of other species for which Conservation Measures apply in the fishery on *C. gunnari*, for example, by means of an Inspector on board, an increase of the TAC to 13 000-21 000 tonnes (lower 95% confidence limits for Projections 1 and 2 respectively) could be envisaged.

Table 13: TAC levels and assumptions for *C. gunnari* in Subarea 48.3.

<i>C. gunnari</i> TAC (tonnes)	Assumptions/Rationale
21 000	Lower 95% confidence limit of Projection 1
13 000	Lower 95% confidence limit of Projection 2
9 200 - 21 000	Pelagic trawl fishery only Maximum by-catch of <i>N. gibberifrons</i> = 1 470 tonnes (SC-CAMLR-X, Annex 6, Table 16) and <i>N. gibberifrons</i> ≤16% of <i>C. gunnari</i> catch
8 800	Bottom trawl fishery only <i>C. gunnari</i> catch = 6 x maximum by-catch of <i>N. gibberifrons</i> (1 470 tonnes)

6.59 The Working Group stressed that biological information and information on by-catch from any commercial trawl fishery in Subarea 48.3 during 1993/94 is of vital importance for future assessments. The Working Group felt that the effort and biological reporting system introduced in 1992 (Conservation Measure 51/XI) should be maintained.

6.60 The Working Group recommended the closure of directed fishing for *C. gunnari* between 1 April 1994 and the end of the Commission meeting in 1994 (as in the 1992/93 season; Conservation Measure 52/XI) to protect spawning.

6.61 The Working Group noted that a pelagic trawl fishery in Subarea 48.3 would allow both a higher TAC of *C. gunnari* than bottom trawling (Table 13) and would also avoid the possible adverse affects of bottom trawling on the benthic community. It was therefore concluded that the ban on bottom trawling (as in Conservation Measure 20/IX) should be maintained.

6.62 No new information was presented to the Working Group concerning *C. gunnari* mesh selectivity. The Working Group therefore had no reason to propose changes to the 90 mm mesh size regulation (Conservation Measure 19/IX).

Notothenia rossii (Subarea 48.3) - Management Advice

6.63 No new information was available to the Working Group on this stock. Accordingly, the Working Group reiterated the advice offered in 1992 that in view of the likely low stock size of *N. rossii* at present, all Conservation Measures for this species should remain in force (Conservation Measures 2/III, 3/IV and 50/XI).

Notothenia gibberifrons, *Chaenocephalus aceratus* and *Pseudochaenichthys georgianus* (Subarea 48.3) - Management Advice

6.64 No new information was available to the Working Group on these stocks. Accordingly, the Working Group reiterated the advice offered in 1992 that stocks of *N. gibberifrons* and *C. aceratus* have apparently recovered to a high proportion of their initial levels. *P. georgianus* may not have recovered to the same extent. A re-opening of the fishery on these species might be considered. All three species have been taken in quantity only by bottom trawling in the commercial fishery. None of these species can be taken without a significant by-catch of other species. The Working Group recommended that a directed fishery on these three species should remain prohibited because the potential yields could be entirely taken as by-catch in the *C. gunnari* fishery (Conservation Measures 48/XI and 50/XI).

Patagonotothen guntheri (Subarea 48.3) - Management Advice

6.65 No new information was available to the Working Group on this stock. Accordingly, the Working Group reiterated the advice offered in 1992 that the present Conservation Measure should be retained until information which would allow a re-assessment of the stock to be made becomes available (Conservation Measure 48/XI).

Notothenia squamifrons (Subarea 48.3) - Management Advice

6.66 No new information was available to the Working Group on this stock. Accordingly, the Working Group reiterated the advice offered in 1992 that in the absence of any information which would allow an assessment of the stock to be made, the Conservation Measures presently in force should be retained (Conservation Measures 48/XI and 50/XI).

Electrona carlsbergi (Subarea 48.3)

6.67 No new information was available to enable the Working Group to assess this stock.

6.68 The Commission has adopted the use of $F_{50\%SSB}$ (fishing mortality for which the spawning-biomass-per-recruit would be reduced to 50%) as its policy in managing this fishery. At the present meeting it was noted that myctophids in general, are important prey for many predators in the sub-Antarctic pelagic ecosystem (WG-FSA-93/17 and 18; see paragraph 5.20). The choice of TACs based on $F_{50\%SSB}$ rather than $F_{0.1}$ is even more appropriate in this case, since one of the management objectives should be to ensure sufficient escapement in the fishery to avoid serious consequences to dependent predators. It was suggested that a higher level of escapement from the fishery may be required in some circumstances to meet this management objective.

Management Advice

6.69 The Working Group noted the difficulty in providing advice based on data and assessments which are no longer current. The assessments provided in 1991 are now even more out of date than they were in 1992.

6.70 On the basis of the known biological characteristics of the stock, the TAC of 245 000 tonnes set in Conservation Measure 53/XI for *E. carlsbergi* in Subarea 48.3 may be

sustainable. However, any fishery would be based on a stock for which the age structure and biomass are unknown, and in the light of this uncertainty a precautionary TAC should be set below 245 000 tonnes. The species composition and biological characteristics of the by-catch are also unknown. Therefore the Working Group recommends that a new biomass survey be conducted if any fishery on this species is resumed.

SOUTH GEORGIA (SUBAREA 48.3) - CRABS

6.71 Fishing for crabs in Subarea 48.3 was undertaken by one US vessel, *Pro Surveyor*, between 10 July and 12 November 1992.

6.72 Two species (*Paralomis spinosissima* and *P. formosa*) were caught with *P. spinosissima* being the targeted species. A description of the fishery was provided in SC-CAMLR-XI, Annex 5, paragraphs 6.1 to 6.7.

6.73 Large uncertainties are associated with estimating the standing stock of these species (SC-CAMLR-XI, paragraph 4.15). Consequently, the Commission, at its last meeting, adopted a precautionary approach to the development of this fishery and established Conservation Measure 60/XI as an interim management approach pending the development of a longterm management plan for the fishery (CCAMLR-XI, paragraph 9.52).

6.74 The Commission also requested that the Scientific Committee develop a Longterm Management Plan for the Exploratory Crab Fishery and conduct a workshop to begin this process and to advise on data to be reported from this exploratory fishery (CCAMLR-XI, paragraphs 9.48 to 9.50).

Workshop on the Longterm Management of the Antarctic Crab Fishery

6.75 The Workshop was convened by Dr R. Holt (USA) and took place between 26 and 28 April 1993 at the Southwest Fisheries Science Centre, La Jolla, USA. Its terms of reference are set out in SC-CAMLR-XI, paragraph 4.17 and the Workshop report is attached as Appendix E.

6.76 The Working Group recognised the substantial input of data and practical experience provided by the single USA vessel, *Pro Surveyor*, operating in the fishery at this time. Such input was used extensively at the Workshop. The Working Group used the Workshop report as a basis

for the following discussion and recommendations on the development of a longterm approach to the management of this fishery.

Population Characteristics

6.77 In spite of the detailed information provided by the exploratory survey, very little life history, ecological or demographic data on *Paralomis* spp. are available (see Appendix E, paragraphs 2.1 to 2.11). A summary of research topics, data needs and their respective priorities for acquisition identified by the Workshop is presented in Table 1 of the Workshop report.

6.78 The extent and potential impact of parasitic infestation was considered by the Workshop at some length (Appendix E, paragraphs 2.12 to 2.20) and the Working Group agreed that host-parasite interactions in crab stocks subject to fishing should be more extensively modelled in order to assess the potential impact on demographic characteristics and stock yield(s) more effectively.

Stock Assessment

6.79 Various methods have been used to assess other crustacean fisheries and the Workshop identified those which may be applicable to the *Paralomis* fishery. With the exception of yield-per-recruit assessment, the data requirements, assumptions and outputs of these methods were compiled by the Workshop (Appendix E, paragraphs 3.1 to 3.31 and Table 2).

6.80 The Workshop specifically recommended investigations of the application of stock assessment techniques (Appendix E, paragraph 3.1).

6.81 In response to this recommendation, WG-FSA-93/23 describes the application of four production models to a time series of daily catch and effort data from the 1991/92 crab fishery. Preliminary estimates of abundance, catchability, and daily recruitment rate were made in the paper. Using parameters from the best-fitting model, alternative TACs were evaluated for a fishery with spatial and temporal scales similar to those of the 1991/92 fishery. The possible TACs were evaluated under the assumption that an equilibrium catch could be estimated by summing daily net input of crabs to the fishery. Since movement (immigration) was likely to be the most significant input to the 1991/92 fishery, the Working Group noted that this assumption would result in the estimate of an unsustainable TAC.

6.82 The Working Group recognised that the application of production models to analyse catch/effort data for the crab fishery was an improvement over the previous efforts (SC-CAMLR-XI, Annex 5, paragraph 6.11). However, the method was constrained by lack of data outside the small area fished during the 1991/92 season. A further constraint was the lack of knowledge on immigration into the fishing area. In the worst case, the catch rates in the fishing area could remain constant until the number of commercially-sized male crabs located outside the fishing area were substantially reduced.

6.83 Given these constraints, the Working Group agreed that it would not be appropriate at this time to estimate a TAC for the 1993/94 fishery from the analysis in WG-FSA-93/23. Further development along these lines was encouraged.

Developing Longterm Approaches to Management

6.84 The Commission has noted 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).

6.85 The Workshop discussed a number of options for the interim management of the crab fishery while the longterm approach is developed (Appendix E, paragraphs 4.1 to 4.6).

6.86 It had identified the following possible catch controls: (i) indirect controls on catch through regulated minimum legal size, seasonal closures and prohibitions on harvesting females; and (ii) direct controls through catch or effort limits (Appendix E, paragraph 4.1).

6.87 The Workshop had noted that the combination of direct and indirect controls can mean that catch limits need not be set precisely or conservatively, since the indirect controls should protect the stock from reproductive failure in the short-term even if the catch is too high to be sustainable in the longterm. However, if the catches exceed the longterm sustainable level, the fishery will be affected by having greater sensitivity to variations in recruitment, lower average catch rates, and greater proportion of the catch with new shells and thus low meat quality (Appendix E, paragraph 4.4).

6.88 The current management approaches adopted at CCAMLR-XI (Conservation Measure 60/XI) include both direct and indirect controls on harvesting. The Working Group agreed that these should continue to be applied in management of the crab fishery. In this context, it

considered further measures that could be applied as well as the requirements for a longterm management plan.

6.89 Specific suggestions for additional measures were identified by the Workshop and subsequently endorsed by WG-FSA as having high priority for investigation. These include:

- (i) the use of time-release or biodegradable devices to reduce the effects of ghost fishing should pots be lost from a line, should be considered;
- (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.

6.90 The Working Group agreed that the development of a management approach for the crab fishery should be based on the following actions:

- (i) design of methods, taking into account limitations of resources available, for acquiring data necessary for assessments of:
 - (a) target species,
 - (b) the strengths of multi-species interactions;
- (ii) evaluation (using simulations where appropriate) to determine whether the methods are likely, in principle, to achieve their objectives; and
- (iii) development of a feedback management framework within which the methods and assessments will be used for providing advice to the Scientific Committee and Commission (CCAMLR-X, paragraph 6.13). As part of this process the methods used for data acquisition should be reviewed on a regular basis.

6.91 The Working Group endorsed the Workshop recommendation that, for all the methods available for assessing crab stocks, estimates of uncertainty of current stock status should be made

and sensitivity to underlying assumptions and data quality should be explored (Appendix E, paragraph 3.1).

6.92 The Working Group noted that data for stock assessment are currently limited to those obtainable during commercial fishing operations. On the basis of this restriction and the need to assess the suitability of the different stock assessment methods to this type of fishery, the Working Group recommends that depletion- and production-based methods should be considered in more detail at this stage.

6.93 WG-FSA-93/22 proposes a refined method for assessing *Paralomis* stocks using a depletion experiment around South Georgia conducted within a commercial fishery. The strategy was drawn up in collaboration with a commercial fishing captain and was designed to answer specific, *a priori* questions about the population dynamics of *P. spinosissima*, and consisted of three phases to be conducted over a period of two fishing seasons:

Phase 1 - survey of the crab distribution around South Georgia at the start of the first fishing season by fishing in designated blocks. After completion, normal fishing operations would continue until the TAC for that season was attained or the vessels voluntarily left the fishery.

Phase 2 - series of depletion experiments conducted in local areas to start at the beginning of the second fishing season. After Phase 2 normal fishing operations would be conducted.

Phase 3 - fishing effort would be redirected to the local areas depleted during Phase 2. This would occur towards the end of the second fishing season. It would commence just prior to cessation of the fishery resulting from the TAC being attained or by each vessel wishing to voluntarily leave the fishery.

6.94 In order to maximise the potential output of the experiment, WG-FSA-93/22 also noted that all phases of the experiment should be conducted by all vessels entering the fishery, that they be required to participate independently in the experiment and that the catches should come from the TACs for the respective seasons.

6.95 The Working Group agreed that this type of experimental approach was necessary for obtaining the best possible data required for making assessments. WG-FSA-93/22 identified a number of objectives that could only be met using this approach. These were endorsed by the Working Group:

- (i) to elucidate large-scale distribution patterns, how these change with time, and the numbers and locations of centres of aggregation;
- (ii) to determine how trends in catchability and movement of crabs affect length-frequency distributions and estimates of local abundance;
- (iii) to determine the effects of harvesting on the dynamics of local populations and the importance of movement, recruitment and parasitism; and
- (iv) to assess the comparative values in the assessment of crab stocks of data arising from normal commercial fisheries operations with those derived from the more structured experimental approach.

6.96 In addition, the Working Group recognised that the proposal put forward in WG-FSA-93/22 to integrate the experimental and commercial fisheries was a useful approach while resources for independent stock assessment are limited. Also, the Working Group agreed that such integration must still allow vessels to fish in a rational manner.

6.97 The analyses that can be attempted with the data from the experimental fishery are outlined in Table 14.

Table 14: Potential analyses using data collected during the experimental phase of the crab fishery.

Experimental Phase	Analyses with One Vessel	Additional Analyses with More than One Vessel
Phase 1 -- "Survey"	<ul style="list-style-type: none"> • Spatial analysis of variance components in CPUE and biological data. • Mapping general boundaries of areas of high abundance (may allow extrapolation of localised estimates of abundance). 	<ul style="list-style-type: none"> • Change-in-ratio estimates of abundance. • Index-removal estimates of abundance. • Mapping crab distribution patterns over time (may allow model construction of spatial dynamics).
Phases 2/3 -- "Depletions"	<ul style="list-style-type: none"> • Depletion estimates of local abundance (Leslie-De Lury methods). • Estimation of movement/recolonisation rates. 	<ul style="list-style-type: none"> • Analysis of variance components in CPUE data associated with vessels that have different fishing powers.
Normal Operations	<ul style="list-style-type: none"> • Traditional analyses of catch and effort and biological data from the fishery. 	

6.98 In line with the general objectives for developing a longterm management plan, the Working Group agreed that an important consideration for the implementation of Phase 1 should be to collect data necessary for evaluating the methods to be employed in Phases 2 and 3. Simulations are required to evaluate the power of the experimental design to address the objectives specified in paragraph 6.95. The Working Group encouraged Members to undertake this evaluation in the intersessional period in order that the experimental design for Phases 2 and 3 could be refined, if required, as soon as possible.

6.99 In this context, the Working Group recommends that, if possible, Phase 1 be conducted in such a way as to provide useful information on stock abundance and distribution in relation to depth strata within the designated blocks around South Georgia. In addition, the commercial fishing operators are encouraged, after Phase 1 in the first fishing season, to concentrate catches in two squares (26 n miles² each) for 50 000 pot hours to determine if it is possible to deplete local populations in the time designated for such manipulations in Phase 2.

6.100 For the evaluation of Phases 2 and 3, the Working Group suggests the following points for consideration:

- (i) Is there value in monitoring a square with no fishing (control) for each experimental depletion square? Such controls could be useful for determining the magnitude of effect of the experimental fishing on stock size. How many replicates are required to be able to discriminate between depletion and control treatments if an effect of depletion occurs? How much effort needs to be expended assessing the control squares?
- (ii) What size of area surrounding the experimental squares is required in which commercial fishing should be excluded in order that the experimental fishing areas are kept independent of effects that may arise from the commercial fishery? Also, what configuration of experimental, control and commercially fished areas should be employed for cost-effective experimental and commercial operations?
- (iii) What magnitude of depletion is required for adequately addressing the objectives? How long should a square be fished to ensure a significant depletion has occurred?
- (iv) Should Phases 1, 2 and 3 recur in order to maintain adequate stock assessments in a longterm management plan? If so, at what frequency?
- (v) What method should the Secretariat use to advise when Phase 3 should begin such that the TAC will not be exceeded and Phase 3 will be completed.

6.101 The Working Group identified that stock assessments independent of the fishery are important for determining the utility of data from the commercial operations in assessing the status of stocks. Consequently, the Working Group recommends that surveys of crab stocks independent of commercial fishing operations using trawls or video transects should be given a high priority.

6.102 Data required for stock assessments identified by the Workshop (Appendix E, paragraphs 5.1 to 5.18) and agreed by the Working Group are:

Catch and Effort Data:

Cruise Descriptions

cruise code, vessel code, permit number, year.

Pot Descriptions

pot shape, dimensions, mesh size, funnel attitude, number of chambers, presence of an escape port.

Effort Descriptions

date, time, latitude and longitude of the start of the set, compass bearing of the set, total number of pots set, spacing of pots on the line, number of pots lost, depth, soak time, bait type.

Catch Descriptions

retained catch in numbers, by-catch of all species, incremental record number for linking with sample information.

Biological Data:

For these data, crabs are to be sampled from the line hauled just prior to noon, by collecting the entire contents of a number of pots spaced at intervals along the line so that at least 35 specimens are represented in the subsample.

Cruise Descriptions

cruise code, vessel code, permit number.

Sample Descriptions

date, position at the start of the set, compass bearing of the set, line number.

Data

species, sex, length of at least 35 individuals, presence/absence of rhizocephalan parasites, record of the destination of the crab (kept, discarded, destroyed), record of the pot number from which the crab comes.

6.103 The Workshop discussed data reporting and the spatial and temporal scales for which data should be reported (Appendix E, paragraphs 5.11 to 5.18). No recommendation on these issues was provided by the Workshop. The Working Group agreed that haul-by-haul data are important for effective development and evaluation of longterm management plans but recognised that these data may be confidential. The Working Group noted that the issue of industrial confidentiality associated with the provision of very fine-scale catch information (Appendix E, paragraph 5.13) is an issue of policy on which the Commission needs to provide guidance.

Management Advice

6.104 Topics for high priority for future research are identified in paragraph 6.89 and should be investigated as soon as possible.

6.105 The experimental fishery design outlined in paragraph 6.93 should be instituted from 1993/94 season onwards:

- (i) every vessel participating in the fishery should undertake sampling according to the experimental design, regardless of what year they enter, until the experimental design is modified or terminated by the Commission;
- (ii) catches from the experimental fishery should be considered as part of any prevailing TAC; and
- (iii) the experimental fishery will be subject to any other Conservation Measures in force.

6.106 The current TAC of 1 600 tonnes and other measures contained in Conservation Measure 60/XI revised in light of this report should remain in force at this time.

6.107 The data required for collection from the fishery are detailed in paragraph 6.102 and these 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

6.108 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. Accordingly, the Working Group reiterated the advice offered in 1992 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 57/XI and 58/XI).

STATISTICAL AREA 58

6.109 In 1992/93 fishing took place only for *D. eleginoides* in Division 58.5.1. The catch comprised 2 722 tonnes (Table 15) of which 1 896 tonnes were taken by Ukraine and 826 tonnes were taken by France. The bulk of the catch (2 630 tonnes) was caught in the northern sector by trawling. Only 92 tonnes were caught in the western sector by a single longline vessel.

6.110 No fishing or research activities were reported from any of the other divisions of Statistical Area 58. The Working Group was unable to provide new assessments on the fish stocks of Ob and Lena Banks and off the coast of the Antarctic continent.

Table 15: Total catches by species and subarea in Statistical Area 58. Species are designated by abbreviations as follows: ANI (*Champocephalus 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 58.5	WIC 58.4	TOP				NOR			NOS			ANS		MZZ			SRX 58.5.1
	58	58.5			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	-			1742		4370	11308			239			
1981		1122	2			16	40	-		217	7924		2926	6239			375	21		
1982		16083				83	121	-		237	9812		785	4038			364	7		
1983		25852				4	128	17			1829		95	1832	50		4	17	1	
1984		7127				1	145	-		50	744		203	3794	229			611 ¹	17	
1985		8253		279		8	6677	-		34	1707		27	7394		966		11	7	
1986		17137		757		8	459	-		-	801		61	2464		692			3	
1987		2625		1099		34	3144	-		2	482			930	1641		28			
1988		159		1816		4	554	488		-	21			5302	41		66			

Split-Year	ANI		WIC 58.4.2	TOP			NOR 58.5.1	NOS		ANS	
	58.5.1	58.5.2		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 ²	-	-	-	1944	-	287	575	-	-	-
1992	44	3	-	-	7492 ³	-	-	-	1	-	-
1993	-	-	-	-	2722	-	-	-	-	-	-

1 Mainly *Rajiformes spp.*

2 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.

3 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.

Kerguelen Islands (Division 58.5.1)

Notothenia rossii and *Notothenia squamifrons* (Division 58.5.1) - Management Advice

6.111 No new data on these species were submitted in the last year. The existing prohibition of fishing for *N. rossii* should remain in force. Given the low stock size of *N. squamifrons* estimated in previous assessments, the fishery on *N. squamifrons* should remain closed.

Dissostichus eleginoides (Division 58.5.1)

Life History

6.112 WG-FSA-93/15 summarised the life cycle of *D. eleginoides* at the Kerguelen Islands. Ichthyoplankton surveys provide evidence of winter pelagic development of eggs offshore and on the shelf zone. After a juvenile phase of several years on the shallower shelf, fish migrate progressively to the shelf break. Here the size range of fish is depth dependent. Length compositions collected from the commercial catches from 1984/85 to 1991/92 show no consistent trend, but rather suggest that different depth strata have been exploited in different years. There appeared to be a trend towards fishing in deeper strata in recent years.

Development of the Fishery

6.113 WG-FSA 93/15 provided a description of the course of the fishery. A directed fishery on *D. eleginoides* has been conducted since 1984/85 mainly by trawling. In contrast to South Georgia, longlining was not introduced before 1991/92, after some trials had been carried out in 1990/91.

6.114 Three separate fishing grounds have been identified (Figure 10):

- the western sector from 48°10'S to 50°10'S and 67°00'E to 68°10'E;
- the northern sector from 47°00'S to 47°30'S and 69°00'E to 69°40'E;
- the northeastern sector from 48°05'S to 48°25'S and 71°00'E to 71°20'E.

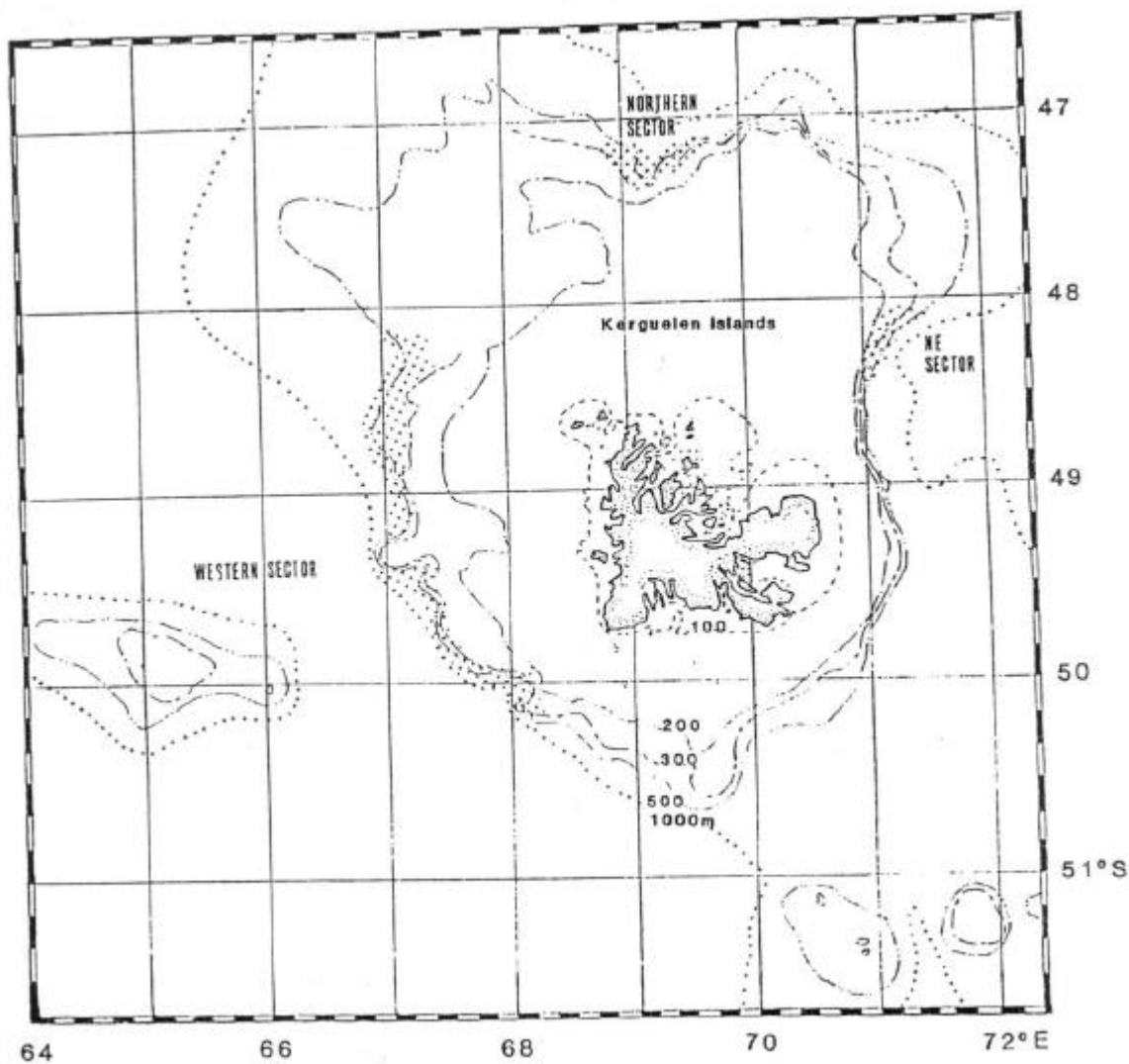


Figure 10: Fishing grounds (geographical sectors) of *D. eleginoides* around the Kerguelen Islands.

6.115 The western sector was the first fishing ground to be exploited (1984/85) and was fished by trawlers in the depth range 300 to 600 m until 1991/92. Longlining has since replaced trawling in this area, exploiting a similar and slightly deeper depth range (350 to 640 m).

6.116 The largest annual catch of 6 465 tonnes was taken in 1984/85 when the fishing ground was discovered. From 1984/85 to 1992/93, a total catch of 14 317 tonnes has been reported from the western sector, including 903 tonnes (6.3%) taken by longlining.

6.117 The northern sector was first fished in 1990/91 after some experimental fishing in 1989/90. A similar depth range to the western sector of 300 to 600 m is being exploited by trawling. The

highest annual catch of 6 379 tonnes was taken in the 1991/92 season. From 1990/91 to 1992/93, a total catch of 10 505 tonnes has been reported from the northern sector.

6.118 Based on the difference in catch rates between the western and northern sectors, there are believed to be at least two separate stocks which should be analysed separately (WG-FSA-93/15). From 1992/93 the western and northern sectors have been subject to catch and effort limitations.

6.119 The northeastern sector has not yet been exploited on a commercial scale.

Assessment of Western Stock

6.120 Two surveys of the Kerguelen area were completed in the summers of 1986/87 and 1987/88. The biomass in 1988 was estimated to be 27 200 tonnes following restratification of the survey area (SC-CAMLR-VIII, Appendix 10). Of this total biomass, 19 000 tonnes were estimated to be in the western sector. However, it appears that the main fishing ground discovered in the northern sector was not included in these surveys and therefore stock size is unknown for this area.

6.121 The length frequency of the fish taken in the 1988 survey on the western grounds shows a restricted size distribution mainly between 50 and 110 cm (Duhamel, 1993⁸, Figure 18). The total biomass of the western *D. eleginoides* stock is much larger than the survey estimate, which represents the biomass in the age groups from about 4 to 12 years only.

6.122 The trawl fishery on the western grounds has mainly taken fish in the size range from 35 to 120 cm (WG-FSA-93/15). However, very few fish over 110 cm were taken, although the mean size has increased as deeper fishing grounds have been explored. It is assumed that the larger fish are not vulnerable to the trawl fishery and may live in deeper water. Longline catches in the last few years in the same area as the trawl fishery have included larger fish over 140 cm but have been dominated by the medium size range from 90 to 100 cm.

⁸ Duhamel, G. 1993. Distribution, abondance et principales caractéristiques biologiques des espèces de la ZEE des îles Kerguelen. In: Duhamel, G. (Ed.). *Les Rapports des campagnes à la mer: Campagnes SKALP 1987 et 1988 aux îles Kerguelen. Les Publications de l'Institut Français pour la Recherche et la Technologie Polaires*, 93-01: 194-251.

Yield Calculations

6.123 The following assumptions were made to estimate longterm sustainable yields:

- (i) the unexploited biomass of *D. eleginoides* in the age range 4 to 12 years in the western stock was taken to be 29 000 tonnes. This is based on the survey estimate of 19 000 tonnes plus the sum of the catches in the area from 1984/85 to 1986/87;
- (ii) natural mortality (M) was taken to be 0.1;
- (iii) fish from 4 to 12 years were considered vulnerable to the trawl fishery, but younger and older fish were not considered to suffer fishing mortality; and
- (iv) fish growth ($L_8=214$ cm, $K=0.055$, $t_0=0.039$) and length/weight relationship ($a=0.682 \cdot 10^{-5}$ and $b=3.072$) followed the pattern described in WG-FSA-92/9.

YPR Model

6.124 Based on growth and mortality rates in the population, the biomass of *D. eleginoides* in the age range 4 to 12 years in an unexploited population makes up 15% of the total stock biomass. Therefore the unexploited population would have been about 190 000 tonnes.

6.125 The $F_{0.1}$ for the fishery was 0.151, which corresponded to a catch/biomass ratio of 13.3% of the fish in the age range 4 to 12 years. The $F_{0.1}$ yield was 1 820 tonnes based on an equilibrium biomass of 47.3% of the unexploited biomass (29 000 tonnes). However, at this exploitation rate the spawning biomass was reduced to only 28% of the unexploited spawning stock biomass. This was regarded as too low a proportion. Therefore yield was estimated for $F_{50\%SSB}$ (fishing mortality at which the spawning stock biomass was half the unexploited level). At this value of F (0.08) longterm equilibrium yield from the western stock based on the deterministic YPR model was 1 400 tonnes. This represents a catch/biomass ratio of 7.3% of the fish in the age range 4 to 12, with the stock size at 66% of the unexploited abundance.

Sensitivity Analysis

6.126 To take account of the uncertainty associated with the yield estimated above, sensitivity to three of the assumptions listed above was considered.

- (i) The unexploited biomass was varied between 25 000 and 35 000 tonnes. This resulted in a proportional change in the yield, ranging from 1 210 tonnes to 1 690 tonnes.
- (ii) Natural mortality was varied between 0.05 and 0.15. The yield was not very sensitive to M changes and varied between 1 390 tonnes (M=0.05) and 1 420 tonnes (M=0.15).
- (iii) The range of ages at which the fish are vulnerable to the trawl was extended to between 4-14 and 4-16 years. The yields dropped with increased age range to 1 170 tonnes (4 to 14 years) and 1 020 tonnes (4 to 16 years).

Assessment of Northern Stock

6.127 The history of the fishery has been similar to that of the first few seasons in the western grounds. The mean and range of lengths of fish caught are very similar to those from western grounds. Initially, smaller size classes were caught, but mean size increased as deeper grounds were exploited. Catch-per-unit-effort in the northern area has been higher than for equivalent stages of exploitation in the western sector, ranging between 2.87 and 5.04 tonnes/hour for French trawlers and 1.67 and 3.22 tonnes/hour for Ukrainian trawlers. As yet the time series is too short to indicate the effects of fishing on the stock. Catch rates have increased in the fishery as knowledge of the distribution and depth range of the fish has improved (WG-FSA-93/16). The longterm sustainable yield is unknown.

Management Advice

6.128 The Working Group noted that there is some evidence for at least two stocks of *D. eleginoides* in this area and agreed that they should be managed separately. Although there is information available for the fishery in the western sector since 1984/85, a detailed stock assessment was not possible. No assessment was attempted for the northern sector.

6.129 Based on YPR considerations, the sustainable fishing rate which maintained a spawning stock biomass of 50% of the unexploited level was determined. As this fish is slow growing, sustainable yield is low. Using a biomass estimate of the western stock from the 1988 trawl survey

and the history of catches from 1984/85, the unexploited stock size was determined. A longterm sustainable yield of 1 400 tonnes was estimated for the western stock.

6.130 It is likely that the western spawning stock biomass is still above 50% of the unexploited level, based on the catches reported since 1984/85. The fishery in this area has more recently been carried out by longlining. This could increase the sustainable yield above 1 400 tonnes if larger fish were taken in the fishery.

6.131 The status of the northern stock is unknown. Over 6 000 tonnes was taken in 1991/92, but the impact of these catches cannot be determined. A precautionary approach should be taken in setting catch levels to prevent the spawning stock size falling to low levels before the stock has been adequately assessed.

6.132 The Working Group considered the type of information required to assess these stocks, in addition to the biological and fishery data already being collected. For depletion methods, catch and effort data on a haul-by-haul basis within small areas would be required. Trawl surveys of the whole stock could also provide indices of abundance to model the stock dynamics and sustainable yield.

Champtocephalus gunnari (Division 58.5.1)

Kerguelen Plateau

6.133 No commercial fishing was reported for this species in Division 58.5.1.

6.134 In the past, the Working Group has been able to estimate stock sizes for *C. gunnari* from 1982 to 1992 using cohort analysis (SC-CAMLR-X, Annex 6, Figure 20). In order to complete its understanding of the fishery the Working Group has requested biological data from the fishery prior to 1980 (SC-CAMLR-XI, Annex 5, Appendix D). A paper by V. Gerasimchuk (1993)⁹, available to the Working Group this year, provided figures of size composition of the *C. gunnari* fishery collected by 'search and scientific research vessels' from 1968/69.

6.135 These length compositions show that in 1971 and 1972 a number of ages (predominantly age 2 to 4) were taken, but from 1973 the fishery was dominated by a number of strong cohorts

⁹ Gerasimchuk, V.V. 1993. States of stocks *Champtocephalus gunnari* on the shelf of the Kerguelen Islands. In: Duhamel, G. (Ed). *Les Rapports des campagnes à la mer: Campagnes SKALP 1987 et 1988 aux îles Kerguelen. Les Publications de l'Institut Français pour la Recherche et la Technologie Polaires*, 93-01: 266-276.

appearing singly in the fishery at three year intervals. The first of these was spawned in 1970 and taken in small numbers in 1972 before dominating the fishery as 2 year olds in 1973. In several years (1975, 1978, 1981 and 1987) some old-cohort age 4+ fish were caught in addition to age 1+ fish from a more recent cohort. In 1971 and 1972 the fishery took place over the northwest, north and northeast edges of the Kerguelen plateau but gradually moved to be concentrated to the east and northeast of the island.

6.136 Although these length frequency distributions give useful information about the stock, information about their origin and the state of the early fishery was not considered sufficient to enable a calculation of historical extensions to the cohort analysis performed by the Working Group in 1991 (SC-CAMLR-X, Annex 6, paragraph 7.241). They have been used, however, to create approximate splits of the catch tonnages from 1971 for illustrative purposes in Figure 11.

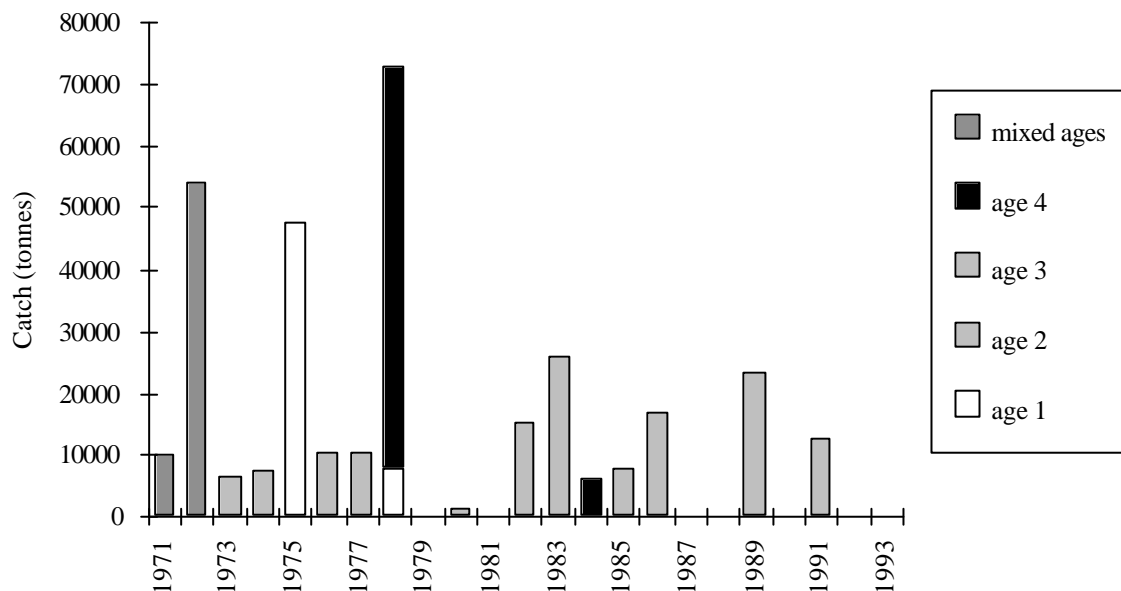


Figure 11: Catches of *C. gunnari* on the Kerguelen plateau. Note: Small, unquantifiable catches of age 4 fish were taken in 1973 and 1975. The area was closed in 1979.

6.137 This figure, together with Figure 20 in the 1991 report (SC-CAMLR-X, Annex 6), contributes to evidence that the 1982, 1985 and 1988 cohorts have not been as large as earlier cohorts. The 1988 cohort appears to have been especially small, although last year the Working Group was unclear whether the extremely low catch of age 3 fish in 1992 was due to lack of fish or low effort.

6.138 No information is available on the size of the 1991 cohort. However, if the 1991 cohort is no larger than the previous three cohorts have been, the greatest yield could be expected to be derived from age 3 fish, and would not be more than the maximum obtained from the last three cohorts, 24 000 tonnes.

6.139 The existence of the three-year cycle of cohort recruitment implies that these fish have their major spawning event at age 2. Since the fishery takes place before spawning, postponing the fishery until fish are aged 3+ would maximise the spawning potential of the stock.

Management Advice

6.140 In view of the lack of information on the status of the currently recruiting cohort, the Working Group recommends that fishing is delayed until 1994/95 season, and only restricted fishing on the 3+ age group that is expected to form the fishery in that year should be allowed. Additional precautionary measures limiting the catch are likely to improve the chances for improved future recruitment.

Skif Bank

6.141 Separate catches and cohort analyses for Skif Bank were presented to the 1990 Working Group in WG-FSA-90/17. This fishery was also dominated by single cohorts appearing at three year intervals not coincident with the Kerguelen Shelf stock, with the first identified being a 1980 cohort. No further information was available to the Working Group to assess this stock.

Heard Island (Division 58.5.2)

6.142 An Australian research survey to assess the stocks of *C. gunnari* and *D. eleginoides* was completed from the end of August to the end of September 1993. As on previous occasions, *D. eleginoides* was widely distributed over the plateau but in low densities. There were two areas where concentrations of *C. gunnari* were found. Some of their biological properties, such as length frequency distributions, sexual maturity, were different from those observed in *C. gunnari* in the Kerguelen area at the same time of the year. This suggests that the fish in the two areas should be treated separately for management purposes. A more detailed report on results from this cruise will be presented at next year's meeting.

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

6.143 No new data on the fish stocks in these areas became available. Therefore, no management advice can be provided for these areas.

Ob and Lena Banks (Division 58.4.4)

6.144 A TAC of 1 150 tonnes of *N. squamifrons* (715 tonnes for Lena Bank and 435 tonnes for Ob Bank) valid for a two-year period was set by CCAMLR in 1992.

6.145 A survey scheduled for January/February 1993 proposed by Ukraine to assess the state of the stocks of *N. squamifrons* on these banks did not take place. A similar survey is proposed for the 1993/94 season (WG-FSA-93/10). A discussion on the proposal is provided in paragraph 8.5.

Management Advice

6.146 There is a TAC already in force until the end of the Commission meeting in 1994 (Conservation Measure 59/XI). One of the requirements of Conservation Measure 59/XI was that the fishing will be subject to review at the 1993 meetings of the Scientific Committee and the Commission. The proposed survey by Ukraine was not undertaken in 1992/93. Therefore the Working Group was unable to revise its assessment carried out in 1992. The Working Group reiterates its recommendation from the 1992 meeting that a survey to determine age structure and stock size on both banks be conducted and the stock be re-assessed before the fishery is re-opened (SC-CAMLR-XI, Annex 5, paragraph 6.231).

GENERAL ADVICE ON THE MANAGEMENT OF FISH STOCKS

6.147 There have been a number of initiatives recently, by the UN and FAO, concerning high seas fisheries and straddling stocks. In particular, the UN Conference on Straddling Stocks and Highly Migratory Fish Stocks (New York, July 1993) charged FAO with: (i) providing further information on the suitability of the MSY concept; (ii) providing information on implementation of the precautionary approach; and (iii) developing a system of statistics for high seas fisheries. These matters are due to be discussed by the Scientific Committee and the Working Group considered that it could advise the Scientific Committee accordingly.

High Seas Fisheries and Straddling Stocks

6.148 Regarding straddling stocks, it was noted that there is evidence that *D. eleginoides* in the South Atlantic is a straddling stock, occurring around South Georgia and to the north and west of Subarea 48.3 in FAO Statistical Divisions 41.3.2 and 41.3.3. Furthermore, other species also probably come into the category of straddling stocks: myctophids, squids and *Micromesistius australis*. Subject to Article XI of the Convention such species may be viewed as stocks or associated species which occur both inside and outside the Convention Area. Thus the initiatives concerning high seas fisheries and straddling stocks should be pertinent to CCAMLR with a view to harmonising the development of measures in respect of such stocks.

6.149 From data available to the Working Group, it was clear that substantial fishing has occurred on *D. eleginoides* not only in Subarea 48.3 but also in areas immediately adjacent to but outside the CCAMLR Convention Area. Effective management of this fishery is obviously contingent on managing the stock as a whole. Therefore guidance of the Commission is sought on the effective harmonisation of management measures across the Convention's boundaries.

MSY

6.150 In regard to MSY, the Working Group noted that Article II of CCAMLR does not use this concept, addressing itself instead to "population ... levels below those which ensure ... stable recruitment" and "greatest net annual increment".

6.151 A management objective of MSY usually leads to the setting of highly variable catch limits from year to year, as the catch which gives MSY depends on estimated stock size and composition. This brings the MSY approach into conflict with another frequent objective of management, the maintenance of stable catches over a number of years. The MSY approach becomes hardly meaningful when biological interactions are taken into account as it is not possible to maximise the yield from both a predator and its prey species simultaneously. For this reason, MSY is not often a suitable management approach.

6.152 In this context, the Working Group noted that WG-Krill had considered the problem of stability in the krill fishery under changing management advice, and had sought Commission guidance on the frequency at which precautionary catch levels should be revised to ensure the fishery's stability (SC-CAMLR-XII/4, paragraph 6.18).

Precautionary Approach

6.153 The guiding principle of a precautionary approach should be able to evaluate in advance if the methods used for fisheries management are sufficient to achieve their management objectives. The Revised Management Procedure recently developed by the Scientific Committee of the International Whaling Commission is a good example of such a “textbook” precautionary approach. However, the term “precautionary approach” is also applied to management procedures which take into account uncertain or unknown effects of that management so that, on available information at least, the chances of the management objectives not being met are minimised.

6.154 Examples of the latter such precautionary approaches have been introduced by CCAMLR,

- (i) to prevent uncontrolled expansion of the krill fishery by setting precautionary catch limits for krill fisheries in the Convention Area;
- (ii) to create provision for advance notification and data requirements prior to the development of new fisheries which led to catch and effort regulations being applied to exploratory fishing (e.g., crabs in Subarea 48.3 and *D. eleginoides* in Subarea 48.4); and
- (iii) to safeguard against unknown effects of bottom trawling on mixed fish communities and benthos by prohibiting bottom trawling.

6.155 The practice of providing a range of management options together with an evaluation of the risks associated with these options, a format adopted by WG-FSA in the past, is another example of contribution to a precautionary approach.

Management Under Uncertainty

6.156 In 1992 the question of setting TACs when there is no or insufficient advice due to uncertainty about stock size and sustainable yield was raised by the Commission (CCAMLR-XI, paragraph 9.23) which asked the Scientific Committee to provide advice on the matter. The consideration of what management measures are appropriate under conditions of uncertainty also contributes to a precautionary approach.

6.157 It was pointed out that this question had arisen partly in response to the situation with *E. carlsbergi* in 1992. The Working Group had expressed reservations about using its old

assessments to set a TAC for the stock since the life span of these fish was so short that there were no data on the current biomass of the stock (SC-CAMLR-XI, Annex 5, paragraph 6.105). Despite this uncertainty, the Commission maintained the TAC for the 1992/93 season.

6.158 It was agreed that there were two extremes of data availability and uncertainty:

- (A) HIGH DATA AVAILABILITY/LOW UNCERTAINTY, when sufficient data are available to enable a complete assessment of stock and short term future yield; under these conditions, specific advice on catch levels or other management measures is possible.
- (B) LOW DATA AVAILABILITY/HIGH UNCERTAINTY, when little information is available from which to assess the current status of a stock, which may or may not have supported a fishery recently; under these conditions, a precautionary approach to management, for example based on risk analysis of potential yield, and the choice of conservative (low risk) management measures with low precautionary catch limits would be appropriate.

6.159 The Working Group envisaged that under conditions of increasingly poor data availability, as situation (A) becomes situation (B) (for instance when no new data have been reported for a number of years) management measures would most appropriately start to follow options from a choice of precautionary low catch levels, as specific advice on TACs from traditional assessments became less reliable. However, the Working Group stressed that an arbitrary phase-out rule, for instance where TACs would drop to zero following a fixed number of years of low data availability either in the presence or absence of fishing, may not be appropriate. Rather, a range of precautionary limits including rationale for reducing TACs to be applied under conditions of uncertainty should be developed taking into account the dynamics of various exploitable stocks.

6.160 The Working Group noted that the recently Revised Management Procedure developed by the International Whaling Commission explicitly and automatically takes uncertainty in the stock assessments into account when calculating catch limits. The procedure has the property that when assessments have high coefficients of variation (CV), catch limits are low. Catch limits increase when the CVs become lower, for example, as more data accumulate about the status of the stocks, or when more precise estimates become available.

6.161 It was pointed out that the time scale over which a stock is judged to have moved from situation (A) to situation (B) might be influenced by the life expectancy of the species concerned. Thus for a long-lived species such as *D. eleginoides*, assessments provided five years ago may still

be appropriate to the majority of the stock, but for *E. carlsbergi* a 5-year old assessment would be entirely inappropriate as none of the fish now alive would have been spawned five years ago.

Safe Biological Limits

6.162 Dr K-H. Kock (Germany) drew attention to the use of Minimum Biologically Acceptable Limits (MBAL) by ICES. The MBAL is an estimated stock size at which recruitment is likely to fall below a level necessary for maintenance of the stock. It may alternatively be formulated in terms of increasing probabilities of recruitment failure.

6.163 The Working Group noted that there may be other methods to estimate safe biological limits of fish populations and recommended that these approaches be investigated for application to stocks in the CCAMLR Convention Area at next year's meeting.

Development of High Seas Fishery Statistics

6.164 At present FAO plans several meetings to pursue this issue further. In particular, an *Ad Hoc* Consultation on the Role of Regional Fishery Agencies in Relation to High Seas Fishery Statistics is planned to be held from 13 to 16 December 1993 at La Jolla, California, USA. This meeting will advise guidelines for the type of statistics and data reporting systems necessary for the collection of high seas fisheries statistics by FAO (see (iii) in paragraph 6.147 above). The Secretariat has received an invitation to participate at the above meeting (SC-CAMLR-XII/BG/12).

6.165 The Working Group noted that the FAO initiative on high seas fisheries statistics should be of importance for CCAMLR. The Working Group therefore recommended that the CCAMLR Secretariat be represented at the FAO Consultation in December 1993.

CONSIDERATION OF ECOSYSTEM MANAGEMENT

INTERACTIONS WITH WG-KRILL

Mortality of Larval and Juvenile Fish in Krill Trawls

7.1 The Scientific Committee has recognised that an assessment of the by-catch of young and larval fish in krill trawling is an urgent problem (SC-CAMLR-XI, paragraph 3.17). The Commission

has noted that measures may need to be taken to reduce the by-catch of fish in krill trawls (CCAMLR-XI, paragraph 4.17). Three papers evaluating this problem were presented to the Working Group (WG-FSA-93/8 Rev. 1, WG-Krill-93/50 and 51).

7.2 WG-FSA-93/8 documented juvenile Antarctic fish caught during fishing by the krill trawler, *Grigory Kovtun*, in the region of South Georgia during May-June 1992. Juvenile fish were observed in 18.2% of all 55 krill hauls. If only hauls taken over the shelf were considered, juvenile fish occurred in 45.5% of tows. For *C. gunnari*, the number of fish per tonne of krill caught were 966 ± 225 and $2\ 434 \pm 579$ for all hauls and for shelf hauls respectively. Similarly, for *Lepidonotothen larseni*, the corresponding averages were 557 ± 103 and $1\ 388 \pm 248$.

7.3 WG-Krill-93/51 presented observations of juvenile fish in commercial trawls near South Georgia during July and August 1992. 27% of trawls had juvenile fish present. The results, when calculated in the same units as for WG-FSA-93/8, showed that a maximum of 520 fish were caught per tonne of krill, most of which were *L. larseni* with some *C. gunnari*. WG-Krill-93/50 presents comparable results for the 1990/1991 season with 24.5% of hauls during scientific sampling having juvenile fish present. There was no data in either paper to determine the proportion of trawls or abundance of by-catch in trawls taken only over the shelf.

7.4 The Working Group noted that the results of these three papers are comparable and that mortality of juvenile *C. gunnari* in krill trawls may be an important source of mortality for this species. Two estimates of the potential impact were made:

- (i) the krill catch in Subarea 48.3 was 36 000 tonnes in May-June 1992 (the same time as the survey in WG-FSA-93/8 Rev. 1). Thus, the mean number of *C. gunnari* caught in krill trawls in May-June 1992 was approximately 35 million individuals. Recruitment of one year old *C. gunnari* between 1977 and 1989 estimated from Run 5 of the VPAs (paragraph 6.53) averaged 850 million individuals. If this is taken to be the average recruitment in any year then the proportion of juvenile *C. gunnari* eliminated in the krill fishery would have been approximately 4% in those two months. If the commercial fishery is concentrated over the shelf area then this mortality rate would be higher; and
- (ii) an estimate based on the number of *C. gunnari* juveniles caught in the krill catch for 1992 and a population projection of these juveniles assuming a constant natural mortality rate of 0.48 showed the potential loss of *C. gunnari* from the stock to be approximately 12 000 tonnes.

7.5 The Working Group agreed that the issue of fish mortality in commercial krill trawls over the shelf area warrants serious attention by the Scientific Committee. Particular topics identified were the relative catch rates of fish compared to catch rates of krill and whether krill hauls were taken on the shelf. It was agreed that a methodology should be developed for assessing the significance of reported rates of by-catch of young fish in conjunction with estimates of recruitment provided by assessment methods such as VPA. Further information will also be required and should be submitted on the locations and time of year during which juvenile fish would be most vulnerable to krill fishing activities.

Importance of Krill as Prey of Fish

7.6 WG-FSA-93/24 describes temporal and spatial variation in the diet composition and feeding intensity of *C. gunnari* around South Georgia. Notably, the reproductive performance of *C. gunnari* seems directly related to the availability of krill. The Working Group noted that the presence of krill in the diet of the icefish is likely to be due to a combination of downward movement of krill into deep water and upward movement of icefish into surface waters. The potential importance of krill in the diets of demersal fish species suggests that WG-Krill may need to investigate in more detail the proportion of the krill population that moves to depths greater than the 150 m.

INTERACTIONS WITH WG-CEMP

Indicator Species

7.7 Two papers were made available to the Working Group for consideration of the blue-eyed shag (*Phalacrocorax atriceps bransfieldensis*) as an indicator species in the CCAMLR Ecosystem Monitoring Program (WG-CEMP-93/25 Rev. 1 and 26 Rev. 1). WG-CEMP-93/26 Rev. 1 describes a study from South Shetland Islands in which the fish species represented by the examination of otoliths in shag pellets corresponds qualitatively, and also in order of abundance, with the fish species regularly caught in trammel nets nearby. WG-CEMP-93/25 Rev. 1 presents a rationale for using these pellets to monitor the species composition of littoral fish fauna and for identifying when commercial species may be declining in the region by their absence in pellets.

7.8 The Working Group noted that the purpose to be served by these observations needs to be specified. Given such a specification, it would then be possible to evaluate whether the proposed observations would be able to fulfil this purpose. Also, the Working Group identified a number of

criteria that need to be met before accepting that monitoring pellets of blue-eyed shags would contribute to its work:

- (i) otoliths from fish species important to the work of the Commission found in pellets of blue-eyed shags are related to the abundance of those species;
- (ii) the absence of otoliths of these species is not due to preferential feeding by shags for other fish species or due to differential digestion rates of otoliths of different species or differences in rates of digestion at different times, such as occurs during egg production by the birds; and
- (iii) there is a direct relationship between composition of nearshore fish assemblages and the status of offshore stocks of interest to CCAMLR.

7.9 The Working Group noted that these studies highlight the need for a good understanding of the biology and natural history of species being proposed for use as indicator species.

7.10 The Working Group agreed that, should these criteria be met, an index of recruitment from otolith abundance in pellets might be useful as a qualitative signal for recruitment of commercial species.

Incidental Mortality of Birds During Longline Fishing

7.11 Streamer lines for use in longline operations to minimise the incidental mortality of seabirds were introduced by CCAMLR in 1992 in Conservation Measure 29/XI. These streamer lines were tested by New Zealand and modifications are proposed in SC-CAMLR-XII/BG/13. The Working Group briefly discussed these modifications but were unable to agree on advice to the Scientific Committee due to the lack of information as to why the current streamer lines should be modified. The Working Group noted that a comparison of the performance of the current and proposed streamer lines should be based on their (i) effectiveness in deterring birds from striking bait; and (ii) efficiency of operation (deployment, retrieval and maintenance).

7.12 The Working Group noted that the practice of some fishing vessels to discard by-catches of fish in longline activities during fishing operations may contribute to attracting and subsequent fouling of birds in longlines (SC-CAMLR-XII/BG/4).

Ecological Interactions

7.13 Two papers were presented to the Working Group on the role of myctophids in the Southern Ocean ecosystem (WG-FSA-93/17 and 18). WG-FSA-93/17 describes these species as being zooplanktivores that are important prey of higher predators such as squid, nototheniid fish, sea birds and mammals. WG-FSA-93/18 discusses the mechanisms by which *E. carlsbergi* might migrate across the South Polar Frontal Zone.

Prey Requirements of Predators

7.14 At its 1992 meeting, the Working Group discussed how it might contribute to the deliberations of WG-CEMP on parameters that could assist in interpreting changes in abundance and distribution of predator and prey species (SC-CAMLR-XI, paragraph 5.61; SC-CAMLR-XI, Annex 5, paragraphs 7.9 to 7.12). Submissions on this topic have been encouraged by the Working Group but no new information was presented.

OTHER INTERACTIONS

7.15 No new information is available on the potential impact of bottom trawling on benthic assemblages. The Working Group was informed that Australia is currently doing quantitative assessments of benthos in Prydz Bay that may help with these assessments.

RESEARCH SURVEYS

TRAWL SURVEY SIMULATION STUDIES

8.1 In 1991 and 1992 the Working Group drew priority attention to the difficulties which had been experienced in the application of the swept area method (Saville, 1977¹⁰) and associated *t*-statistics, to species with patchy distributions, such as *C. gunnari*. WG-FSA-93/20 addressed some of the statistical issues related to this issue, and reported the results of some simulation studies on trawl survey estimation based on using Aitchison's delta distribution to model the underlying statistical distribution of trawl survey densities. The paper also developed a method for calculating confidence intervals for the abundance estimates. Tests of the method showed that unbiased estimates of

¹⁰ Saville, A. (Ed.). Survey methods of appraising fisheries resources. *FAO Fish. Tech. Pap.*, 71: 76.

abundance were obtained, along with confidence intervals which give approximately the correct coverage probability.

8.2 A computer program which implemented these methods has been submitted to CCAMLR, and was used in preparing the assessment for *C. gunnari*. The Working Group agreed that the methods appeared to be an improvement over the use of the usual simple sample statistics in the analysis of trawl surveys. Dr de la Mare indicated that he would be carrying out further simulation testing of the method to examine the robustness of the delta distribution estimators to different underlying statistical distributions.

8.3 The need for further work on the formulation of a range of fish behaviours to determine the possible forms of such statistical distributions, as specified in WG-FSA-92 (SC-CAMLR-XI, Annex 5, paragraphs 8.5 to 8.7) was reiterated. The Convener, Dr de la Mare, and Dr Kock agreed to continue to coordinate this activity.

DRAFT MANUAL FOR BOTTOM TRAWL SURVEYS

8.4 The Draft Manual for Bottom Trawl Surveys in the Convention Area (SC-CAMLR-XI, Annex 5, Appendix H, Attachment E) was circulated during the intersessional period. Only one survey has been conducted in the Convention Area since last year, and so too little experience has been gained in the use of the Manual to suggest any major revision at this stage. However, Dr de la Mare drew attention to the common practice of using the same set of stations when conducting repeat surveys, rather than choosing a new set of random stations. He noted that, although this practice had important practical advantages (e.g., in cases where there was rough trawling ground), it would not lead to the estimates being statistically consistent, in the sense of the mean of series of survey estimates converging on the true abundance, if the physical distribution of fish had a persistent geographic pattern. Using the same stations may be appropriate for the case where a time series of estimates is to be used as an index of abundance. In such cases, the estimation of a proportionality coefficient (q) would be desirable. Using re-randomised stations would be appropriate for improving the precision and accuracy of a total abundance estimate from repeat surveys. In the recent Australian survey at Heard Island the survey design was based on half of the stations being repeated, with the remainder being newly selected at random. It was suggested that it would be appropriate for some brief discussion of this matter to be included in the Draft Manual.

RECENT AND PROPOSED SURVEYS

8.5 The design of a bottom trawling survey on the Ob and Lena Banks has been proposed by Ukraine in WG-FSA-93/10. A review of the TACs for these banks is pending the outcome of this survey (paragraphs 6.144 and 6.145). The Working Group raised a number of points from the proposal that should be addressed:

- (i) Why are net monitor cables required? The reasons given in the proposal indicate that an acoustic net monitor transmission would be preferred.
- (ii) Why are trawls to be of one hour duration when survey trawls around South Georgia Island can be conducted successfully over a half hour period in the same depth range?
- (iii) The results of the survey should be reported in the CCAMLR research database format.

8.6 A UK scientific research cruise for finfish in Subarea 48.3 is planned for the 1993/94 season. The proposal is detailed in WG-FSA-93/28. The survey design is similar to those of recent years with approximately 80 randomly located stations covering three depth strata. An additional element noted by the Working Group is the plan to study concentrations of *C. gunnari* if they are encountered during the survey.

8.7 Resolution 9/XI requires the Scientific Committee, in consultation with its Working Groups, to develop standardised guidelines and formats for Members to submit research plans for use of “commercial fishing or fishing support vessels or vessels of a similar catching capacity to conduct fishing for research purposes when the estimated catch of finfish may exceed 50 tonnes”. The Working Group agreed that the format proposed in WG-FSA-93/12 Rev. 1 is suitable for attachment to this resolution.

8.8 The Working Group noted that a 50 tonne limit for normal research operations was a practical restriction intended to ensure that sufficient survey work could be undertaken without having a substantial impact on stocks, without a requirement to notify CCAMLR. It was noted that this restriction will be unlikely to affect the operation of research vessels carrying out typical bottom trawl surveys, but that it would affect those vessels used for other research purposes which catch commercial quantities of fish. Consequently, the requirement to submit plans to CCAMLR is unlikely to be applicable to most research operations. In this context, the Working Group recognised that

the Resolution aimed to create a distinction between research fishing on a commercial scale and the scale of fishing usually required for the purposes of scientific research.

DATA REQUIREMENTS

9.1 Details of data requirements identified by the Working Group are given in Appendix D.

SOFTWARE AND ANALYSES REQUIRED FOR THE 1994 MEETING

9.2 Following the principles adopted at other Working Groups, the Secretariat was requested to undertake validation of the method of analysing trawl surveys described in WG-FSA-93/20. Following validation, receipt of detailed user instructions and final versions of the programs, this software will be made available for distribution through the Secretariat to interested researchers.

9.3 The Secretariat was requested to provide an enhancement to its stochastic population projection program to incorporate drawing the starting population age structure at random from a choice of prior distributions. Drs de la Mare and Constable agreed to liaise with the Secretariat on this matter.

9.4 This year much time was spent by several participants in identifying local depletion events in the haul-by-haul longline dataset for *D. eleginoides*. The Working Group requested that the Secretariat develop a program to scan these data automatically to assist in the identification of depletion events, or to provide some software which would allow rapid visual scanning.

9.5 The CCAMLR ADAPT VPA program, developed initially for the 1992 meeting of WG-FSA, has now been used for two years and has undergone some minor development. Participants were requested to contact the Secretariat with suggestions for improvements to the output or input to make the software more user-friendly.

OTHER BUSINESS

10.1 Some participants have experienced problems in using files generated by applications not available at the Secretariat. Fixing these problems requires considerable effort by the Secretariat's Computer Specialist.

10.2 In an attempt to alleviate this problem, the Working Group decided the following:

- (i) the Secretariat should prepare and circulate with the invitation to the WG-FSA meeting, a summary of all software and hardware maintained at the Secretariat;
- (ii) for the more specialised assessment and analysis packages, participants should be asked to keep this summary under constant review and advise the Secretariat when new versions of the software are released; and
- (iii) it will be the responsibility of participants to bring with them licensed copies of any software they intend to use at the meeting which is not maintained at the Secretariat, and bring compatible drivers for these applications.

10.3 The report of the Workshop on the Management of the Antarctic Crab Fishery contains a suggestion that it would be useful for CCAMLR to maintain an ongoing bibliography for Antarctic crabs (Appendix E, paragraph 7.1).

10.4 At present, the Secretariat is working on a complete bibliography of papers presented at CCAMLR meetings. It also maintains a bibliography of reprints of published papers provided to the Secretariat by the CCAMLR scientists. A bibliography on Antarctic oceanography, hydrology and related aspects of krill distribution was recently compiled by the Secretariat on request from WG-Krill.

10.5 Compiling and maintaining such specialised bibliographies takes a considerable amount of time and effort by the Secretariat. At the same time, such bibliographies are being maintained by individual CCAMLR scientists working on specific projects.

10.6 The Working Group decided that as a common approach, the Secretariat should compile a register of scientists working on specific projects of interest to CCAMLR and of bibliographies they maintain, including any available bibliographies on Antarctic crabs. The register should be readily available to all CCAMLR scientists on request to the Secretariat.

10.7 The Working Group also requested that the Secretariat continue cataloguing its reprints. In order to keep the catalogue complete and updated, scientists are requested to send reprints of their publications to the CCAMLR library.

10.8 WG-Krill and WG-CEMP have both discussed the development of the Southern Ocean - International Global Ecosystem Dynamics (SO-GLOBEC) (see SC-CAMLR-XII/4, paragraphs 7.4

to 7.10; SC-CAMLR-XII/3, paragraphs 9.7 to 9.12). Both Working Groups have suggested that the Scientific Committee should consider nominating an observer to the SO-GLOBEC Program and that the liaison between SO-GLOBEC and the Scientific Committee and its Working Groups should continue.

10.9 The Working Group decided that having a full knowledge of the SO-GLOBEC development and implementation is of importance to CCAMLR. This would help to avoid certain overlap and competition between SO-GLOBEC and various programs of the CCAMLR Scientific Committee.

ADOPTION OF THE REPORT AND CLOSE OF THE MEETING

11.1 The report of the meeting was adopted.

11.2 In closing the meeting the Convener thanked the rapporteurs, conveners of various *ad hoc* subgroups and the Secretariat for their hard work which had enabled the meeting to be conducted in a most effective manner. Due to their efforts, the report of the meeting was prepared and adopted in the shortest time ever.

11.3 Dr Kock (Chairman of the Scientific Committee) congratulated the Convener for conducting the meeting in an efficient and productive fashion. He also extended his thanks to the Convener and participants on behalf of the Scientific Committee.

AGENDA

Working Group on Fish Stock Assessment
(Hobart, Australia, 12 to 19 October 1993)

1. Opening of the Meeting
2. Organisation of the Meeting
3. Adoption of the Agenda
4. Observation and Inspection
5. Review of Material for the Meeting
 - 5.1 Data Requirements Endorsed by the Commission in 1992
 - 5.2 Catch and Effort Statistics
 - 5.3 Mesh/Hook Selectivity and Related Experiments Affecting Catchability
 - 5.4 Other Documents
 - 5.5 Seabed Areas
6. Assessment Work and Management Advice
 - 6.1 New Fisheries
 - 6.2 South Georgia (Subarea 48.3) - Finfish
 - 6.3 South Georgia (Subarea 48.3) - Crabs
 - 6.4 South Orkney Islands (Subarea 48.2)
 - 6.5 Antarctic Peninsula (Subarea 48.1)
 - 6.6 Kerguelen Islands (Division 58.5.1)
 - 6.7 Ob and Lena Banks (Division 58.4.4)
 - 6.8 Coastal Areas of Antarctic Continent (Divisions 58.4.1 and 58.4.2)
 - 6.9 Pacific Ocean Sector (Area 88)
 - 6.10 General Advice
7. Considerations of Ecosystem Management
 - 7.1 Interactions with WG-Krill
 - 7.2 Interactions with WG-CEMP

- 7.3 Other Interactions (e.g. Multispecies, Benthos, etc.)
- 7.4 Coordination with Other Working Groups

- 8. Research Surveys
 - 8.1 Trawl Survey Simulation Studies
 - 8.2 Draft Manual for Bottom Trawl Surveys
 - 8.3 Recent and Proposed Surveys

- 9. Future Work
 - 9.1 Data Requirements
 - 9.2 Software to be Prepared or Developed Prior to the Next Meeting and Data Analyses Required

- 10. Other Business

- 11. Adoption of the Report

- 12. Close of the Meeting.

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(Hobart, Australia, 12 to 19 October 1993)

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LIST OF DOCUMENTS

Working Group on Fish Stock Assessment
(Hobart, Australia, 12 to 19 October 1993)

WG-FSA-93/1	PROVISIONAL AGENDA AND ANNOTATION TO THE PROVISIONAL AGENDA FOR THE 1993 MEETING OF THE WORKING GROUP ON FISH STOCK ASSESSMENT (WG-FSA)
WG-FSA-93/2	LIST OF PARTICIPANTS
WG-FSA-93/3	LIST OF DOCUMENTS
WG-FSA-93/4	REPORT OF THE WORKSHOP ON THE MANAGEMENT OF THE ANTARCTIC CRAB FISHERY (La Jolla, California, USA, 26 to 28 April 1993)
WG-FSA-93/5	ANALYSES PERFORMED AT THE 1992 MEETING OF THE WORKING GROUP ON FISH STOCK ASSESSMENT D.J. Agnew (Secretariat)
WG-FSA-93/6 Rev. 1	CROSS-SECTIONAL STRUCTURE AND VALIDATION OF THE TIMING OF ANNULUS FORMATION IN OTOLITHS OF THE ANTARCTIC FISH <i>NOTOTHENIA CORIICEPS</i> RICHARDSON (NOTOTHENIIDAE) Julian R. Ashford and Martin G. White (United Kingdom)
WG-FSA-93/7	A METHOD FOR PREPARING LARGE NUMBERS OF OTOLITH SECTIONS FOR VIEWING BY SCANNING ELECTRON MICROSCOPE J.R. Ashford, K. Robinson and M.G. White (United Kingdom)
WG-FSA-93/8 Rev. 1	BY-CATCH OF JUVENILE ANTARCTIC FISH FROM KRILL (<i>EUPHAUSIA SUPERBA</i> DANA) FISHERIES IN THE SOUTH GEORGIA AREA, IN 1992 E.A. Pakhomov and S.A. Pankratov (Ukraine)
WG-FSA-93/9	ASPECTS OF THE DISTRIBUTION AND INTERANNUAL VARIATIONS IN LARVAL FISH ASSEMBLAGES AT SOUTH GEORGIA, ANTARCTICA Martin G. White (United Kingdom)
WG-FSA-93/10	A SUGGESTED BOTTOM TRAWLING SURVEY ON THE OB AND LENA BANKS (Ukraine)
WG-FSA-93/11	SOME PROBLEMS OF WATER FLOW THROUGH TRAWL CODEND Waldemar Moderhak (Poland)

- WG-FSA-93/12 Rev. 1 SUBMISSION OF PLANS FOR CONDUCTING FINFISH SURVEYS IN THE CONVENTION AREA
Secretariat
- WG-FSA-93/13 SIZE VARIATIONS ASSOCIATED WITH ABUNDANCE CHANGES IN JUVENILE *NOTOTHENIA ROSSII*, OBSERVED AT POTTER COVE, SOUTH SHETLAND ISLANDS, SINCE THE END OF THE FISHERY IN THE AREA
Enrique R. Marschoff and Esteban R. Barrera-Oro (Argentina)
- WG-FSA-93/14 THE EARLY LIFE HISTORY AND THE ONSET OF SCALE FORMATION IN THE PATAGONIAN TOOTHFISH, *DISSOSTICHUS ELEGINOIDES* SMITT, 1898
Karl-Hermann Kock (Germany)
- WG-FSA-93/15 THE *DISSOSTICHUS ELEGINOIDES* FISHERY IN DIVISION 58.5.1 (KERGUELEN ISLANDS)
G. Duhamel (France)
- WG-FSA-93/16 THE PATAGONIAN TOOTHFISH (*DISSOSTICHUS ELEGINOIDES*) FISHERY ON THE KERGUELEN ISLAND SHELF
V.G. Prutko (Ukraine)
- WG-FSA-93/17 ON THE STATUS OF MESOPELAGIC FISH (MYCTOPHIDAE) IN THE SOUTHERN OCEAN ECOSYSTEM
A.N. Kozlov (Russia)
- WG-FSA-93/18 THE MIGRATION PATTERNS OF *ELECTRONA CARLSBERGI* (TÅNING, 1932)
A.N. Kozlov (Russia)
- WG-FSA-93/19 ESTIMATES OF SEABED AREAS WITHIN SELECTED DEPTH RANGES
E.N. Sabourenkov, A. Blake and D.J. Agnew (Secretariat)
- WG-FSA-93/20 ESTIMATING CONFIDENCE INTERVALS FOR FISH STOCK ABUNDANCE ESTIMATES FROM TRAWLSURVEYS
William K. de la Mare (Australia)
- WG-FSA-93/21 STOCK STATE OF *DISSOSTICHUS ELEGINOIDES* AT SUBAREA 48.3 AND ADJACENT ZONES
C.A. Moreno and P.S. Rubilar (Chile)
- WG-FSA-93/22 PROPOSAL FOR AN EXPERIMENTAL CRAB FISHERY IN SUBAREA 48.3
George Watters (USA)
- WG-FSA-93/23 USING PRODUCTION MODELS TO ASSESS THE STOCK OF *PARALOMIS SPINOSISSIMA* AROUND SOUTH GEORGIA ISLAND
George Watters (USA)

- WG-FSA-93/24 VARIATIONS IN THE DIET COMPOSITION AND FEEDING INTENSITY OF MACKEREL ICEFISH (*CHAMPSOCEPHALUS GUNNARI*) AT SOUTH GEORGIA (ANTARCTIC)
K.-H. Kock and S. Wilhelms (Germany), I. Everson (UK) and J. Gröger (Germany)
- WG-FSA-93/25 ON THE TAXONOMY OF THE *LEPIDONOTOthen SQUAMIFRONS* GROUP (PISCES, PERCIFORMES, NOTOTHENIOIDEI)
R. Schneppenheim and K.-H. Kock (Germany), G. Duhamel (France) and G. Janssen (Germany)
- WG-FSA-93/26 TIMESCALE OF OVARIAN MATURATION IN *NOTOTHENIA CORIICEPS* (RICHARDSON); EVIDENCE FOR A PROLONGED ADOLESCENT PHASE
Inigo Everson (UK)
- WG-FSA-93/27 DISTRIBUTION OF CATCHES OF *DISSOSTICHUS ELEGINOIDES* IN SUBAREAS 48.3 AND 48.4, 1992/93 SEASON
Secretariat
- WG-FSA-93/28 UK SCIENTIFIC RESEARCH CRUISE FOR FINFISH: SUBAREA 48.3
Delegation of UK
- WG-FSA-93/29 REVISION OF THE COMMERCIAL CATCH AT AGE OF THE ANTARCTIC ICEFISH *CHAMPSOCEPHALUS GUNNARI* OVER THE PERIOD 1976/77 TO 1990/91
G.B. Parkes (UK)
- OTHER DOCUMENTS
- WG-Krill-93/50 FISHES IN PELAGIC CATCHES IN THE VICINITY OF THE SOUTH SHETLAND ISLAND DURING THE 6TH ANTARCTIC EXPEDITION OF RV *KAIYO MARU*, 1990/1991
Tetsuo Iwami, Taro Ichii, Haruto Ishii and Mikio Naganobu (Japan)
- WG-Krill-93/51 FISHES CAUGHT ALONG WITH THE ANTARCTIC KRILL IN THE VICINITY OF THE SOUTH GEORGIA ISLAND DURING THE AUSTRAL WINTER MONTHS OF 1992
Tetsuo Iwami (Japan)
- WG-CEMP-93/25 Rev. 1 BLUE-EYED SHAGS AS INDICATORS OF CHANGES IN LITTORAL FISH POPULATIONS
Ricardo Casaux and Esteban Barrera-Oro (Argentina)
- WG-CEMP-93/26 Rev. 1 THE DIET OF THE BLUE-EYED SHAG, *PHALACROCORAX ATRICEPS BRANSFELDENSIS* AT THE WEST ANTARCTIC PENINSULA
Ricardo Casaux and Esteban Barrera-Oro (Argentina)

CCAMLR-XII/5	EVALUATING NEW AND EXPLORATORY FISHERIES Delegation of USA
SC-CAMLR-XII/BG/2	CCAMLR DATABASES AND DATA AVAILABILITY Secretariat
SC-CAMLR-XII/BG/3	REPORT OF A COORDINATION MEETING OF THE CONVENERNS OF THE WORKING GROUPS ON KRILL, CEMP AND FISH AND THE CHAIRMAN OF THE SCIENTIFIC COMMITTEE
SC-CAMLR-XII/BG/4	AN EXPLORATORY FISHING EXPEDITION FOR <i>DISSOSTICHUS</i> <i>ELEGINOIDES</i> AROUND THE SOUTH SANDWICH ISLANDS, ANTARCTICA Delegations of Chile and United Kingdom
SC-CAMLR-XII/BG/11	FISHING AND CONSERVA TION IN SOUTHERN WATERS Delegation of Germany
SC-CAMLR-XII/BG/13	OBSERVATIONS ON CCAMLR SPECIFICATIONS FOR STREAMER LINES TO REDUCE LONGLINE BY-CATCH OF SEABIRDS Delegation of New Zealand

DATA REQUIREMENTS FOR THE WORKING GROUP

I Data Required by WG-FSA-92	II Data Received by WG-FSA-93	III Data Requested by WG-FSA-93
1. Data from the crab fishery should be collected and submitted (paragraphs 6.20 (v) and (vi))	Data reported	-
2. <i>D. eleginoides</i> , Subarea 48.3 (paragraph 6.176) <ul style="list-style-type: none"> studies on hook selection factors required studies on loss rates of fish 	None received	<i>D. eleginoides</i> , Subarea 48.3 <ul style="list-style-type: none"> studies on hook selection factors required studies on loss rates of fish
3. <i>D. eleginoides</i> , Subarea 48.3 <ul style="list-style-type: none"> age and maturity determination required for an expanded range of lengths from historical and current commercial and research catches (paragraph 6.123 to 6.126) fish should be measured in 1 cm length classes and all data should be submitted to CCAMLR (paragraph 6.142) 	Data received from current fishery	<i>D. eleginoides</i> , Subarea 48.3 <ul style="list-style-type: none"> age and maturity determination required for an expanded range of lengths from historical and current commercial and research catches
4. <i>E. carlsbergi</i> , Subarea 48.3: <ul style="list-style-type: none"> description of operation (CCAMLR-IX, paragraph 4.27) further information requested on by-catch in commercial <i>E. carlsbergi</i> fishery (paragraph 6.103) new surveys required (paragraph 6.105) 	No information	-
5. 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	No information but no fishery	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
6. Trawl fisheries in Subarea 48.3: <ul style="list-style-type: none"> 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 (paragraphs 6.72 and 6.93) research data should be submitted to the Secretariat 	No information	Trawl fisheries in Subarea 48.3 <ul style="list-style-type: none"> 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 (paragraph 6.64) research data should be submitted to the Secretariat
7. <i>N. rossii</i> , Subarea 48.3 <ul style="list-style-type: none"> biological information on incidental catch haul-by-haul data from historical fishery requested (paragraph 6.34) 	No information	-
8. Length and age, <i>N. squamifrons</i> , Subarea 48.3 - commercial data for past years (paragraph 6.90)	No information	-
9. Commercial age and length data for <i>N. gibberifrons</i>	No information	-

I	II	III
10. <i>P. guntheri</i> , Subarea 48.3 - clarification of position of past catches around South Georgia requested (paragraph 6.86)	No information	-
11. <i>E. carlsbergi</i> <ul style="list-style-type: none"> clarification of position and time of catch of 1 518 tonnes reported for Subarea 48.2 in 1990/91 (paragraph 6.178) clarification of position and time of catch of 50 tonnes in Subarea 48.1 in 1991/92 (paragraph 6.203) 	No information	<i>E. carlsbergi</i> <ul style="list-style-type: none"> clarification of position and time of catch of 1 518 tonnes reported for Subarea 48.2 in 1990/91 clarification of position and time of catch of 50 tonnes in Subarea 48.1 in 1991/92
12. Age/length data from catches of <i>C. gunnari</i> in Division 58.5.1 prior to 1980	Data in Gerasimchuk, 1993 ¹	-
13. Commercial length and age data for the <i>D. eleginoides</i> trawl and longline fisheries in Division 58.5.1	Submitted by France	-
14. <i>N. squamifrons</i> , Division 58.5.1 <ul style="list-style-type: none"> length and age/length key data catch data separated for Division 58.5.1 data consistency 	No further data are available Zaitsev, 1989 ²	-
15. Information on levels of discarding and conversion rates from fish products to nominal weight are required	No information	-
16. Call for detailed charts to assist the Secretariat in the calculation of seabed areas (paragraph 8.11)	Charts received by Secretariat	-
17. 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 (paragraphs 8.5 and 8.6)		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
18.		<i>D. eleginoides</i> , Subarea 48.3 <ul style="list-style-type: none"> stock identification studies data on the position or bearing of each end of longlines (paragraph 6.16)
19.		Crab fishery, Subarea 48.3 Investigations on the use of time-release devices, escape ports and pot selectivity (paragraph 6.89)

¹ Gerasimchuk, V.V. 1993. States of stocks *Champsocephalus gunnari* on the shelf of the Kerguelen Islands. In: Duhamel, G. (Ed). *Les Rapports des campagnes à la mer: Campagnes SKALP 1987 et 1988 aux îles Kerguelen. Les Publications de l'Institut Français pour la Recherche et la Technologie Polaires*, 93-01: 266-276.

² Zaitsev, A.K. 1989. Growth and age/length structure of populations of *Notothenia (Lepidonotothen) squamifrons* (Nototheniidae) in various areas of the Indian sector of the Southern Ocean. In: *Selected Scientific Papers, 1989 (SC-CAMLR-SSP/6)*. CCAMLR, Hobart, Australia: 123-139.

**REPORT OF THE WORKSHOP ON THE MANAGEMENT
OF THE ANTARCTIC CRAB FISHERY
(La Jolla, California, USA, 26 to 28 April 1993)**

**REPORT OF THE WORKSHOP ON THE MANAGEMENT
OF THE ANTARCTIC CRAB FISHERY**
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OPENING OF THE MEETING

1.1 The Workshop was held at the Southwest Fisheries Science Center, La Jolla, California, from 26 to 28 April 1993. The Convener, Dr R. Holt (USA) chaired the Workshop.

1.2 The participants of the Workshop were welcomed by the Director of the Southwest Fisheries Science Center, Dr M. Tillman, on behalf of the US Government.

ORGANISATION OF THE MEETING AND APPOINTMENT OF RAPORTEURS

1.3 The following were appointed rapporteurs:

- Dr R. Holt, Agenda Items 1, 6, 7, 8 and 9;
- Dr R. Otto (USA), Agenda Item 2 (i) to (iii);
- Dr I. Everson (UK), Agenda Item 2 (iv);
- Dr M. Basson (UK), Agenda Item 3;
- Dr A. Rosenberg (USA), Agenda Item 4; and
- Dr D. Agnew (CCAMLR Secretariat), Agenda Items 5 and 6.

A list of participants is given in Attachment A. A list of papers tabled at the meeting is given in Attachment B.

ADOPTION OF THE AGENDA

1.4 A draft agenda had been prepared by the Convener and the CCAMLR Secretariat. This agenda was adopted and is included as Attachment C.

BACKGROUND OF THE MEETING

1.5 Following notification to the Commission by the United States in 1991 of a potential new fishery for Antarctic crab *Paralomis* in Subarea 48.3 (CCAMLR-X, paragraphs 6.7 to 6.12), a fishery operated in Subarea 48.3 from July to November 1992.

1.6 The Scientific Committee had recommended that a conservative management strategy be followed in the development of the fishery for the species, and had recommended a series of measures to manage the fishery in this stage of its development.

1.7 The Commission requested the Scientific Committee to develop a Longterm Management Plan for the Exploratory Crab Fishery. This CCAMLR Workshop was asked to specify the data needed and the actions required to acquire the relevant information from the exploratory crab fishery that will allow the estimation of appropriate harvest levels and methods in accordance with Article II of the Convention, for review by the Scientific Committee (CCAMLR-XI, paragraphs 9.48 to 9.50).

OBJECTIVES OF THE MEETING

1.8 The objectives of the Workshop (SC-CAMLR-XI, paragraph 4.17) were:

- (i) to design an approach to management of this fishery that will enable WG-FSA to measure:
 - (a) the productivity and abundance of the stock; and
 - (b) the effect of different harvest strategies;
- (ii) to establish the types and scale of data necessary to implement the above approach to management; and
- (iii) to establish reporting requirements for the fishery.

INFORMATION ON THE *PARALOMIS SPINOSISSIMA* STOCK

Biological Characteristics

2.1 A summary of the types of data discussed in this section, their methods of acquisition and priority for acquisition is given in Table 1.

2.2 The Workshop considered available information on *Paralomis* spp. contained in WS-Crab-93/4, 24 and 25 as well as WG-FSA-92/29. The working group noted that two species of *Paralomis* are found in Subarea 48.3. *Paralomis spinosissima* is of major concern as this was the target species during the 1992 fishery but *Paralomis formosa* is also found in abundance and may be of commercial interest in the future.

2.3 The two species have similar geographic distributions and are known from the Scotia Sea north to the Atlantic continental shelf waters of South America. They are not known from the eastern Atlantic or from Pacific Ocean waters. Available records summarized by Macpherson (WS-Crab-93/25) show *P. spinosissima* occurs in areas west of 34° longitude ranging north to 46°S latitude at depths of 132 to 824 m. *Paralomis formosa* ranges north to about 37°S latitude and is found at depths to 1 600 m. Records from a Spanish trawl survey in 1987 and 1991 show that both species occur to the south of South Georgia (56°S) (WS-Crab-93/19) but were not found at South Orkney or the South Sandwich Islands. Little is known of their abundance in areas outside Subarea 48.3. Suggestions for research on biological parameters and data collection expressed in this report largely apply to both species although only *P. spinosissima* is considered here.

2.4 The genus *Paralomis* is in the family Lithodidae, anomuran crabs closely allied to the hermit crabs. The family includes the genera *Lithodes* and *Paralithodes* which are commonly known as king or stone crabs and contain species that provide important commercial fisheries world wide. The genus *Paralomis* is known from all the World's oceans except the Arctic and is usually found at extreme depths. In the Southern Oceans members of the genus are, however, found in continental shelf and slope waters. *Paralomis granulosa*, for example, is harvested in Chile and to a lesser extent in Argentina as well as the Falkland Islands.

2.5 Anomurans differ from the true crabs (Brachyura) in that females lack spermathecae and cannot store sperm during mating and fertilize eggs at a later time. Female anomuran crabs mate and extrude eggs immediately after moulting with fertilization occurring during or immediately after extrusion. The abundance and size of mature males relative to that of females may be more important in fishery management of anomuran crabs than it is in the management of brachyurans. This is especially true if the moulting-mating season is relatively short. The correlation between moulting and mating times may also influence the timing of fishing seasons.

2.6 The Workshop considered available information on reproduction in *P. spinosissima* in Subarea 48.3 and noted the following:

- (i) Size at maturity is probably lower at Shag Rocks than at South Georgia Island. Chela allometry indicates that males mature at about 66 mm carapace length at Shag Rocks and 75 mm at South Georgia Island. Differences in female size at maturity (based on the frequency of ovigerous specimens by size group) were less apparent; 50% of the females were carrying eggs at a size of 62 mm carapace length (data combined from both locations). The minimum and average sizes of ovigerous females were, however, smaller at Shag Rocks than at South Georgia Island. Determination of size at maturity

was difficult due to the high frequency of rhizocephalan parasites. The size of ovigerous females is directly proportional to functional maturity. There was some discussion of the possibility that morphometric maturity as determined for males may not be directly equatable to the size at which males actually participate in mating and are hence functionally mature.

- (ii) Field and subsequent microscopic observations of embryos being brooded by females during July 1992 suggest that mating probably occurs over substantial portions of the year. Developmental stages ranged from external eggs showing only the formation of blastodiscs, to those that had completed development and were in the process of hatching. Females carrying only the remnants of hatched eggs were also commonly encountered. While these observations are indicative of a protracted spawning period, in the absence of seasonal monitoring it is not clear whether spawning within the population occurs throughout the year. If there is a seasonal component to the frequency of spawning, its timing may influence spatial distribution of males relative to females and the frequency of moulting.
- (iii) The number of newly fertilized eggs in *P. spinosissima* ranged from approximately 2 000 to 14 000 and increased exponentially with carapace length. The relationship between fecundity and size was compared to that for *Lithodes aequispina* from the Aleutian Islands. While fecundity in *P. spinosissima* is an order of magnitude lower than many other crab species, at any given size average fecundity in *P. spinosissima* is higher than that for *L. aequispina*. Participants noted that recruitment in other crab and crustacean populations is highly variable and not necessarily well related to population egg production. However, the importance of fecundity observations and their application to understanding stock/recruitment relationships should not be ruled out for *Paralomis* spp. Also, participants noted that it would be desirable to describe the relationship between numbers of brooded embryos and body size at later stages of embryologic development in order to estimate the number of larvae hatched.
- (iv) Data on the diameter of oocytes relative to the developmental stage of brooded embryos indicated that spawning does not immediately follow hatching in *P. spinosissima*. If it is assumed that embryologic development lasts for one year and that vitellogenesis occurs at a roughly constant rate, then the spawning cycle may approach two years. This would be similar to spawning cycle of *L. aequispina* which has a similar depth range in the North Pacific, an embryologic period of one year, similar egg size and is capable of lecithotrophic larval development. The possibility

that *P. spinosissima* has lecithotrophic, benthic larvae was discussed as this sort of life history may influence stock/recruitment relationships.

2.7 Apart from the above reproductive data and limited information on size frequency, participants noted that there was very little life history, ecological or demographic information available. Due to the limited area that has been fished and from which biological data has been collected, considerable attention should be given to areal differences in all parameters.

Distribution and Stock Identity

2.8 The Workshop considered data presented in documents WS-Crab-93/17, 19, 24 and 25 as well as WG-FSA-92/29. It was noted that the Spanish trawl survey of continental shelf and slope waters of the Scotia Arc encountered crabs only at South Georgia Island and Shag Rocks. It was agreed that CCAMLR Members should attempt to assemble existing, unpublished, information on the geographic distribution of crabs in the Southern Oceans.

2.9 Differences in mean size and the size at maturity between Shag Rocks and South Georgia Island suggest that discrete stocks may exist. Discussions indicated that comparative morphology and demographic studies were most generally used to identify stocks of crabs and that recent studies were proving the utility of genetic techniques in stock identification. Tagging studies have also been used to delineate stocks for the purposes of fishery management. It was generally agreed that differences in demographic characteristics were frequently sufficient to warrant separate treatment of populations inhabiting various grounds even if populations could be considered as parts of the same interbreeding unit (deme) genetically.

2.10 The Workshop suggested that in addition to biological and fishery data collection, oceanographic data also be collected. If this is available from other sources it should be interfaced with the biological data. Most crab populations show significant changes in size over time, which may be related to environmental factors. Data on seasonal water temperatures and probably current patterns are desirable. These data could be best obtained by established hydroacoustically released gear. Expendable Bathy Thermographs (XBTs) give a snap shot of conditions at a given time, but given the limited commercial effort, would probably be insufficient in quantity to provide a useful time series of data.

Demographic Characteristics

2.11 Participants agreed that information on size-specific growth, mortality and stock abundance was most important at the moment. At present these elements can most easily be estimated by analogy with other species and stocks. The interaction of reproductive and life history parameters with stock/recruitment relationships was discussed as was the importance of parasitism. Participants agreed that the acquisition of demographic information would be influenced by the selectivity of pots in the fishery. Comparative fishing experiments between pots with small and large mesh size and between pots and trawls were suggested.

Parasitism

2.12 Investigations during the experimental crab fishing study had indicated that in some areas a very high proportion of the *P. spinosissima* were parasitised by rhizocephalan*. Microsporidian infections were also found but at much lower incidence. The incidence of infection was greatest in small individuals of both sexes and was more prevalent at South Georgia than at Shag Rocks. These parasites were not found in *P. formosa* (WG-FSA-92/29). Incidence of rhizocephalans and microsporidians is probably underestimated as early stages of infection are cryptic.

2.13 The implications on the *P. spinosissima* population of this rhizocephalan infestation were considered in the study described in WS-Crab-93/7 and supported by more general models in WS-Crab-93/9. The following conclusions had been drawn in this study:

- (i) the spawning stock of a population with a high prevalence of rhizocephalan infestation is likely to be below the spawning stock of an uninfected population;
- (ii) the spawning stock ratio (exploited SSN**/unexploited SSN) decreases as fishing mortality increases when only healthy animals are harvested. This is also true in the absence of parasitism but the 'starting point' or the unexploited level of spawning stock is lower when there is any infestation; and
- (iii) when healthy and parasitised animals are harvested the spawning stock ratio decreases less rapidly than is the case when only healthy animals are harvested and in some cases there may be an increase in the spawning stock for relatively low levels of fishing mortality.

* genus Briarosaccus class Cirripedia, phylum Crustacea

** SSN = Spawning Stock Number

2.14 It was noted that in modelling the situation it was important to take account of the recruitment dynamics of the parasite and host. This in turn meant it was important to determine the larval distribution and be able to determine stock identity.

2.15 Even though the rhizocephalan tends to cause feminisation in *P. spinosissima*, it was noted that there was a higher prevalence of parasitisation in males than females. During the field study presence of pleopods had been taken as diagnostic that the crab was female.

2.16 A significant proportion of the rhizocephalans were themselves infected by an undescribed species of isopod. The dynamics of this hyperparasitisation were unknown and merit analysis through extension of models in WS-Crab-93/7 and 9.

2.17 Even though the majority of the rhizocephalan infected *P. spinosissima* were smaller than the minimum size adopted in WG-FSA-92/29, it was agreed that destroying infected individuals is more likely to have an overall benefit to the crab population. It was considered that there was no chance of further infection if such crabs were crushed and returned directly to the sea.

2.18 Infection by the rhizocephalan is thought to occur during the immediate post-moult period. The externa, the external manifestation of the parasite, becomes visible some months later.

2.19 No information was available to indicate whether high levels of parasitisation were a localised or widespread phenomenon. Information on this topic could be obtained by analysis of data on infestation rates on a haul-by-haul basis taking account of the location of the catches.

2.20 The prevalence of rhizocephalan parasitism undoubtedly influences demographic characteristics and stock recruitment relationships in any stock that may be defined. This host-parasite interaction should be more extensively modelled to predict its influence on demographic characteristics and yield.

ASSESSMENT METHODS

3.1 Various assessment methods that have been used in other crustacean fisheries and that may be applicable to the *P. spinosissima* and *P. formosa* fishery in Subarea 48.3 were identified. The methods can be grouped as follows:

depletion methods;
change-in-ratio and index-removal methods;
size/length-based assessment analyses;
calibration of abundance indices;
production models; and
yield-per-recruit.

These methods, with the exception of yield-per-recruit, are discussed in turn and their main assumptions, data requirements and outputs are summarised in Table 2. For all of the assessment methods described below estimates of uncertainty of current stock status should be made and sensitivity to underlying assumptions and data quality should be explored.

3.2 These methods can be divided into two groups. The first group (depletion, change-in-ratio, index-removal, size/length-based assessment, and production model methods) require that the fishery substantially reduces the population from the study area since it is the change in the population due to known removals that is the basis of the estimation. The second group does not require that the fishery reduce the population size.

Depletion Methods

3.3 Depletion methods (also referred to as Leslie-De Lury methods) can, in theory, be applied to aggregated data over a whole fishing season or several years to obtain estimates of total population size. In the context of the crab fishery at South Georgia, it is at this stage more appropriate and feasible to consider local depletion models applied to data at a finer temporal and spatial scale.

3.4 Local depletion models use commercial catch-per-unit-effort (CPUE) and cumulative catch data to estimate local population densities in relatively small areas. These density estimates can then be used to extrapolate to a population size over a larger area if data on distribution of the stock are available. The main assumptions are that CPUE is proportional to the density and that the population is closed over the period considered in the analysis. The second assumption can often be relaxed though additional information may be required.

3.5 It is important that an appropriate measure of effort is used when constructing CPUE. Soak time of pots may, for example, have to be taken into account if there is any relationship between catch per pot and soak time or if there is any sign of saturation. The aggregated data on catch per pot and average soak time presented in WS-Crab-93/24 seem to show some form of saturation in

catch rate at a soak time of around 30 hours. Saturation can be due to many effects, for example, degradation of bait, and is usually determined from field studies.

3.6 Ideally, catch/effort data should be on as fine a spatial and temporal scale as possible. This is particularly relevant in this case because the level of effort is currently relatively low. Data at a coarse scale of, for example, 10-day periods by gridsquare (1° longitude by 0.5° latitude) may disguise any depletion occurring at a finer scale.

3.7 Some participants felt sceptical about the possibility of detecting any depletion effects, even on a local scale. Firstly, this is because there is a possibility that spawning and moulting are protracted for this species. Secondly, there is a single vessel in the fishery and it would tend to avoid depletion. The first issue can be addressed by developing a variation of the standard depletion method to take growth and recruitment into account, though this would clearly require additional information.

3.8 The second issue could be addressed by using an experimental approach. One possibility may be to request the fishing vessel(s) to do repeated sampling by settings of many strings in a relatively small area over a short period of time. Catch/effort data from this type of 'fishing experiment' may be very valuable for estimation of local density from depletion methods. From the point of view of a fishing vessel, this may be feasible over a period of one week or less since it is not in a vessel's interest to continue fishing once catch rates have dropped to very low levels. However, repeated sampling may generate emigration from the area.

3.9 It was noted that the assumption of constant catchability may not be realistic in this new fishery where fishermen are still in a process of learning. As long as the analysis is applied to data over a short time-period (one or two weeks rather than the entire season, for example) this should not be a problem.

3.10 Extrapolation from estimates of local density to larger areas should be done with great care as topology, substratum characteristics, depth, etc. may vary considerably between areas containing crab. Only areas of similar physical characteristics should be included in extrapolation, perhaps creating a need for more study areas. In some cases it may not be appropriate to extrapolate at all because of factors such as movement or migration of crabs and changes in size of animals by area (and/or depth).

Change-In-Ratio (CIR) and Index-Removal (IR) Methods

3.11 Descriptions of the CIR and IR methods and their application to snow crab are given in WS-Crab-93/10. Both these methods require some form of survey, either by appropriate trawl gear or pots, to randomly sample animals before and after the fishery. Total removals (i.e., total catch) is also required.

3.12 The CIR method uses the random samples to obtain estimates of the proportions of legal and sub-legal sized crabs before and after fishing. These proportions and the total removals are then used to estimate the population size and the number of legal-sized crabs before fishing, as well as catchability coefficients. The IR method uses estimates of catch rates before and after fishing from the random samples and the total removals to estimate the same parameters as the CIR method. It is also possible to combine estimates from the two methods as indicated in WS-Crab-93/10.

3.13 Both these methods are based on the assumption that the population is closed. The CIR method further assumes that all legal sized animals have the same probability of being caught. The IR method assumes that the probability of capture does not vary within or between surveys. As in the case of the depletion method, there are ways of relaxing these assumptions.

3.14 Most of the comments made with respect to the depletion method also apply to these two methods. The main difference is, however, that additional information from fishing at random locations is required for CIR and IR whereas the commercial fishery may not be prosecuted at random locations. There may be some advantage in looking at the feasibility of requesting the commercial vessel(s) to carry out fishing at random locations.

3.15 It would be particularly useful if estimates of population size from both the CIR/IR and depletion methods could be obtained. These estimates could also be combined with appropriate weighting (by, for example, inverse variance) to possibly improve the precision of the estimates.

Size/Length-based Methods

3.16 There are various methods that fall within this category. Length-based cohort analysis (or Jones method) is basically a deterministic model that uses catch in numbers by size class with estimates of growth rate, natural mortality and terminal fishing mortality to estimate population size. The main assumption which generally limits the use of this method is that the population is in equilibrium. The deterministic nature of this method means that it can, in theory, be applied to a single year's data though results would obviously be interpreted with great caution.

3.17 Length-converted catch curves are used to estimate total mortality. They require data and assumptions similar to those required for length-based cohort calculations. With a virgin population, length-converted catch curves can potentially be used to estimate natural mortality.

3.18 The length-based De Lury method (Conser, 1992) uses time series of indices of population numbers, by at least two size classes, and total catches together with some description of growth and mortality to estimate population sizes and fishing mortalities by size class. This method estimates parameters using a likelihood criterion.

3.19 Catch-at-size analysis (CASA) is similar to the length-based De Lury method but requires further information as indicated in Table 2.

3.20 All the size-based methods of assessment require relatively large amounts of detailed data and cannot really be applied to the crab fishery around South Georgia at this early stage.

3.21 These size-based methods also focus on the need to estimate growth parameters. Estimates of growth rates are also required for estimating other quantities such as yield. Since it is not possible to directly age crabs, other methods, for example, length frequency analyses have to be used. There are many problems associated with length frequency analyses although they have been applied to data from other crab fisheries. The first problem is that commercial data from pots are unlikely to be representative of the whole population. Ideally random samples from trawl catches or, possibly, from fine-meshed pots should be used. It may be feasible to use some fine-meshed pots on strings of commercial pots.

3.22 The second problem is that there is often a large degree of variability in the relationship between size and age because not all animals moult every year. A given cohort may exhibit a bi-modal or multi-modal distribution of sizes. As in the case of many other crustacean and fish species, the size distributions at older age classes overlap thus obscuring any modes at larger size in length frequency distributions.

3.23 Two of the most promising methods for obtaining good growth data are tagging studies and holding of pre-moult animals. These methods generally provide information on moult increments by size. Information on moult frequency by size is far more difficult to obtain.

3.24 There are clear advantages in starting tagging experiments at this early stage of the fishery. It is important to note that the design and extent of such an experiment would depend on its main purpose. If the main purpose of a tagging experiment is to obtain information on growth (rather than

estimating the population size, for example) then it would be appropriate to do intense tagging in a small area and return at a later stage to try and recover tagged animals. Such data would be useful even if the percentage of returned tags is low. Concern was expressed as to the feasibility of using tagging methods given the current low levels of effort in the fishery.

3.25 It was pointed out that tagging can produce reduced moult increments and high incidental mortality. Holding tank experiments are also advisable.

Calibration of Abundance Indices

3.26 The calibration of abundance indices include the following two methods. The first consists of using the catch rates (catch-per-pot) and some estimate of the effective area fished by a pot to calculate the population density and then extrapolate over a 'fishable' area. The main problem with this method is estimating the effective area fished by a pot. Since pots are baited, crabs are effectively attracted and the gear is therefore not passive. Furthermore, the area of attraction may well depend on the orientation of the string relative to currents and migration 'routes' of crabs. This method is not generally recommended for assessment unless the effective area fished can be estimated in a direct way by, for example, using radio-tagged crabs.

3.27 The second method consists of using a trawl to estimate density by the swept-area method and then doing comparative fishing trials to relate catch rates of traps to the density estimated by the trawl. For this purpose, it is best to estimate the gear efficiency of the trawl (e.g., by mounting a camera on the trawl). However, in some cases it may be acceptable to use the trawl density estimates uncorrected for gear efficiency (i.e., minimum trawlable biomass) as has been used for other crustacean fisheries.

3.28 There are various types of appropriate gear for crab surveys, including 'Nephrops' trawls and beam trawls. A type of 'snow plough' gear (Maynard and Conan, 1985) which employs a camera to photograph crabs lifted off the bottom and pushed up against a grid, for easy counting and measuring, has also been employed with success. The use of camera sleds in conjunction with line transect type survey methods could also be investigated.

3.29 Research surveys, independent of the commercial fishery, are of great value for comparison with other assessment methods based on the commercial data. Even if the likelihood of surveys for this fishery seems remote at this stage, it should be borne in mind as an assessment and monitoring method for the future.

Production Models

3.30 Production models, like depletion models, use changes in indices of abundance such as CPUE to estimate population size. This method has been applied to Dungeness crabs (Stocker and Butler, 1990¹). These methods work best where there is some contrast in the data and therefore many of the comments regarding the depletion methods and the relatively low current level of effort would also apply to production models.

Other *Ad Hoc* Methods

3.31 One of the *ad hoc* methods used in WG-FSA-92/29 for estimating appropriate catch levels (rather than population size) was to consider comparable species. This method is fraught with difficulties, as recognised by the WG-FSA, and is not recommended now that more information has been obtained.

MANAGEMENT APPROACHES

Harvesting Regimes

4.1 The goal of management of the Antarctic crab resource is preventing the reduction of the stock below the level at which the stock will be able to produce the maximum sustainable yield on a continuing basis. Working paper WS-Crab-93/5 reviews the management methods applied to crab stocks in other areas. In general, there are two primary categories of regulations controlling harvesting: (i) indirect controls on mortality through regulated minimum legal size, seasonal closures and prohibitions on harvesting females; and (ii) direct mortality controls through catch or effort limits.

4.2 The Workshop noted that controls on the size of the animals landed, prohibition on retaining female crabs and seasonal closures during peak spawning or moulting periods are very widely used for regulating crab fisheries. These measures have the advantage of being applicable even when information on the population dynamics of the resource is quite limited. For example, with the data available from the first year of fishing around South Georgia, minimum legal sizes have been determined which are expected to allow male crabs at least one mating year before they are vulnerable to the fishery. The justification for the prohibition of retaining females can be based on the basic biology of the animal, though further work is needed in the future to ensure that reproductive

¹ Stocker and Butler. 1990. *Fish. Res.*, 9: 231-254.

success is not impaired due to the reduction of the adult male population. Determining the appropriate timing of seasonal closures will require additional information on the life history of these crabs, in particular the seasonal patterns in moulting and spawning.

4.3 The Workshop participants also noted that size, sex and seasonal regulations would not restrict the expansion of the fishery and hence are termed ‘indirect controls’. In order for the development of the fishery to be geared to the collection of information necessary for conserving the resource, further controls on fishery expansion are required. The experience in Alaskan crab fisheries is that in those areas where direct controls on the mortality, through catch limits, have not been imposed, fishing mortality appears relatively high. Therefore, the Workshop recommends that both indirect and direct control measures be applied to the Antarctic crab fishery.

4.4 It was noted that the combination of direct and indirect controls can mean that catch limits need not be set precisely or conservatively, since the indirect controls should protect the stock from reproductive failure in the short-term even if the catch is too high to be sustainable in the longterm. However, if the catches exceed the longterm sustainable level, the fishery will be affected by having greater sensitivity to variations in recruitment, lower average catch rates, and greater proportion of the catch with new shells and thus low meat quality.

4.5 More specifically, a minimum legal landing size for both *P. spinosissima* and *P. formosa* should be applied. Only legal sized male crabs should be retained in the catch, except if an experimental strategy for reducing parasite infestation is attempted (paragraph 4.8). No seasonal closure can be recommended at present until more biological data become available. Investigation of yield/recruitment and maturation processes may influence the setting of minimum sizes in the future.

4.6 In the future, a catch limit should be calculated based on analysis of the available data to determine both an assessment of biomass (virgin and current) and the maximum proportion of the exploitable stock that can be harvested on a sustainable basis. There is no reliable assessment of stock biomass currently available (see Section 3 above).

Approaches to Management

4.7 The Workshop discussed additional approaches to management which should yield substantial new information as well as improve conservation of the crab resource. To reduce the number of crabs below the minimum legal size which are caught, a minimum mesh size or the requirement for an escape port in the pots should be considered. In addition, to prevent lost pots from continuing to kill crabs, a biodegradable or galvanic time release device which opens the traps

should be required. Reducing the number of crabs caught and then discarded should improve conservation. There is some evidence that crabs caught and then discarded may not die immediately after capture and so mortality due to handling can be substantially underestimated. Additional studies on handling mortality are desirable.

4.8 The Workshop discussed the management implications of modelling studies of the parasite infestation of *P. spinosissima* (WS-Crab-93/7 and 9). Harvesting of the infected crabs may reduce the prevalence of the parasite in the population and so improve the reproductive potential of the stock (the parasite renders an infected crab sterile). One possibility discussed was the destruction of any infected crabs caught, irrespective of crab size. The Workshop recommended that the feasibility of this be investigated.

4.9 In order to obtain more information on the dynamics of the parasite infection as well as on the response of the crab stock to different levels of harvest, the Workshop recommended that the fishing area might be divided into differential fishing zones. In one zone, the catch would be much smaller than in the other. Each zone would be further partitioned so that in one part, sub-legal size parasite infected *P. spinosissima* would be destroyed and in the other part they would not. Pots in an experimental management regime should enable capture of parasitised crabs.

4.10 The Workshop recognised that such an experimental management regime would not be an ideal statistical experiment since replicate treatments would not be possible. However, it was the consensus of the participants that substantial information could be obtained in this way, even if a formal statistical test would not be feasible, particularly if the system was operated over several fishing seasons.

4.11 Finally, the Workshop discussed multispecies implications of the developing crab fishery. There are two concerns: (i) that crabs may be important prey items for other species in the area of the fishery; and (ii) that there is a by-catch in the crab fishery which is likely to impact other stocks. There is, at this stage, no real evidence to suggest that either of these concerns warrant additional restrictions with respect to the development of the fishery or its subsequent management.

DATA AND REPORTING REQUIREMENTS

5.1 Table 1 summarises basic biological, demographic and distributional data required for a more complete understanding of *Paralomis* spp. and to enable more sophisticated use of the methods discussed under Agenda Item 3. These data may not necessarily be obtainable from the commercial fishery but if they can be obtained this will usually require the presence of observers.

WS-Crab-93/6 describes some biological and catch/effort data that may be obtained from the fishery without the use of observers.

5.2 The logbook issued by the US to the vessel engaged in fishing in 1992 and 1993 for recording haul-by-haul catch and effort details (WS-Crab-93/16) currently contains the following:

Cruise Descriptions:

cruise code, vessel code, permit number, year.

Pot Descriptions:

pot shape, dimensions, mesh size, funnel attitude,
number of chambers, presence of an escape port.

Effort descriptions

date, time, latitude and longitude of the start of the set;
number of pots set, number of pots lost, depth, soak time;
bait type.

Catch Descriptions

retained catch in numbers;
catch of regulated fish, if present.

5.3 To these, the Workshop suggested that the following should be added:

number of pots on the line;
spacing of pots on the line;
by-catch of all species, irrespective of regulated status; and
incremental record number, for linking with sample information.

5.4 If a management strategy involving the destruction or utilisation of parasitised undersized males and parasitised females were to be imposed it would be important that the numbers of crabs in these categories were recorded on the catch and effort logbook.

5.5 Currently, commercial vessels are required to measure a subsample of 35 crabs (all species combined) each day, although there is no specific guidance about the way the catch should be sampled. A random sampling strategy is extremely important if the resultant data are to be a representative, statistically robust sample of the catch.

5.6 Crabs could be sampled by (i) taking 35 crabs from the whole catch over the day, (ii) taking 35 crabs randomly from the total catch of a single line, or (iii) taking 35 crabs from a number of pots on a line. The former two methods suffer from the likelihood of bias by selection by fishermen, and

the latter produces imprecise estimates due to aggregation by the pots - (crabs might aggregate by sex, size or parasitic infection, for instance).

5.7 As long as the likelihood of aggregations is recognised and considered in statistical analyses (cluster sampling, analysis of inter-pot variance) the latter method is likely to prove most reliable in this fishery. It has the additional advantage that it is likely to be the least disruptive of fishing activities. Pots typically contain less than 35 crabs, so a number of pots may have to be sampled.

5.8 Accordingly, the Workshop recommends that crabs are sampled from the line hauled just prior to noon, by collecting the entire contents of a number of pots spaced at intervals along the line so that at least 35 specimens are represented in the subsample.

5.9 The logbook for recording biological data (WS-Crab-93/14) currently contains the following:

Cruise Descriptions:

cruise code, vessel code, permit number

Sample Descriptions

date, position

Data

species, sex, length for 35 individuals.

5.10 The Workshop suggested that the subsample should be linked to the line information by including:

line number; and

position of the start of the set,

and that the following additional information should be collected:

presence/absence of rhizocephalan parasites;

a record of the destination of the crab: kept, discarded, destroyed; and

a record of the pot number from which the crab comes.

5.11 Paragraphs 5.2 to 5.10 above discuss the data which should be collected by commercial vessels fishing for crab. Paragraph 7 of Conservation Measure 60/XI requests that the Workshop decide which of these detailed data should be reported to CCAMLR and in what form. The conservation measure sets minimum guidelines for this in its paragraph 5: (i) fine-scale data with a

resolution of at least 1° longitude by 0.5° latitude by 10 day period; and (ii) species, size and sex composition of a subsample.

5.12 The Workshop agreed that data at the finest scale possible would be desirable for good assessment and management of the fishery according to the methods outlined under Agenda Items 3 and 4. However, the Workshop did not agree on the precise format of data to be submitted to CCAMLR.

5.13 Dr Holt expressed the opinion that since a single vessel was engaged in the fishery, haul-by-haul data containing precise positional and depth information would be considered confidential and could not be submitted to CCAMLR except in summary form.

5.14 It was pointed out that since the fishery was in its early stage, there were certain management measures that could be taken which would not demand data of as fine a resolution as the haul-by-haul data for the current year. As the fishery proceeded an increase in precision might be necessary as management and assessment methods became more sophisticated.

5.15 It might also be possible to report data using methods which retained a sufficient degree of detail to be used in the assessment and management, but which did not reveal the commercially confidential details. Translocation/transformation of position, categorisation of depth and aggregation of data by areas smaller than 1° longitude by 0.5° latitude were examples of these.

5.16 Prof. J. Beddington (UK) expressed the view that since the highest resolution of these data was haul-by-haul and many of the assessment and management methods were most efficient when the finest scale data are available for use, haul-by-haul data should be reported. Although the types of categorisation suggested in paragraph 5.15 could perhaps eventually be used in management, it would not be possible to decide on the appropriateness of these scales until haul-by-haul data had been examined.

5.17 Examples from other crab fisheries indicated that on the east and west coast of the US some haul-by-haul data are provided for management analyses. However, such data is kept confidential to protect commercial operators. In other cases only aggregated data are reported.

5.18 In view of these differences, the Workshop was unable to provide a unanimous recommendation for the data reporting requirements of Conservation Measure 60/XI, paragraph 7.

Management Measures

6.1 Following the management approaches adopted at CCAMLR-XI, the fishery should continue to be managed by both indirect and direct controls on harvesting:

Indirect: limits on retention of crab by size, sex (males only) and in the future possibly season (the 3S approach).

Direct: catch limits for each season, initially set as a precautionary measure and refined as data become available.

6.2 The use of galvanic time releasers or biodegradable devices, which effectively destroy the pot long before normal decay processes would, will reduce the effects of ghost fishing should pots be lost from a line and should be considered.

6.3 Adoption of a minimum mesh size and/or the inclusion of an escape port (usually a metal ring set into the side of the pot) in pots should be considered following research on mesh or port selectivity, to better select only crabs of harvestable size and reduce the number of discards (paragraph 4.7).

6.4 Harvesting or destruction of parasitised crabs of all ages and sexes may reduce the prevalence of parasitism in the population, and should be considered (paragraph 4.8). In this regard, use of pots with smaller mesh or escape port sizes would catch more parasitised crabs, but would expose small unparasitised crabs to the high wind chill factors on deck, with a consequent possibility of discard mortality.

6.5 The Workshop recommended the use of depletion methods, the change-in-ratio and index-removal methods and the analysis of length frequency distribution methods for assessment purposes at this stage (paragraphs 3.3, 3.11 and 3.21).

6.6 The Workshop recommended that the possibility of designing an experimental approach to harvest strategies should be considered, for instance, one in which local depletion of the population is encouraged over a short period of time or a survey is conducted before and after the fishing season (paragraphs 3.8 and 3.11).

6.7 A further experimental approach would be to divide Subarea 48.3 into several crab management areas. Different levels of fishing effort would then be applied to the different areas (by imposition of area-specific catch limits), and/or they could receive different parasite management strategies or mesh size strategies as discussed in paragraph 4.9.

Data Requirements

6.8 There are a number of biological phenomena which require investigation (Table 1). Much of the biological data required, by Table 1, could be obtained by observers on commercial vessels. In this case, the Workshop suggested that pots with finer mesh or escape ports should be added to lines of commercial pots to collect crabs of all sizes (paragraph 3.21).

6.9 Fine-meshed pots or small escape port pots will also provide data on the overall length frequency of the population. Despite the difficulties in interpreting these length frequencies to estimate growth and natural mortality (paragraph 3.17) the Workshop recognised that a large dataset collected at the start of the fishery (when the population is still in a virgin state) would have the potential to be extremely valuable in the future when other factors required for its interpretation (such as moult frequency and size increments) are better understood.

6.10 Additional information which observers could collect includes data on discard mortality. However, in crabs, discard mortality may not be evident until some months after the catching incident, because damage may result in an inability to moult rather than immediate death, and consequently discard mortality studies should be of long duration.

6.11 The Workshop agreed on the data that should be collected by commercial vessels fishing for crab. These are given in Section 5. The Workshop was unable to provide a unanimous recommendation for the data reporting requirements of Conservation Measure 60/XI, paragraph 7.

OTHER BUSINESS

7.1 Recognising that very little information concerning Antarctic crabs is available, Dr A. Paul (USA) suggested that it would be useful for CCAMLR to maintain an ongoing bibliography for these species.

ADOPTION OF THE REPORT

8.1 The report was adopted.

CLOSE OF THE MEETING

9.1 In closing the meeting, the Convener thanked all participants for their hard work and cooperation during the meeting. He congratulated the participants for producing critical information requested by CCAMLR.

9.2 He also thanked the Secretariat for their high standards of professionalism and hard work in making sure the meeting ran smoothly and efficiently.

9.3 Finally, he expressed appreciation to the staff of the Southwest Fisheries Science Center for their support during the meeting.

9.4 The Convener then closed the meeting.

Table 1: Research needs for *P. spinosissima* and *P. formosa*.

Knowledge Required	Sources	Priority
<u>Reproductive Dynamics</u>		
Number of eggs extruded by size of crab	Lab analyses	High ^a
Number of eggs hatched by size of crab	Lab analyses	High
Incubation period by season and duration [estimated: 1year]	Tank holdings, tagging, seasonal monitoring	High
Female mating frequency by season [estimated:1-2 years]	Tank holdings, tagging, seasonal monitoring	High
Percent carrying fertilized eggs by season and size of crab	Catch sampling	High
Egg hatching location by season and depth	Research survey, catch sampling	Low
Larvae location by season and depth	Research survey	Low
Duration of larval stage	Research survey, lab holdings	Low
Proportion maturity by size	Catch sampling	High ^a
<u>Growth Dynamics and Mortality</u>		
Growth rate	Catch data, length frequency	High
Moult increment by season and size	Tank holdings, tagging	High
Duration of intermoult period by season and size	Lab studies, tagging, radioisotope studies	High
Allometry of chela (estimation of size at maturity)	Commercial observer, research survey	High ^a
Mortality (by size)	Catch monitoring, length frequency analysis, tagging	Med
<u>Host-Parasite Interaction</u>		
Reproductive output of rhizocephalan	Tank holdings	Med
Brooding period of rhizocephalan	Tank holdings	Med

^a Some data are already available for this item (WS-Crab-93/24 and WG-FSA-92/29)

Table 1 (continued)

Knowledge Required	Sources	Priority
Fine-scale prevalence of rhizocephalan	Catch sampling	High
Host susceptibility characteristics	Lab experiments	Med
Effect of parasite on growth	Lab experiments	Low
Incidence of hyperparasitisation	Catch sampling	Med
Effect of hyperparasitisation	Catch sampling, lab experiments	Med
Parasite larval duration	Lab experiments	High
Intensity of symbiotic egg predators	Catch sampling	Med
<u>Distribution and Stock Identity</u>		
Depth range by sex, size, reproductive condition, parasitic infestation, substratum type	Commercial observer, research survey	High
Geographic distribution	Exploratory survey	High
Larval dispersion	Plankton survey (old plankton records)	Low
Stock identity	Morphometrics genetics (mitochondrial DNA)	Low

Table 2: Assumptions and data requirements of assessment methods.

Method	Data Requirements	Main Assumptions	Outputs
Depletion methods	<ul style="list-style-type: none"> Catch And appropriate measure of effort to construct CPUE; or Some other INDEX of abundance 	<ul style="list-style-type: none"> Closed* population CPUE is proportional to population size 	<ul style="list-style-type: none"> Population size (or local abundance) Catchability coefficient Exploitable rate (fishing mortality) Fishing power of gear Possible estimate of recruitment
Change-in-ratio (CIR) and Index-removal (IR)	<ul style="list-style-type: none"> Random samples before and after fishing Total catches 	<ul style="list-style-type: none"> Closed population CIR: all animals have same probability of being captured IR: probability of capture does not vary within or between surveys 	<ul style="list-style-type: none"> Population size Catchability coefficient Exploitable rate (fishing mortality) Fishing power of gear Possible estimate of recruitment
Length-based cohort analysis	<ul style="list-style-type: none"> Catch in numbers by size class Growth rate Natural mortality Terminal fishing mortality 	<ul style="list-style-type: none"> Closed population Equilibrium population 	<ul style="list-style-type: none"> Population numbers by size class Fishing mortality by size class
Length-converted catch curves	<ul style="list-style-type: none"> Abundance in numbers by size class Growth rate Age at full recruitment 	<ul style="list-style-type: none"> Equilibrium population Closed population 	<ul style="list-style-type: none"> Total mortality $Z = F + M$
Length-based De Lury (Conser, 1992)	<ul style="list-style-type: none"> Index of population size in numbers by size class over time Total catch over time Growth (parameters or description) Natural mortality 	<ul style="list-style-type: none"> Closed population 	<ul style="list-style-type: none"> Population numbers by size class Fishing mortality by size class Catchability coefficient(s)
Catch-at-size analysis	<ul style="list-style-type: none"> Index of population size in numbers by size class over time Total catch over time Growth (parameters or description) Natural mortality Probability distribution for length-at-age Selectivity coefficient 	<ul style="list-style-type: none"> Closed population 	<ul style="list-style-type: none"> Population numbers by size class Fishing mortality by size class Catchability coefficient(s)
Calibrating index of abundance	<ul style="list-style-type: none"> Index of abundance Estimate of calibration factor Catchability coefficient 	<ul style="list-style-type: none"> Various - depends on the type of index 	<ul style="list-style-type: none"> Population size Exploitation rate
Production models	<ul style="list-style-type: none"> Catch and effort data 	<ul style="list-style-type: none"> Various - depends on model used 	<ul style="list-style-type: none"> Population size Parameters relating to growth/recruitment and “carrying capacity”

* Closed to known immigration and emigration.

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(La Jolla, California, USA - 26 to 28 April, 1993)

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LIST OF DOCUMENTS

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(La Jolla, California, USA - 26 to 28 April 1993)

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- WS-CRAB-93/19 NOTA SOBRE LA PRESENCIA DE *PARALOMIS SPINOSISSIMA* Y *PARALOMIS FORMOSA* EN LAS CAPTURAS DE LA CAMPAÑA “ANTARTIDA 8611”
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- WS-CRAB-93/20 DEMOGRAPHY OF THE KOREAN BLUE CRAB, *PORTUNUS TRITUBERCULATUS* FISHERY EXPLOITED IN THE WEST COAST OF KOREA AND THE EAST CHINA SEA
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- WS-CRAB-93/21 A BRIEF EXPLOITATION OF THE STONE CRAB *LITHODES MURRAYI* (HENDERSON) OFF SOUTH WEST AFRICA, 1979/80
R. Melville-Smith (South Africa)
- WS-CRAB-93/22 QUANTITATIVE STOCK SURVEY AND SOME BIOLOGICAL AND MORPHOMETRIC CHARACTERISTICS OF THE DEEP-SEA RED CRAB *GERYON QUINQUEDENS* OFF SOUTH WEST AFRICA
C.J. De B. Beyers and C.G. Wilke (South Africa)

WS-CRAB-93/23 A SYSTEM-OF-EQUATIONS APPROACH TO MODELING AGE-STRUCTURED FISH POPULATIONS: THE CASE OF ALASKAN RED KING CRAB, *PARALITHODES CAMTSCHATICUS*
Joshua A. Greenberg, Scott C. Matulich and Ron C. Mittelhammer (USA)

WS-CRAB-93/24 PLOTS OF SOUTH GEORGIA ISLAND CRAB DATA
R.S. Otto (USA)

WS-CRAB-93/25 EXTRACT FROM: MACPHERSON, E. 1988. REVISION OF THE FAMILY LITHODIDAE SAMOUELLE, 1819 (CRUSTACEA, DECAPODA, ANOMURA) IN THE ATLANTIC OCEAN. *MONOGRAFÍAS DE ZOOLOGÍA MARINA* VOL. 2: 9-153

OTHER DOCUMENTS

WG-FSA-92/29 A PRELIMINARY REPORT ON RESEARCH CONDUCTED DURING EXPERIMENTAL CRAB FISHING IN THE ANTARCTIC DURING 1992 (CCAMLR AREA 48)
Robert S. Otto and Richard A. MacIntosh (USA)

AGENDA

Workshop on the Management of the Antarctic Crab Fishery
(La Jolla, California, USA - 26 to 28 April 1993)

1. Opening of the Meeting
 - (i) Review of the Meeting Objectives
 - (ii) Adoption of the Agenda

2. Information on the *Paralomis spinosissima* stock
 - (i) Biological Characteristics
 - (ii) Distribution, Stock Identity
 - (iii) Demographic Characteristics
 - (iv) Parasitism

3. Assessment Methods

4. Management Approaches
 - (i) Harvesting Regimes
 - (ii) Approaches to Management

5. Data and Reporting Requirements

6. Advice to the Scientific Committee
 - (i) Longterm Management Plan for the Crab Fishery
 - (ii) Data Reporting Requirements

7. Other Business

8. Adoption of the Report

9. Close of the Meeting.

1993 ASSESSMENT SUMMARIES

Assessment Summary: *Notothenia rossii*, Subarea 48.3

Source of Information: This Report

Year:	1988	1989	1990	1991	1992	1993	Max ²	Min ²
Recommended TAC			0					
Agreed TAC			300	300	0			
Landings	197	152	2	1	1	0		
Survey Biomass	1699	2439	1481 ^a 3915 ^b 3900 ^b	4295 ^c 10022 ^d	7309 ^c			
Surveyed by	USA/POL	UK/POL	UK/POL ^a USSR ^b	UK ^c USSR ^d	UK ^c			
Sp. Stock Biomass ³		No information available						
Recruitment (age...)		since 1985/86						
Mean F (.....) ¹								

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 and 3/IV

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	SSB	Catch	F	SSB	Catch	

Weights in tonnes

Assessment Summary: *Champscephalus gunnari*, Subarea 48.3

Source of Information: This Report

Year:	1988	1989	1990	1991	1992	1993	Max ²	Min ²
Recommended TAC	31500	10200	12000		8400-61900	9200-15200		
Agreed TAC	35000	- ⁴	8000	26000	0	9200		
Landings	34619	21359	8027	92	5	0		
Survey Biomass	15716	24241	72090 ^a	27111 ^a	43763 ^a			
Surveyed by	USA/POL	UK/POL	442168 ^b UK/POL ^a USSR ^b	192144 ^b UK ^a USSR ^b	UK ^a			
Stock Biomass ³	70	50	50	50.5				
Recruitment (age 1)	500	500	(millions)					
Mean F (.....) ¹					0			

Weights in '000 tonnes

¹ ... weighted mean over ages (...)

³ From VPA (2+)

² Over period 1982 to 1992

⁴ Prohibition from 4 November 1988

Conservation Measures in Force: 19/IX and 33/X

Catches:

Data and Assessment: Extensive re-analysis of VPA and survey estimates of biomass produced a more consistent past series of *C. gunnari* biomass. However, for stock projections the 1992 survey was used to estimate 1993/94 biomass between 51 and 396 '000 tonnes

Fishing Mortality:

Recruitment:

State of Stock: Unknown pending a proposed 1993/94 survey by the UK.

Forecast for 1993/94:

Option Basis	1993		1994		Implications/ Consequences
	F	Stock	Catch	Catch	
F _{0.1}					
Projection 1	95% confidence limits			20850	
Projection 2	95% confidence limits			13209	

Weights in '000 tonnes

Note: Age 2+, assumes recruitment at lower 95% confidence limit

Assessment Summary: *Patagonotothen guntheri*, Subarea 48.3

Source of Information: This Report

Year:	1988	1989	1990	1991	1992	1993	Max ²	Min ²
Recommended TAC		-	-	20-36000	0			
Agreed TAC		13000	12000	0	0			
Landings	13424	13016	145	0	0	0		
Survey Biomass				584 ^a	12746			
Surveyed by				16365 ^b				
				UK ^a	UK			
				USSR ^b				
Sp. Stock Biomass ³			na					
Recruitment (age 1)			na					
Mean F (3 - 5) ¹			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: 34/X

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	SSB	Catch	F	SSB	Catch	

Weights in tonnes

Assessment Summary: *Dissostichus eleginoides*, Subarea 48.3

Source of Information: This Report

Year:	1988	1989	1990	1991	1992	1993	Max ²	Min ²
Recommended TAC			-					
Agreed TAC			-	2500 ⁵	3500	3350		
Landings	1809	4138	8311	3843	3703	2990		
Survey Biomass	674	326	9631 ^{*a}	335 ^{+a}	19315 [*]	3353 [*]		
			1693 ^{*b}	3020 ^{+b}	885 ⁺	2460 ⁺		
Surveyed by	USA/ POL ⁴	UK/ POL ⁴	POL/UK ^a USSR ^b	UK	UK			
Stock Biomass ³			20745 - 435817			11000-17000		
Recruitment (age...)			na					
Mean F (.....) ¹			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: 35/X, 36/X, 37/X

Catches: TAC of 3 350 tonnes, 2 990 tonnes taken due to problems with projecting date of closure of the fishery.

Data and Assessment: Haul-by-haul data enabled estimates of local density based on CPUE analysis for individual vessels. Exploitable biomass estimated to be 10 700 tonnes to 17 400 tonnes at beginning of 1992/93 season.

Fishing Mortality: Exceeds $F_{0.1}$.

Recruitment: No new information.

State of Stock: Model projections indicate exploitable biomass may have been depleted to around 30% of the unexploited level. Suggested catch levels: 900 to 1 700 tonnes.

Forecast for 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	SSB	Catch	F	SSB	Catch	

Weights in tonnes

Assessment Summary: *Notothenia gibberifrons*, Subarea 48.3

Source of Information: This Report

Year:	1988	1989	1990	1991	1992	1993	Max ²	Min ²
Recommended TAC					500-1500			
Agreed TAC					0			
Landings	5222	838	11	3	4	0		
Survey Biomass	7800	8500	17000	25000	29600			
Surveyed by	USA	UK	UK USSR	UK USSR	UK			
Sp. Stock Biomass ³	4300	3300	4300	6200				
Recruitment (age 2)	24000	21000	27000	25000				
Mean F (.....) ¹	0.86	0.54	0.014	0.0002				

Weights in tonnes

- ¹ Weighted mean over ages 2 to 16
- ² Over period 1975/76 to 1991/92
- ³ From VPA using survey $q = 1$ model

Conservation Measures in Force: 34/X

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	Stock	Catch	F	Stock	Catch	

Weights in tonnes

Assessment Summary: *Chaenocephalus aceratus*, Subarea 48.3

Source of Information: This Report

Year	1988	1989	1990	1991	1992	1993	Max ²	Min ²
Recommended TAC		1100	0	300	300-500			
Agreed TAC		0	300	300	0			
Landings	313	1	2	2	2	0	1272	1
Survey Biomass	6209	5770	14226 ^a	13474 ^c	12500			
			14424 ^b	18022 ^d				
			17800 ^b					
Surveyed by	USA/POL	UK/POL	UK/POL ^a	UK ^c	UK			
			USSR ^b	USSR ^d				
Sp. Stock Biomass ³	4156	4404	5098 ⁴					
Recruitment (age 2)	8648	6717	4047 ⁴					
Mean F (.....) ¹	0.13	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: 34/X

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	Biomass	Catch	F	SSB	Catch	

Weights in tonnes

Assessment Summary: *Pseudochaenichthys georgianus*, Subarea 48.3

Source of Information: This Report

Year	1988	1989	1990	1991	1992	1993	Max ²	Min ²
Recommended TAC		1800	0	300	300-500			
Agreed TAC			300	300	0			
Landings	401	1	1	2	2	0	1661	1
Survey Biomass	9461	8278	5761 ^a 12200 ^b 10500 ^b	13948 ^c 9959 ^d	13469			
Surveyed by	USA/POL	UK/POL	UK/POL ^a USSR ^b	UK ^c USSR ^d	UK			
Sp. Stock Biomass ³	8090	8889 ⁴						
Recruitment (age 1)	1372							
Mean F (.....) ¹	0.15							

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: 34/X

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	Biomass	Catch	F	SSB	Catch	

Weights in tonnes

Assessment Summary: *Notothenia squamifrons*, Subarea 48.3

Source of Information:

Year	1988	1989	1990	1991	1992	1993	Max ²	Min ²	Mean ²
Recommended TAC			0	300	300				
Agreed TAC			300	300	0				
Landings	1553	927	0	0	0	0	1553	0	563
Survey Biomass	409	131	1359 ^a	1374	1232				
Surveyed by	USA/POL	UK/POL	UK/POL ^a	UK	UK				
			534 ^b						
			USSR ^b						
Sp. Stock Biomass ³									
Recruitment (age...)									
Mean F (....) ¹									

Weights in tonnes, recruits in

1 ... weighted mean over ages (...)

2 Over period 1982 to 1992

3 From VPA using (.....)

Conservation Measures in Force: 34/X

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	SSB	Catch	F	SSB	Catch	

Weights in tonnes

Assessment Summary: *Electrona carlsbergi*, Subarea 48.3

Source of Information:

Year	1988	1989	1990	1991	1992	1993	Max ²	Min ²	Mean ²
Recommended TAC	-	-	-	-	-	-			
Agreed TAC	-	-	-	-	245000				
Landings	14868	29673	23623	78488	46960	0			
Survey Biomass	1200 kt	USSR ⁴							
Surveyed by	160 kt	USSR ⁵							
Sp. Stock Biomass ³									
Recruitment (age...)									
Mean F (.....) ¹									

Weights in tonnes, recruits in

- 1 ... weighted mean over ages (...)
- 2 Over period 1982 to 1992
- 3 From VPA using (.....)
- 4 WG-FSA-90/21 large portion of Subarea 48.3
- 5 WG-FSA-90/21 Shag Rocks region

Conservation Measures in Force: 38/X; TAC 245 000 tonnes. 39/X, 40/X.

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	Exploitable Biomass	Catch	F	Exploitable Biomass	Catch	

Weights in '000 tonnes

Assessment Summary: *Notothenia rossii*, Division 58.5.1

Source of Information: This Report

Year	1988	1989	1990	1991	1992	1993	Max ²	Min ²	Mean ²
Recommended TAC									
Agreed TAC									
Landings	21	245	155	287	0	0			
Survey Biomass									
Surveyed by									
Sp. Stock Biomass ³									
Recruitment (age...)									
Mean F (.....) ¹									

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°: 18, 20, 32 (for details see SC-CAMLR-VIII, Annex 6, Appendix 10, page 290).

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	SSB	Catch	F	SSB	Catch	

Weights in tonnes

Assessment Summary: *Notothenia squamifrons*, Division 58.5.1

Source of Information: This Report

Year	1988	1989	1990	1991	1992	1993	Max ²	Min ²	Mean ²
Recommended TAC									
Agreed TAC	2000	2000 ⁴							
Landings	39	1553	1262	98	1	0			
Survey Biomass									
Surveyed by									
Sp. Stock Biomass ³									
Recruitment (age...)									
Mean F (.....) ¹									

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 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	SSB	Catch	F	SSB	Catch	

Weights in tonnes

Assessment Summary: *Champocephalus gunnari*, Division 58.5.1

Source of Information: This Report

Year	1988	1989	1990	1991	1992	1993	Max ²	Min ²	Mean ²
Recommended TAC									
Agreed TAC									
Landings (Kerguelen)	157	23628		12644	44	0			
Landings (Combined)									
Survey Biomass									
Surveyed by									
Sp. Stock Biomass ³									
Recruitment (age...)									
Mean F (.....) ¹									

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 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	SSB	Catch	F	SSB	Catch	

Weights in tonnes

Assessment Summary: *Dissostichus eleginoides*, Division 58.5.1

Source of Information: This Report

Year	1988	1989	1990	1991	1992	1993	Max ²	Min ²	Mean ²
Recommended TAC									
Agreed TAC									
Landings	554	1630	1062	1848	7492	2722	7492	121	
Survey Biomass	27200								
Surveyed by									
Sp. Stock Biomass ³									
Recruitment (age...)									
Mean F (.....) ¹									

Weights in tonnes, recruits in

- ¹ ... weighted mean over ages (...)
- ² Over period 1982 to 1992
- ³ From VPA using (.....)

Conservation Measures in Force: Catch limit in 1992/93.

Catches: Western grounds: 92 tonnes trawl } France 941 tonnes
 Northern grounds: 2 630 tonnes trawl } Ukraine 1 781 tonnes

Data and Assessment: 1988 survey estimate of 27 200 tonnes divided between western stock (19 000 tonnes) and other areas. Northern grounds not included in survey area however.

Fishing Mortality: $F_{0.1}=0.151$ (13.3% catch/biomass ratio)
 $F_{50\%SSB}=0.08$ (7.3% catch/biomass ratio)

Recruitment: No information.

State of Stock: Northern stock - unknown.
 Western stock - likely to be above 50% unexploited spawning stock size.

Forecast for 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	SSB	Catch	F	SSB	Catch	

Weights in tonnes

Western stock: $F_{0.1}$ gives 1 820 tonnes yield but recommend use of $F_{50\%SSB}$
 $F_{50\%SSB}$ gives 1 400 tonnes longterm yield

Northern stock: Precautionary TAC needed. Recent catches likely to be too high.

Assessment Summary: *Notothenia squamifrons*, Division 58.4.4

Source of Information: This Report

Year	1988	1989	1990	1991	1992	1993	Max ²	Min ²	Mean ³
Recommended TAC (Lena Bank)									
Agreed TAC									
Landings (Ob Bank ^a)	2989	850	867	?	0		4999	0	1151
Landings (Lena Bank ^a)	2013	3166	596	?	0		6284	0	1335
Landings (Combined ^b)	5002	4016	1463	575	0	0	11283	027	2487
Survey Biomass (Ob Bank)		12700							
Survey Biomass (Lena Bank)									
Surveyed by		USSR							
Sp. Stock Biomass ⁴				na					
Recruitment (age...)				na					
Mean F (.....) ¹									

Weights in tonnes, recruits in

¹ ... weighted mean over ages (...)

^a From WG-FSA-92/5

² Over period 1982 to 1992

^b From SC-CAMLR-IX/BG/2

³ Assumes TAC of 267 tonnes for Ob Bank and 305 tonnes for Lena Bank was taken in 1991

Part 2 (Statistical Bulletin)

⁴ From VPA using (.....)

Conservation Measures in Force: 2/III and 4/V

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	SSB	Catch	F	Biomass	Catch	

Weights in tonnes

**REPORT OF THE WORKING GROUP FOR THE
CCAMLR ECOSYSTEM MONITORING PROGRAM**
(Seoul, Republic of Korea, 16 to 23 August 1993)

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Antarctic Fur Seal

Further Discussion on the Modelling Exercise

LIAISON WITH WG-KRILL AND WG-FSA

OTHER BUSINESS

IUCN Assessment of Marine Protected Areas

Sixth SCAR Symposium on Antarctic Biology
SO-GLOBEC
SCAR Antarctic Pack-ice Seals (APIS) Program
Exploratory Fisheries

SUMMARY OF RECOMMENDATIONS AND ADVICE

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REPORT OF THE WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM

(Seoul, Republic of Korea, 16 to 23 August 1993)

INTRODUCTION

1.1 The Eighth Meeting of the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP) was held at the Hoam Faculty House, Seoul National University, Seoul, Republic of Korea from 16 to 23 August 1993. The meeting was chaired by the Convener, Dr J.L. Bengtson (USA).

1.2 The Convener opened the meeting and welcomed participants. On behalf of the Working Group, he expressed thanks to both the Government of the Republic of Korea and the Korea Ocean Research and Development Institute for inviting the Working Group to hold its meeting in Seoul.

1.3 Scientists from 13 Member countries, namely, Argentina, Australia, Chile, Germany, Italy, Japan, the Republic of Korea, Norway, Russian Federation, South Africa, Sweden, UK and USA, participated in the meeting. The Working Group noted its disappointment that, due to unavoidable delays, Dr T. Øritsland (Norway) was unable to join the meeting until near the end of the session when most agenda items had been closed.

1.4 The Convener welcomed the increased participation in the WG-CEMP meeting. Indeed, he noted that, following his letter to scientists from four Member countries encouraging wider participation in CEMP (SC-CAMLR-XI, Annex 7, paragraph 3.10), Germany had nominated Dr J. Plötz, from the Alfred-Wegener Institute for Polar and Marine Research, to attend the meeting. However, the Working Group noted with regret the absence from the meeting of scientists from Brazil, France and New Zealand. A further discussion of this issue is provided in paragraphs 3.3 and 3.4.

ADOPTION OF THE AGENDA

2.1 The Provisional Agenda was introduced and discussed. Three additional topics were proposed for consideration under "Other Business", namely, "SO-GLOBEC", "SCAR APIS Program" and "Exploratory Fisheries". With these changes, 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 D. Agnew (Secretariat), P. Boveng (USA), J. Croxall (UK), B. Fernholm (Sweden), K. Kerry (Australia) and E. Sabourenkov (Secretariat).

REVIEW OF MEMBERS' ACTIVITIES

3.1 During the 1992/93 season Members continued to be actively involved in the collection of data using CEMP Standard Methods and in other research in support of CEMP. A total of 52 documents were submitted for consideration at the meeting. A summary of Members' activities is given in Tables 1, 2 and 3.

3.2 Scientists present at the 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 Working Group noted that important work of direct relevance to CEMP is being conducted by scientists from Brazil, France, New Zealand and Poland. Unfortunately, these scientists were unable to participate in the meeting or to contribute data.

3.4 The Convener advised the Working Group that, as requested (SC-CAMLR-XI, Annex 7, paragraph 3.10), he had written to 17 scientists in France, Germany, New Zealand and South Africa during the intersessional period apprising them of WG-CEMP's activities and encouraging their participation. Responses received indicated an interest in becoming involved, but noted that funding and scheduling difficulties were hampering this. The Working Group asked the Convener to continue to encourage participation from these and other relevant scientists.

3.5 In order to facilitate correspondence between scientists of various countries working on CEMP-related studies, the Secretariat was requested to compile a list of names and addresses of relevant scientists. This list should be made available to all interested scientists on request to the Secretariat.

3.6 The Working Group recommended that a short newsletter, describing major results and conclusions of its work, similar to the Krill Newsletter currently being circulated to scientists in the SCAR and CCAMLR communities, should be prepared and distributed annually following the

completion of the Scientific Committee meeting. This newsletter should be distributed as widely as possible to all scientists involved in CEMP-related studies. An initial distribution list should comprise the current membership of WG-CEMP, WG-Krill (and others on the Krill Newsletter mailing list), the Scientific Committee, the SCAR Subcommittee on Bird Biology and the SCAR Group of Specialists on Seals. A call for further names and addresses should be included in each newsletter.

MONITORING PROCEDURES

Predator Monitoring

Sites and Species

4.1 The Delegations of Chile and the USA submitted a draft management plan for the protection of Cape Shirreff and the San Telmo Islands, South Shetland Islands (SSSI No. 32), as a site included in the CCAMLR Ecosystem Monitoring Program (WG-CEMP-93/5). According to the procedure agreed at the last meeting (SC-CAMLR-XI, Annex 7, paragraph 4.5) it had been reviewed by the subgroup on sites which consisted of Dr P. Penhale (USA) and Dr Kerry. They reported that the proposal was in an acceptable form and that only minor editorial changes were suggested. The Working Group recommended that, subject to these being made, the Scientific Committee should consider the draft management plan. The authors expressed their intention to incorporate the proposed changes and submit a revised management plan to the Scientific Committee.

4.2 No other proposals were received for the protection of CEMP sites or for the inclusion of new species for monitoring.

Development of Monitoring Procedures

4.3 The Convener drew attention to the procedures which the Working Group had agreed at its previous meeting for evaluating proposals for new monitoring methods, modifying existing procedures and the incorporation of new species (SC-CAMLR-XI, Annex 7, paragraphs 4.5 to 4.7). Members are required to submit written proposals, together with supporting documentation, to the Convener in advance of the meeting for consideration by the subgroup on practical aspects of monitoring methods. Such proposals will only be considered at a meeting of WG-CEMP if they are received by the Convener for circulation and review no later than three months prior to the start of the WG-CEMP meeting. The subgroup is responsible for reviewing such proposals and presenting its recommendations to the Working Group for appropriate action.

4.4 No proposals had been received by the due date for consideration at this meeting of WG-CEMP.

Field Research Procedures

4.5 Papers were tabled relating to three topics of relevance to the work of WG-CEMP in undertaking predator monitoring:

- (i) relevant to Existing Standard Methods for approved Predator Parameters;
- (ii) relevant to the development of Standard Methods for Potential Predator Parameters;
and
- (iii) relevant to the Potential Impact on Predators of using certain Field Procedures.

Developments Relevant to Existing Standard Methods

Method A4 - Age-specific Recruitment and Survival in Penguins

4.6 Data deriving from detailed demographic research on Adélie penguins at Admiralty Bay, King George Island had been contributed to the exercise examining functional relationships between predators and prey (SC CIRC 93/13 and 93/18). A standard method already exists for the collection of field data for this parameter but not for the analysis and submission of these data. Based on the methods used to produce the contribution referred to above, Dr W. Trivelpiece (USA) agreed to provide a draft text on these topics for consideration by the methods and statistical subgroups and by the Data Manager before the next meeting of WG-CEMP.

Method B3 - Age-specific Recruitment and Survival in Black-browed Albatross

4.7 The paper on the 17-year study of the population dynamics of black-browed albatrosses at Bird Island, South Georgia (WG-CEMP-93/6) includes details of the methods of data collection and analysis. An outline standard method already exists for this parameter in respect of data collection; however, the details of appropriate techniques for data analysis and presentation of results would be a useful addition to the standard method. Dr Croxall agreed to provide a draft text for consideration

by the methods and statistics subgroup and the Data Manager prior to the next meeting of WG-CEMP.

Method C1 - Duration of Foraging Trips by Female Antarctic Fur Seals

4.8 Dr Croxall noted that WG-CEMP-93/10 included data and analyses indicating that the relationship between this parameter and fur seal reproductive performance and environmental variation suggests that measurement of foraging trip duration is a particularly valuable part of the CEMP suite of monitoring parameters.

Method C2 - Pup Growth

4.9 For some time WG-CEMP has been requesting a comparison of the two procedures for obtaining indices of fur seal pup growth (serial individual or cross-sectional population weighings). A relevant comparison, from Bird Island, South Georgia, is provided in WG-CEMP-93/9. In this study, some 100 pups were weighed every 7 to 14 days from birth to weaning and the results (for four years) compared with appropriate data from a 15-year data series on birth mass and three subsequent samples of 100 pups weighed at monthly intervals. Growth rates from cross-sectional data were higher in every year (and significantly so for male pups in all years and for female pups in two years). Variances were slightly lower for cross-sectional data. The differences between methods may reflect repeated handling of the serially-weighed pups but other sources of bias are possible. In studies of fur seal pup growth, the two procedures cannot be used interchangeably.

Standard Methods for Potential Predator Parameters

Foraging Performance

4.10 At its 1991 meeting, WG-CEMP discussed the desirability of assessing the extent to which data on at-sea behaviour (and especially those available through the use of time-depth recorders (TDRs) on penguins and seals) might be developed into appropriate indices for incorporation into CEMP.

4.11 At that stage, the intention was to try to convene a workshop to review data, identify suitable indices and propose standard methods for collecting and processing such data.

4.12 However, at its meeting in 1992, WG-CEMP agreed that further progress should await the results of a workshop on the analysis of data from TDRs being held in Alaska in September 1992 and the completion of work by UK scientists on selection of sampling intervals for TDR studies and on delimitation of foraging bouts and derivation of foraging indices (SC-CAMLR-XI, Annex 7, paragraph 4.18).

4.13 The paper by Dr I. Boyd (UK) (WG-CEMP-93/14) on the influence of the sampling interval on the analysis and interpretation of TDR data shows that the sampling interval affects the detection of dives and statistics of diving behaviour; e.g., an increase in the sampling interval from 5s to 15s resulted in 20% of dives of fur seals being unrecognised, a 38% increase in mean maximum dive depth, and a 29% increase in duration of surface interval. He concluded that critical comparisons should be confined to data collected using similar data intervals.

4.14 The study of foraging bouts and indices referred to in paragraph 4.12 above, which UK scientists will complete in time for circulation at the Scientific Committee meeting in 1993, provides a new method for the delimitation of foraging bouts (intended to supersede the use of log-frequency and probit analysis methods) and compares foraging performance of Antarctic fur seals over five years of studies using a variety of indices.

4.15 A related paper by Dr Y. Mori (Japan) (WG-CEMP-93/17), described the use of TDRs in recording diving bouts (determined by log-frequency analysis) and related characteristics for chinstrap penguins.

4.16 The report of the Alaska Workshop (WG-CEMP-93/18) covered many topics of considerable relevance to WG-CEMP, particularly on dive and bout classification and statistical analysis of TDR data.

4.17 In his summary to this report, the Convener of the Workshop, Dr J.W. Testa, concluded that a set of cohesive analysis protocols would not be sufficient for the variety of data being collected with TDRs and related instruments. Rather, each research project will require unique data analyses that suit the specific research questions, the behaviour of the species under consideration and the required technical approach.

4.18 Noting this, the Working Group reaffirmed that WG-CEMP should try to develop its own set of guidelines and methods for the use of TDRs to provide standardised sets of data which could be used to derive indices of diving and/or foraging performance.

4.19 Variables that might be relevant in a consideration of potential indices include duration of foraging trip, time spent in searching and feeding, number of diving bouts, duration of bouts and dive characteristics such as duration and depth.

4.20 The Working Group agreed to address this topic by arranging an intersessional collation and exchange of information, reviewing this at its next meeting and then deciding on whether or not it would be appropriate to seek to hold a workshop on this topic, perhaps in 1995. The Working Group recommended that the Scientific Committee should consider providing funds to support such a workshop.

4.21 To proceed with this initiative the Working Group agreed:

- (i) that attention should initially be restricted to Adélie, chinstrap, gentoo and macaroni penguins, Antarctic fur seals and crabeater seals; and
- (ii) that during the next intersessional period scientists who have TDR data from any of these species should be asked by the Secretariat, in consultation with the Convener of WG-CEMP, to send to Dr Boveng as soon as possible summaries of the nature and content of such data (with particular attention to the availability of data on the variables listed in paragraph 4.19), together with copies of published and unpublished reports and papers on these data and notification of relevant work in progress.

Dr Boveng agreed to collate the information for review by the Working Group at its next meeting.

Potential Impact of Field Procedures on Predators

4.22 Dr Kerry presented WG-CEMP-93/19, which provided information on the effects of flipper bands, implanted electronic tags, gastric lavage and external instrument attachments on Adélie penguins at the Béchervaise Island CEMP monitoring site. The attachment of satellite tracking devices during the incubation period and on several consecutive trips during chick rearing increased foraging trip duration and reduced breeding success. Attachment for a single foraging trip post-hatching caused no significant increase in foraging trip duration. No reduction in fledging rates of chicks from nests of stomach-lavaged birds was detected over two breeding seasons. The return rate for birds banded as breeding adults was 63% in each of two successive years for the same population. There was no evidence of either tag or band loss over one season for birds carrying both marking systems.

4.23 Dr Trivelpiece presented the draft report (WG-CEMP-93/20) of a “Workshop on Researcher-Seabird Interactions” which was held from 14 to 18 July 1993 in Minnesota, USA. The 28 participants addressed six major areas of concern:

- (i) banding and marking techniques;
- (ii) diet sampling and stomach lavage;
- (iii) instrument attachment, external technologies;
- (iv) instrument implantation, internal technologies;
- (v) physiological studies; and
- (vi) general disturbance.

4.24 Key points arising from the meeting are summarised below:

- (i) flipper bands, even if properly applied by trained operators, may affect the swimming and hence foraging performance of the penguin and cause mortality, particularly of fledglings;
- (ii) band loss is known to occur but is difficult to estimate. The use of implanted electronic tags in banded birds is now providing the possibility to determine this and, if used alone, providing a method of identification which should not affect performance. However, new research is needed to develop alternative ways of identifying which birds are carrying the tags;
- (iii) diet sampling through stomach lavage is considered a safe procedure if conducted by skilled and experienced operators. Further, current studies have found no measurable effects on penguin chick growth and mortality providing lavaging is performed once per season and on only one member of an adult pair (see also WG-CEMP-93/19); and
- (iv) the effects of instrument packages attached to the birds’ feathers by tape or glues are minimised by streamlining and placing them low on the back. Packages do affect the performance of birds, at least initially.

4.25 The Working Group noted the importance and timeliness of the Workshop and thanked the US for hosting the meeting. Since the report contained much that impinged directly on monitoring methods and the likelihood of biasing the data, the Working Group asked the *ad hoc* subgroup on monitoring methods to further evaluate the final report, expected to be available by 1 December 1993, and to recommend what modifications might be made to the CEMP Standard Methods.

4.26 The Working Group strongly encouraged Members to take note of the report as a basis for assessing the impact of their own field research practices on the species being monitored. Further, where a number of research programs by different operators (national groups) are being undertaken in a region, they should consider developing a control site at which to measure the impact of their research.

4.27 The Working Group noted that implanted electronic tags were now being used by a number of Members but there were no national registration schemes or experience requirements for operators, as in present bird banding schemes. It was suggested that such schemes were urgently required and noted that SCAR was being asked to address this requirement. It was recommended that Members maintain a national register, similar to that of a banding register, of tags used and should ensure field staff are properly trained in implanting techniques. As a minimum requirement, a record should be kept of date, place, species, tag brand, the location on the bird where the tag is inserted, tag number and band number of all birds tagged.

Prey Monitoring

Krill

4.28 Mr D. Miller (South Africa) (Convener of WG-Krill) recalled that methods for monitoring krill in support of CEMP predator monitoring had been developed by WG-Krill's Subgroup on Survey Design (SC-CAMLR-X, Annex 7, paragraphs 4.55 to 4.68). He noted that no changes to these methods were required at present.

Other Species

4.29 Lic. R. Casaux (Argentina) presented a paper (WG-CEMP-93/26) which showed the diet composition of piscivorous blue-eyed shags at Duthoit Point, Nelson Island, South Shetland Islands, based on an analysis of 50 regurgitated casts (also referred to as pellets) collected in February 1991. The fish component of the diet was comprised of *Harpagifer antarcticus*, *Notothenia neglecta*, *Nototheniops nudifrons* and *Trematomus newnesi*.

4.30 In speaking to a companion paper (WG-CEMP-93/25), Lic. Casaux indicated there was very good agreement between the fish species identified from otoliths in the shags' regurgitated casts and those species regularly sampled with trammel nets in the same area. He noted also that juveniles of the commercially-fished species of *Notothenia rossii* and *Notothenia gibberifrons* had declined

sharply over the period from 1983 to 1990, whereas *N. neglecta*, which has similar ecology but was not subjected to fishing, remained stable. *N. rossii* and *N. gibberifrons* were not found in the casts of the blue-eyed shag.

4.31 These observations led Lic. Casaux to suggest that observations on the diet of the blue-eyed shag might be used to monitor the abundance of littoral fish populations in the South Shetland Islands.

4.32 Dr Croxall noted the considerable potential of the method suggested by Lic. Casaux. Some previous studies, similar to those reported in WG-CEMP-93/26, had identified significant discrepancies between the fish eaten by shags and the otoliths recovered in pellets (e.g., Johnstone *et al.*, 1990, *Bird Study* 37: 5-11). Before the use of pellets could be adopted in a CCAMLR Standard Method, it was likely that evidence, from appropriate validation studies, would be required to demonstrate that similar problems do not occur with blue-eyed shags in the Antarctic.

4.33 The proposal in paragraph 4.31 raised two important issues. The first related to the actual use of the blue-eyed shag to monitor the relative abundance of juvenile fish. The Working Group agreed that, in the first instance, WG-FSA should be asked to review this proposal and then refer the matter back to WG-CEMP.

4.34 The second issue related to the present focus of WG-CEMP and the species selected for monitoring. The Convener recalled that, at its first meeting, the then *ad hoc* Working Group had decided to focus its attention on the krill-based ecosystem and to monitor variables of only a few species which were considered the most likely to provide statistically robust evidence of change. The Working Group acknowledged that there were many other important areas for work in support of the objectives of the Convention as embodied in Article II.

4.35 The Working Group agreed that expanding the scope of WG-CEMP to include species and sites other than those identified as part of the krill-based system would be a step of some magnitude and one that would require careful consideration. It was agreed therefore that consideration of this matter should be deferred until the next meeting, where it would receive detailed attention under a separate agenda item.

Environmental Monitoring

Land-based Observations

4.36 No proposals for changes to Methods F1, F3 and F4 had been received.

Remote Sensing

4.37 The Data Manager presented a report (WG-CEMP-93/15) on calculations of indices of sea-ice data that had been requested by the Working Group at its last meeting (SC-CAMLR-XI, Annex 7, paragraph 4.28). The Working Group welcomed this report, noting that the Secretariat had done an excellent job in moving forward with these analyses. Because the entire data files were too long to print in their entirety only an example was given for index a(i), latitude of the ice edge each week by 5° longitude intervals. For index F2/3, which is defined in the paper as the distance to the ice edge from selected CEMP sites, data for 1989/90 were reported. It is anticipated that once the database has been developed, data could be supplied to Members either as ASCII files for requested dates and areas, or in a form suitable for use in available GIS programs.

4.38 The Working Group agreed that these indices seemed to be a cost-efficient way of standardising the sea-ice data necessary for its work. It therefore recommended that the Secretariat be asked to continue according to the original plans of putting recent (1990/91 and 1991/92) and earlier (back to mid-1980s) data into the database during the forthcoming year.

4.39 In the deliberations of the Working Group some weaknesses in these indices were pointed out. For instance, the US Joint Ice Center (JIC) data are, in some cases, inadequate for the detection of open water masses and/or polynias and this may hamper efforts to detect areas of importance for foraging of predators. Although it was agreed that the JIC data could provide a broad indication of sea-ice distribution it may be desirable to supplement this information with more detailed sea-ice data. Where possible, individual researchers were encouraged to obtain detailed sea-ice images of relevance to particular study areas to help to interpret the coarser data available from JIC (e.g., as shown in WG-CEMP-93/28).

REVIEW OF MONITORING RESULTS

Predator Data

Status of Data Submissions

5.1 The Data Manager noted that data from each standard method for which there is currently a submission form were received within two weeks of the deadline, facilitating the task of calculating and updating predator indices for consideration by WG-CEMP. The Working Group expressed its concern, however, that data were received from only three Members and that, with the exception of the Bird Island black-browed albatross data (paragraphs 5.17 and 5.18), no historical data were received in response to requests made at the last meeting of WG-CEMP (SC-CAMLR-XI, Annex 7, paragraph 5.8). It was again stressed that timely and reliable assessments of predators and their interactions with prey and the environment cannot be achieved without the continual provision of information from several years' research from a broad suite of monitoring sites and species.

5.2 The Working Group recommended that the Scientific Committee strongly encourage Members to make available their predator data for relevant standard methods. These data are critically important to the success of CEMP, and Members were once again urged to submit these data to the CCAMLR Data Centre as a matter of priority.

Report on Indices and Trends

5.3 Indices computed from the CEMP database, including the submissions made this year, were presented in WG-CEMP-93/16. This summary updated the results reported last year in WG-CEMP-92/8 and 12, and in addition presented graphical summaries that were requested last year. Members that submitted data were requested to verify the values reported in WG-CEMP-93/16, so as to guard against errors that may have occurred during transcription from the data forms. Furthermore, Members were again reminded that the analytical methods for computing the indices are given in Appendix 6 of the *CEMP Standard Methods* manual and that software for computing the indices is available for testing and verification from the Secretariat.

5.4 The indices were reviewed by the Working Group, particularly with respect to whether any of the values were incongruous with the typical ranges for these parameters or with the data that were submitted. Because several discrepancies were noted between data submitted and the corresponding index values, it was agreed that, in the future, authors of data should meet with the Data Manager prior to the WG-CEMP plenary to resolve such discrepancies. The Data Manager

noted a few minor modifications to the computational procedures that have become necessary as new data are added to the database; these are described below under headings for the respective methods.

5.5 For several of the methods considered below, some particularly noteworthy or conspicuous patterns are discussed. Further consideration of patterns and the magnitude and significance of changes in the indices is given in paragraphs 6.42 to 6.47.

Standard Methods for Penguins

Method A1 - Mean Weight on Arrival

5.6 Data were submitted for the 1992/93 season from Bird Island and Béchervaise Island.

Method A2 - Duration of Incubation Shift

5.7 Thus far, data on this parameter have been received only for Béchervaise Island.

Method A3 - Breeding Population Size

5.8 Data for this parameter had been received for the 1992/93 season from the sites at Anvers Island, Signy Island, Bird Island and Béchervaise Island.

Method A4 - Age-specific Recruitment and Survival

5.9 Standard protocols for submission of data and calculation of indices for this method have not yet been developed by WG-CEMP, though several Members are collecting data by the agreed field methods. It was anticipated that proposals for the analytical portion of the method will be submitted for consideration at WG-CEMP's next meeting (paragraphs 4.6 and 4.7).

Method A5 - Duration of Foraging Trip

5.10 Data for this parameter had been received for the 1992/93 season from sites at Anvers Island and Seal Island. The Data Manager noted that both indices for this method (brood- and creche-stage trip durations) had been computed in two slightly different ways (WG-CEMP-93/16). The first was unchanged from last year's method (*CEMP Standard Methods*, Appendix 6) and resulted in a large number of cases in which the index values could not be computed because the reported foraging trip durations were not measured during the specified time intervals following peak hatching or peak creching. The second method, therefore, was based on longer time intervals to ensure that indices would result from a greater proportion of the reported foraging trip durations. Members who had submitted these data were encouraged to consider whether this change is sensible with respect to the breeding biology of the penguin species involved and to report back to WG-CEMP at its next meeting.

5.11 The extreme variability in durations of foraging trips by Adélie penguins at Palmer Station that the Working Group noted at its last meeting (SC-CAMLR-XI, Annex 7, paragraph 5.11) was discussed again. Because the standard deviation of the index was frequently larger than the mean, Members questioned the utility of the index for this species and site. Previously, some Members had suggested that the variability may have resulted from patchiness in prey availability. However, Drs Trivelpiece and Kerry indicated that the variability may result from a strategy in which Adélie penguins employ both short and long foraging trips. If so, a modification to the standard method may be appropriate for this species. Drs Trivelpiece and Kerry were encouraged to evaluate their data to determine the feasibility of distinguishing between these two foraging trip types and to report to the Working Group at its next meeting.

Method A6 - Breeding Success

5.12 Data for this parameter had been received for the 1992/93 season from sites at Anvers Island, Seal Island, Signy Island, Bird Island and Béchervaise Island. The Data Manager noted that in order to produce an index from data submitted under Procedure A of this method, data from Method A3 must also be provided.

Method A7 - Chick Weight at Fledging

5.13 Data for this parameter had been received for the 1992/93 season from the sites at Anvers Island, Seal Island and Bird Island. Dr Croxall noted that, at least for gentoo penguins at Bird

Island, a year with high breeding success can also be characterised by relatively light fledglings (i.e., an inverse relationship), suggesting that both indices are necessary for correct interpretation of conditions in any particular year.

Method A8 - Chick Diet

5.14 Data for this parameter had been received for the 1992/93 season from the sites at Anvers Island and Bird Island. Five indices were produced from this method, in contrast to the two produced last year. Members submitting data found it somewhat difficult to check for discrepancies owing to the arcsin transform used in this method. The Data Manager was requested to provide, in future updates, separate tables for the raw data and the computed indices for this method.

5.15 It was noted that when Adélie penguins at Béchervaise Island (WG-CEMP-93/19) in the Prydz Bay ISR undertake short duration foraging trips (paragraph 5.11), they return with shelf-organisms, e.g. amphipods and *Euphausia crystallorophias*, but after longer foraging trips they return with *Euphausia superba*. These results may confound the analysis of this parameter and consideration may need to be given to regional differences in the calculation of indices of chick diet.

Method A9 - Breeding Chronology

5.16 Data for this parameter had been received for the 1992/93 season for the sites at Anvers Island and Seal Island. It was noted that the indices derived from this method are primarily used for establishing the time periods over which indices are computed for the other methods, rather than for monitoring purposes.

Standard Methods for Flying Seabirds

Methods B1 and B2 - Breeding Population Size and Breeding Success of Black-browed Albatross

5.17 Data for these parameters had been received for the 1992/93 season from the site at Bird Island. Dr Croxall noted that WG-CEMP-93/6 included full historical data for these parameters from the years 1977 to 1991 inclusive, thereby completing the provision of all available historical data for these two parameters at this site.

Method B3 - Age-specific Annual Survival and Recruitment of Black-browed Albatross

5.18 Results from a 17-year study of the population dynamics of black-browed albatrosses at Bird Island, South Georgia are contained in WG-CEMP-93/6. This constitutes formal submission of estimates of annual mean adult survival (for both sexes) and recruitment rates.

Standard Methods for Fur Seals

Method C1 - Duration of Foraging Trips by Females

5.19 Data for this parameter had been received for the 1992/93 season from the sites at Seal Island and Bird Island.

Method C2 - Pup Growth Rate

5.20 Data for this parameter had been received for the 1992/93 season from the sites at Seal Island and Bird Island. Data for 1988 to 1993 indicate that pup growth rates at Bird Island have been consistently lower than those at Seal Island. Dr Croxall noted that pup growth rates had decreased consistently from 1986 to 1992 at Bird Island (WG-CEMP-93/9), perhaps suggesting a density-dependent response; this would be consistent with the faster growth at Seal Island, a younger and less dense colony. However, fur seal density remains high at Bird Island and the 1993 pup growth rates were amongst the highest measured there, so this may be too simple an explanation.

Prey Data

5.21 In introducing this item the Convener recalled that WG-CEMP had requested the following data to enable it to undertake its annual assessments and to formulate advice based upon an integrated perspective of predator, prey and environmental data (SC-CAMLR-XI, Annex 7, paragraph 5.19):

- (i) summaries of fine-scale catch data and an analysis of the distribution of catches relative to predator colonies;

- (ii) the most recent estimates of krill biomass (or relative biomass) in each ISR and other subareas or meso-scale survey areas as estimates become available; and
- (iii) results of specific fine-scale surveys near CEMP sites or surveys to determine aspects of distribution movements or behaviour, as they become available.

5.22 Mr Miller, the Convener of WG-Krill, reviewed the highlights of the WG-Krill report as they pertained to this item. The details of his summary are included in the relevant paragraphs below.

5.23 The Data Manager summarised the fine-scale catch data in Statistical Area 48 as reported to CCAMLR for 1991/92 (WG-Krill-93/9). It was noted that there had been a significant decrease in the total krill catch in Statistical Area 48 during the 1992/93 season. At the time of the meeting, 81 394 tonnes had been reported for the 1992/93 season as compared to 302 961 tonnes for 1991/92.

5.24 The reasons for the reduction in catch levels were discussed. In part they reflected the reduction in number of fishing vessels used by Russia, Ukraine, etc. However, the catch by Japanese vessels had also decreased, because of a decrease in fishing effort.

Fine-scale Catch Data

5.25 Mr T. Ichii (Japan) introduced WG-Krill-93/25 which summarised data from the Japanese krill fishery for the 1991/92 season. The main fishing ground was persistently north of Livingston Island. Another interesting result was that the CPUE had decreased during the latter part of the season. It was also noted that similar analyses of trawling positions, CPUE, and length frequency distributions from the Japanese krill fishery had been submitted in each of the past six years. The author was encouraged to prepare a summary of these data to investigate the potential patterns or trends in these data and to table such analyses at the next CEMP meeting.

5.26 The Working Group commended the author for having prepared such an extremely valuable paper, which provided a rich source of information pertaining to the Group's work. It was agreed that it would be very helpful if similar data for the fishery from other nations, especially Russia and Ukraine, could also be provided, especially for those areas in close proximity to CEMP sites including those in Division 58.4.2.

5.27 The need to obtain prey data at various scales for CEMP studies was noted. Larger scales will assist studies of environmental effects and smaller scales provide insight to predator/prey

interactions near CEMP sites. It was concluded that such questions of scaling would be appropriate issues for discussions during a joint meeting of WG-CEMP and WG-Krill.

5.28 A preliminary estimate of CPUE trends for the Chilean krill fishery (WG-CEMP-93/21) was reviewed. This analysis suggested that good and bad years for the fishery seem to be discernible. Mr Miller, however, cautioned that several aspects unrelated to krill biomass (e.g., seasonal distribution, fishing locations) could affect the CPUE estimates.

5.29 In reviewing the status of the krill stock around Elephant Island (WG-Krill-93/8) it was noted that some correspondence between data from research cruises and fisheries is apparent. This observation triggered a discussion on whether the fisheries target a specific part of the total krill population. It was pointed out that the driving forces for the fishermen are krill quality, optimisation of catch in time, etc. Sought-after krill quality may also differ between nations and years (SC-CAMLR-XI, Annex 4, Figure 1).

5.30 The Working Group noted that it had now developed a series of annual indices of predator parameters with which to monitor predator performance. In the context of integrating information from predators, prey and environmental conditions, it felt that increased attention needed to be focused on refining a series of prey indices.

5.31 The Working Group agreed that in addition to prey data from fishery-independent surveys, fine-scale data from the fishery, such as catch locations, CPUE and krill length frequencies would be valuable. The Working Group believed that, although these data were not being used for estimation of biomass, if indices could be defined which described these data on an annual basis from the vicinity of CEMP sites, such indices would provide valuable input into the syntheses of data from the predators, prey and environment (e.g., SC-CAMLR-XI, Annex 7, Table 4).

5.32 It was acknowledged that the above fishery-based indices would represent relative krill availability (local or aggregation density) to the fishery, but would not provide areal indices of krill biomass without additional information on patch distribution such as is provided by searching time (SC-CAMLR-XII/4, paragraph 5.29).

5.33 In this context, the Working Group requested that WG-Krill consider the following questions:

- (i) What fine-scale fisheries data (e.g., catch, effort, demography) are available within 50 and 100 km of the following CEMP sites:

- Cape Shirreff (48.1);

- Seal Island (48.1);
- Signy Island (48.2);
- Laurie Island (48.2);
- Bird Island (48.3); and
- Béchervaise Island (58.4.2)

as well as the three ISRs (Figure 1), throughout the year, but especially during the times of CEMP predator monitoring activities at these sites?

(ii) What fisheries-derived information can be used to calculate the following indices, and what are the most appropriate methods to use for their calculation:

- krill availability to the fishery;
- krill product quality (e.g., gravid, green, white, etc.); and
- krill catch length composition?

(iii) What are the most appropriate ways of deriving indices of krill cohort strength and recruitment from krill length frequency data? To what extent can comparable indices be derived from research vessel, fishery and predator diet data?

This whole topic should be discussed at a joint meeting of WG-Krill and WG-CEMP.

5.34 In common with the criteria used for calculation of CEMP predator monitoring indices, these fishery-derived indices should:

- (i) be statistically defined (i.e. the variance, confidence limits, etc. should be provided);
- (ii) be expected to change as the parameters from which the indices are derived also change; and
- (iii) be presented so that comparisons within seasons and between years can be easily made.

Estimates of Krill Biomass in Integrated Study Regions (ISRs)

5.35 At its 1992 meeting, WG-Krill had responded to WG-CEMP's request for broad-scale biomass estimates for krill in the ISRs by providing estimates of krill biomass from hydroacoustic surveys conducted within portions of the ISRs (SC-CAMLR-XI, Annex 4, paragraph 5.53, Figure 2, Table 4).

It was emphasised that these biomass estimates are only applicable to the area covered by the surveys and should not be extrapolated to cover the total area of the ISRs.

5.36 At the 1993 meeting of WG-Krill, a recalculation of the FIBEX data for Subarea 48.1 resulted in changes in the biomass estimates for Subarea 48.1 (SC-CAMLR-XII/4, paragraph 4.40). It was noted that aside from these changes, the estimates of krill biomass in the ISRs since last year's summary were unchanged. The current biomass estimates for the ISRs are given in Table 4. The areas to which the estimates pertain are shown as shaded zones in Figure 1.

5.37 The Working Group thanked WG-Krill for these estimates and requested these estimates be updated, as possible, to cover the entire area of the ISRs, and to incorporate new data as they become available.

Fine-scale Surveys

5.38 Dr R. Holt (USA) presented WG-CEMP-93/27 which described research undertaken by the US AMLR Program during the 1992/93 field season. He noted this was the fifth year of an ongoing program which carried out *inter alia* hydroacoustic surveys around the Seal Island CEMP site (near Elephant Island). These hydroacoustic surveys were conducted within an approximately 60 x 130 n mile rectangle (and some areas to the southwest) according to the standard method (SC-CAMLR-X, Annex 4, Appendix D, Attachment 4) supplemented with net sampling of zooplankton and CTD/rosette hydrocasts.

5.39 In WG-Krill-93/49, the authors presented a summary of krill biomass estimates near Elephant Island between the years 1981 and 1993. Comparing estimates of recruitment and biomass it was noted that a strong year class of krill one year appears often to be followed by larger biomass estimates the following year. In the following discussion it was pointed out that the availability of data from net hauls for target identification can be used to improve estimates of mean recruitment and its variability (SC-CAMLR-XII/4, paragraph 4.46).

5.40 Members noted that it is important to be clear in using the term "recruitment". For krill, recruitment into the population refers to krill reaching one year of age. Recruitment into the fishery usually pertains to reaching year class 3. Indices for these two kinds of recruitment are obviously of different significance with respect to predators. Recruitment for penguins and seals usually refers to the number of individuals that enter the breeding portion of the population.

5.41 Dr Holt stated that salps were abundant during parts of the 1993 AMLR survey. It was noted that the Chilean fishery had moved from Elephant Island to Livingston Island in March 1993 because of the salp concentrations in the Elephant Island area (WG-CEMP-93/21). Mr Ichii stated that

the Japanese fishery routinely moved to an area over the continental slope north of Livingston Island to avoid salps in years when salps were abundant.

5.42 The Working Group discussed the ecological significance of salps to marine mammals and birds. It was noted that even though surface feeders such as albatrosses are known to eat salps occasionally, there is little evidence that seabirds or pinnipeds prey on salps. It was also pointed out that the relationships between krill and salps are poorly understood and needs further study.

5.43 Krill stock composition and distribution patterns in the vicinity of Elephant Island during the austral summers 1991/92 and 1992/93 were described and compared with information from previous years in WG-Krill-93/8. The length frequency distributions and maturity stage composition reflected relatively good year class success from the 1990/91 spawning season but poor success from 1991/92. Year class success from these and other years appears to be associated with female maturity development and spawning during early summer months. The overall abundance, maturity stage composition and reproductive activity of krill appeared to be affected by dense salp concentrations during 1989/90 and 1992/93.

5.44 The Working Group discussed the results and the hypothesis put forward that spawning success is related to time of spawning. The interpretation of the data is still hampered by the largely unknown effects of flux. The Working Group suggested that these data which represent an important time series of fisheries-independent data, continue to be supplemented and subjected to renewed analyses as new data are acquired.

5.45 Mr H.-C. Shin (Republic of Korea) introduced the paper WG-Krill-93/41 which described a krill survey in the western Bransfield Strait region in 1992/93. Juveniles were dominant in most krill samples, and krill were most abundant in the central Bransfield area. The distribution of krill at different life stages suggested that the young krill encountered had their origin in the coastal waters of Gerlache Strait, to the west of Bransfield Strait.

Environmental Data

Sea-ice Patterns

5.46 As described in paragraph 4.38 above, it is expected that an analysis of sea-ice data from approximately 1985 to 1992 will be available at next year's meeting. It was agreed that, at that time, it would be possible to review these data across a series of years, with the intention of developing appropriate indices for incorporating into the synthesis developed in Table 5.

ECOSYSTEM ASSESSMENT

6.1 At their 1990 meetings, the Commission (CCAMLR-IX, paragraph 4.34), Scientific Committee (SC-CAMLR-IX, paragraphs 5.4, 5.39 and 8.6), and WG-CEMP (SC-CAMLR-IX, Annex 6, paragraphs 41 to 43) agreed that WG-CEMP should 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.

6.2 In 1992, WG-CEMP agreed that this annual assessment procedure should include: (i) a review of background information available to the Working Group in submitted papers; and (ii) assessment of predator, prey, environmental and fishery data. For the first item, the Working Group reviewed papers under the general sub-headings of “Predator Studies”, “Prey Studies”, and “Environmental Studies”.

Review of Background Information

Predator Studies

Population and Demography

6.3 In WG-CEMP-93/6, concerning albatross demography at Bird Island, South Georgia, the periodic low breeding success of black-browed albatrosses (for which krill is the main diet component), in most years attributable to low food availability, is contrasted with the much smaller fluctuations in breeding success of grey-headed albatrosses (for which squid is the main diet constituent). In 1988, however, when late snow and ice in the colonies caused widespread reproductive failure, both species were equally affected. Adult survival rates showed significant interannual variation and future work will try to link these to other indices of reproductive performance and to environmental conditions.

6.4 In WG-CEMP-93/8, the fit of the model based on gentoo penguin population parameters to the data on population fluctuations over 15 years at Bird Island, South Georgia, shows that in the four years of large population decrease (three associated with low krill availability), deferred breeding and increased adult mortality were the likely causes of the observed population changes. The years of poor breeding conditions have disproportionate demographic effects and doubling their frequency in the simulation model would result in a persistent significant rate of population decline.

6.5 In addition to its methodological implications, WG-CEMP-93/9 summarises data on Antarctic fur seal pup growth (collected according to CCAMLR Standard Methods) and intersexual differences therein, at Bird Island, South Georgia between 1973 and 1992. The paper shows that pup growth rates are highly correlated with weaning mass. For 11 years' data there are strong inverse correlations between growth rate and foraging trip duration. However, using data on individuals within seasons, the relationship was only apparent in one in three years.

6.6 WG-CEMP-93/10 reports the results of an investigation of relationships between age, breeding experience and environmental variation (the last being indexed mainly by foraging trip duration) for Antarctic fur seals over 10 years at Bird Island, South Georgia. Many of the results relate to differing performance of primiparae and multiparae and differences between animals breeding first at ages three and four years. For CCAMLR, however, an important conclusion is that the use of data on foraging trip duration consistently improved models of likelihood of pupping and weaning success. After years characterised by longer foraging trips, females arrived to breed later, fewer females pupped and they gave birth to lighter pups. In years of longer foraging trips, females had reduced weaning success.

6.7 Using a sample of 724 upper canine teeth from male Antarctic fur seals dying of natural causes at Bird Island, South Georgia from 1973 to 1989, WG-CEMP-93/11 reported investigation of interannual variations in annual tooth growth (which, in a smaller sample is shown to correlate significantly with body growth). For fur seal cohorts from 1967 to 1988, there was no trend in cohort strength but poor years for growth were closely related to those of poor reproductive performance for females and interannual variation in growth was significantly correlated with the Southern Oscillation Index of climatic variation. Data derivable from tooth sections can thus offer significant insights into predator-environment interactions over time spans much longer than those currently accessible through existing conventional monitoring studies.

6.8 WG-CEMP-93/23 presents results of a preliminary survey of breeding chronology and breeding success of chinstrap and gentoo penguins at Barton Peninsula, King George Island, in the 1992/93 season. Ninety-six chinstrap and 121 gentoo nests were monitored from shortly after egg laying. Chinstrap and gentoo penguins reared 1.45 and 1.32 chicks per breeding pair to the creche stage respectively. The growth of chicks was measured from the beginning of January to the beginning of February. The chinstrap chicks grew from 0.61 to 3.43 kg and gentoos from 0.56 to 4.59 kg.

6.9 Dr D. Torres (Chile) presented summary results of four complete censuses of Antarctic fur seals (between 1966 and 1992) at San Telmo Islands and Cape Shirreff, Livingston Island (WG-CEMP-93/24). These results may help to clarify interpretations of fur seal abundance and population growth at these sites (SC-CAMLR-XI, Annex 7, paragraph 6.7), because the 1966 and

1973 counts, which were from the two sites combined, have previously been ascribed to Cape Shirreff alone.

Predator-Prey Interactions

6.10 Most of the few systematic studies of correlations between at-sea observations of seabirds and seals and data from acoustic surveys for krill collected simultaneously report low correlation coefficients, except for major swarms and concentrations. Results of a fine-scale (seabird records taken at one minute intervals; acoustic resets at 1 n mile intervals) survey by USA and UK scientists around northwest South Georgia in 1986 are reported in WG-CEMP-93/12 and 13. After accounting for variation due to birds and seals commuting to and from breeding colonies (principally at Bird Island) a range of high correlations at different scales and locations, usually different for different species, is reported. As expected, large krill swarms have a disproportionate effect on predator distribution.

6.11 The diving behaviour of chinstrap penguins was observed concurrently with a hydroacoustic assessment of the vertical distribution and abundance of krill in the vicinity of Seal Island during early 1992 (WG-Krill-93/47). Krill showed a distinct diel migration pattern, being dispersed in the upper portion of the water column at night and more concentrated and deeper during the day. On average, chinstrap penguins dived to the shallow limit of the distribution of krill. The maximum depth of penguin dives did not exceed the maximum depth of the distribution of krill.

6.12 The Working Group noted that, although the penguin and krill data were temporally concurrent, there was no information on spatial concurrence. Differences between the areas surveyed hydroacoustically and those actually used by the penguins for feeding may affect the interpretation of results.

At-sea Behaviour of Birds and Seals

6.13 The foraging range of Adélie penguins during autumn and early winter was studied by satellite tracking four birds from the Béchervaise Island CEMP site (WG-CEMP-93/28). Dr Kerry reported birds remained inside the sea-ice zone in close proximity to the edge of the continental shelf (1 000 m isobath) and moved progressively westwards. These studies suggested that Adélie penguins forage during the post moult (autumn) period in the same region as do breeding birds during the breeding season. They are able to remain in the region despite the formation of pack-ice and its

extension to the north. Satellite images of the sea-ice showed the presence of a wide lead in the vicinity of the continental shelf break and its maintenance between at least April to July.

6.14 Food habits of the southern baleen whales were reviewed to examine prey composition and inter-specific relationships (WG-Krill-93/16). The paper provided historic information on prey composition and prey size of baleen whales in the Southern Ocean. The Working Group noted that this provided valuable data for two of CCAMLR's three ISRs, namely South Georgia and Prydz Bay, but not for the Antarctic Peninsula Region, which had been part of an IWC whale sanctuary until 1955.

6.15 Although no clear evidence suggesting inter-specific competition for food between whales was found, the author hypothesised that minke whale groups, while feeding, may disperse krill aggregations to such an extent that the feeding success of blue whales is lowered.

6.16 The Working Group noted, however, that little, if any evidence is available in support of this hypothesis. It was further commented that, by analogy, krill trawlers could interfere with krill predators in that, during fishing operations, trawlers may disperse krill concentrations on which the predators feed.

6.17 Dr K.-H. Kock (Germany) drew the attention of the Working Group to a 1993 IWC resolution to study possible causes which impede the recovery of the stocks of Southern Ocean blue whales.

Prey Studies

Krill Populations and Demography

6.18 The biology and size composition of krill from the Indian Ocean sector was the subject of a study described in WG-Krill-93/45. Krill from the area had the following biological characteristics: lifespan five to six years, growth rate from 0.126 to 0.133 mm/day during the first year, decreasing to 0.028 to 0.041 mm/day during the fifth year. It was suggested that krill stocks from the Sodruzhestva and Kosmonavtov Seas are relatively separate from those in other areas.

6.19 Fine-scale catch data for krill in Statistical Area 48 and estimates of krill biomass in ISRs are reviewed and discussed in paragraphs 5.23 to 5.45.

Krill Interactions with Environment

6.20 Regional and circumpolar distribution of krill and environmental changes during the Austral summer were compared in WG-Krill-93/29. An environmental index, \bar{Q}_{200} , which utilises the integrated value of water temperature from the surface to 200 m in depth was used. The areas of high krill concentrations coincided with the areas of low \bar{Q}_{200} values; mainly falling in the range of 0°C to -1.5°C, corresponding to a thick layer of winter water, especially within the slope and shelf waters south of the Antarctic Divergence Zone.

6.21 It was noted that WG-Krill-93/29 concluded with the suggestion that use of the \bar{Q}_{200} index may supplement hydroacoustic surveys of stock biomass of *E. superba*. Members indicated their interest in receiving further information on the relationship between the environmental gradient index and key features of the biology and distribution of krill. In addition, it was noted that, before this index could be used to supplement acoustic surveys of krill biomass, studies to calibrate the relationships between these two approaches would be essential.

6.22 The relationship between size of krill and extent of sea-ice in the water around the South Shetland Islands was reported using commercial krill data from 1979 to 1992 in WG-Krill-93/26. The mean size of krill near the coastal zone appeared to be small in a summer season immediately following the occurrence of strong ice cover.

6.23 The relationship between an index of phytoplankton abundance and the maturity of krill around the South Shetland Islands was investigated using five years of commercial krill data in WG-Krill-93/27. Interannual fluctuations of maturity in krill populations seemed to be determined by food availability and the size composition of phytoplankton.

6.24 Effects of biological and physical factors on the distribution of krill in the South Shetland Islands during the 1990/91 austral summer were investigated in WG-Krill-93/38. Krill showed an offshore-onshore heterogeneity in abundance and maturity.

Environment Studies

6.25 Hydrographic flux in Statistical Area 58 was investigated in WG-Krill-93/22. Surface geostrophic velocity and volume transport were calculated from four longitudinal transects using data collected aboard the Japanese RV *Kaiyo Maru* and other vessels. In presenting this paper, Dr M. Naganobu (Japan) noted that geostrophic flow calculations suggest that there may be an easterly

flow from the surface or sub-surface to near-bottom in the Southern Indian Ocean in proximity to the shelf break. Satellite imagery has shown that there is a wide lead similar to that shown for May 1993 north of Mawson (WG-CEMP-93/28) parallel to the shelf break to the north of Syowa Station which may be explained partially by the current. This, too, may be important for penguins' foraging during the winter (paragraphs 4.22 and 4.39).

6.26 WG-Krill-93/33 investigated the usefulness of satellite ocean colour remote sensing in the Southern Ocean. A comparison of Coastal Zone Colour Scanner (CZCS) chlorophyll images and ship-measured chlorophyll concentrations in the area around Enderby Land was presented in the paper.

6.27 Spatial and temporal distributions of phytoplankton in the waters around the South Shetland Islands were presented using the Nimbus-7 CZCS data during January to March 1981, in WG-Krill-93/39. Concentrations of phytoplankton pigment were low during the middle of January with blooms beginning during February.

6.28 High concentrations of chlorophyll *a* were observed in the coastal area north of Livingston Island during the 1991 research cruise of the Japanese RV *Kaiyo Maru* (WG-Krill-93/23).

Assessment of Predator, Prey, Environmental and Fishery Data

6.29 The assessment of submitted data on predator parameters could not be undertaken prior to 1992 because of insufficient data and calculated indices (SC-CAMLR-XI, Annex 7, paragraph 6.27).

6.30 At its 1992 meeting, however, WG-CEMP felt that sufficient data were available to commence this process. As a first approach towards the goal set out in paragraph 6.1 above, WG-CEMP in 1992 reviewed all available:

- (i) data submitted in respect of predator parameters monitored according to approved methods;
- (ii) data for these parameters but which had not been collected according to the CEMP Standard Methods;
- (iii) data in tabled papers for predator parameters collected annually in standard fashion but for which standard methods had not been submitted to WG-CEMP;

- (iv) other predator data available in tabled or other papers or through participants' personal knowledge; and
- (v) data on krill CPUE and catches (obtained from STATLANT B submissions and fine-scale data in the CCAMLR database); and data on krill biomass (from papers tabled at WG-Krill and WG-CEMP). Environmental data were provided by participants submitting predator data.

6.31 It should be noted that, because of inconsistencies between data submitted in 1992 and those in the CCAMLR database and the consequent need to carry out checks and validations, it had been impossible to calculate from the submitted data all the required information on magnitude and significance of interannual differences. Therefore, in 1992, the assessment of predator parameters had depended chiefly on subjective evaluation, by the contributors of the data, of the relative magnitude and direction of differences and trends.

6.32 This whole process in 1992 was a very valuable exercise, producing results of considerable utility, and was warmly welcomed by the Scientific Committee and Commission (SC-CAMLR-XI, paragraph 5.19; CCAMLR-XI, paragraph 4.21).

6.33 At its 1993 meeting, the Working Group agreed that it would be undesirable in future to continue to conduct assessments in this fashion. In particular, there was a concern that subjective assessments combining verified and unverified data which may or may not comply with CEMP Standard Methods, could be potentially confusing to scientists and others not familiar with such data or with the deliberations of WG-CEMP.

6.34 Unfortunately, despite the desire expressed in paragraph 6.33, at the 1993 meeting sufficient inconsistencies between the CCAMLR database and submitted data still remained and the amount of newly-submitted data had diminished so that it was judged impracticable to improve the assessment procedure over that undertaken last year.

6.35 In future, however, WG-CEMP agreed that, beginning at its 1994 meeting:

- (i) the formal annual assessment of predator data would be confined to data on parameters collected annually and submitted 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.

6.36 In order to move as quickly as possible to objective assessment, it was essential to resolve inconsistencies between database and submitted data. Members were asked to give this urgent consideration, in consultation with the Data Manager.

6.37 Once this was done the table summarising formal assessments of predator data (i.e., Table 5) could be replaced by one recording the calculated year-to-year changes together with the statistical significance of these differences. It might also be desirable to report the actual annual values of parameters in these tables but this may have implications for the use of these data outside CCAMLR. Members were urged to consider this situation from the point of view of rules governing access to, use of, and publication of CCAMLR data (CCAMLR, 1992¹).

6.38 Appropriate treatment of krill and environment data should be a priority item for discussions at the meeting of WG-Krill and WG-CEMP next year.

6.39 Because it was not possible to improve the assessment procedure at the present meeting (paragraph 6.34), the Working Group updated in Table 5 its subjective summary of the nature, magnitude and direction of change of the data recorded for predator parameters. Some update to environment data was also included. Krill catch, biomass and CPUE data were not updated because WG-CEMP felt there was insufficient expertise within the Working Group to undertake this in a fully reliable fashion.

6.40 Furthermore, it was decided to delete all entries for krill biomass, catch and CPUE in Table 5 because it was felt preferable to complete the assessment only after WG-Krill had considered the best potential indices for assessment and discussed these topics with WG-CEMP at the next joint meeting (paragraphs 5.30 to 5.33).

6.41 The provision of appropriate data on prey for inclusion in summaries such as provided by Table 5 should therefore be a priority topic for consideration at the next joint meeting of WG-CEMP and WG-Krill. Specifically, responses to questions such as those in paragraph 5.33 would substantially help WG-CEMP in this regard.

¹ CCAMLR. 1992. *Basic Documents*. Sixth Edition. CCAMLR, Hobart, Australia: 114 pp.

6.42 The update to the predator and environment data included changes to the previous assessment (marked by asterisks in Table 5) as well as the new summaries for 1993.

6.43 The summaries for Subarea 48.1 (Tables 5.1 to 5.5) indicated that 1993 (1992/93 predator breeding season) was a fairly typical year, with not much change from 1992. For example, at Seal Island (Table 5.5), the only parameters that changed substantially were foraging trip durations of Antarctic fur seals and chinstrap penguins and these changed in opposite directions. At Admiralty Bay (Table 5.3) and at Anvers Island (Table 5.1), 1993 was an average-to-good year for Adélie penguin breeding and population sizes were generally stable.

6.44 In Subarea 48.2 (Table 5.6), 1993 was a good year from the standpoint of reproductive performance of Adélie, chinstrap and gentoo penguins at Signy Island. Breeding population size was stable for Adélie penguins and indicated recoveries for chinstrap and gentoo penguins from reduced levels in 1991 and 1992, respectively.

6.45 In Subarea 48.3 (Tables 5.7 and 5.8), breeding performance in 1993 was good for all species (exceptional for gentoo penguins), although fur seal foraging trip durations were inexplicably longer than in 1992 (paragraph 6.43). Breeding population sizes were either stable or showing recovery after substantial reductions in 1991.

6.46 At Béchervaise Island in Division 58.4.2 (Table 5.9) there was very little change in the parameters for Adélie penguins, despite greater than usual snow cover during the pre-laying period.

6.47 The Working Group noted that, despite the subjective nature of this second annual assessment, the general finding - that conditions during the 1993 breeding season for predators were normal to good - was likely to be quite robust, recognising that five years' data, including those for the uniformly poor season in 1991, are now available.

Potential Impacts of Localised Krill Catches

Distributions of Krill Catch and Predators

6.48 In recent years it has become increasingly apparent that there is a consistent pattern of temporal and spatial overlap between krill harvesting and feeding by land-based predators in Subareas 48.1 and 48.2 during the predators' breeding seasons (SC-CAMLR-XI, paragraphs 5.24 to 5.31). This situation led to recognition that further work is needed to investigate more precisely this

overlap and to assess more accurately the magnitude of potential competition between predators and fishery (SC-CAMLR-XI, paragraph 5.50). Further, WG-CEMP and WG-Krill were encouraged by the Scientific Committee to prepare for such work as a matter of priority, particularly with respect to Subarea 48.1.

6.49 In this regard, WG-CEMP considered two papers presenting updated information about the fine-scale distribution of krill catches in relation to predator colonies. The first, WG-Krill-93/10, updated the analysis presented in WG-Krill-92/19 and indicated that the percentage of the 1992 krill catch within the critical period-distance for breeding seal and seabird predators in Subarea 48.1 (70%) remained similar to, but at the low end of the range of values from previous years. It was noted that the recent percentages tend to be somewhat lower probably because the fishery has been extended into the months of April to June. This difference notwithstanding, the general pattern of the fishery in Subarea 48.1 (concentrations north of Elephant and Livingston Islands) has remained stable. The fine-scale catch data for Subarea 48.2 were incomplete.

6.50 Mr Ichii introduced the second paper, WG-Krill-93/7, which used estimates of prey consumption rates and information on seabird distribution to estimate the spatial and temporal distribution of krill consumption by chinstrap and gentoo penguins breeding on the South Shetland Islands. That distribution was then compared with “finer-scale” catch data (10 x 10 n mile) in an attempt to evaluate the impact on these penguin populations of the Japanese krill catch which, over the past several years, has generally accounted for approximately 80% of the total catch in Subarea 48.1.

6.51 The authors of WG-Krill-93/7 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 foraging areas of the majority of local penguin populations and the areas from which the main catch of krill by the fishery is taken is low; and
- (ii) the current catch by the krill fishery is low compared with the local krill biomass.

6.52 WG-CEMP welcomed this work as a significant step toward assessing the magnitude of potential competition between predators and the fishery. It further noted the utility of the finer-scale data for this type of exercise. There was, however, considerable discussion of whether the authors’ conclusion about the likelihood of adverse impact was in fact supported by the analysis. This discussion included the following points:

- (i) the results appear sensitive to the accuracy of the estimates of penguin population size and to knowledge of where penguins from Low Island forage. Use of more recent data on seabird abundance and distribution in that area (Woehler, 1993²) might lead to better results but data on foraging areas of Low Island penguins are unlikely to be available in the near future;
- (ii) the analysis assumed a constant per-capita rate of krill consumption by penguins during the months of December to March. Therefore, the potentially equally critical post-breeding period, when prey consumption increases markedly due to foraging by adults preparing to moult and by fledglings, was not considered. Very little is presently known about how far from the colonies these groups of penguins forage;
- (iii) the analysis assumed that prey consumption by penguins was spread evenly over the area considered; the actual distributions of prey consumption may have been different but there are few data with which to model this; and
- (iv) the analysis does not account for such factors as krill flux through the area, the fine-scale foraging patterns of the predators in relation to the distribution and density of krill, and potential effects caused by the fishery on krill availability to penguins (e.g., trawling activity disrupting krill aggregations).

6.53 The first three points above, (as well as the analysis in WG-Krill-93/25), emphasise the need to obtain refined information on predator distribution and foraging locations, allowing a more closely comparable analysis of detailed predator data with the finer-scale fishery data. Progress in this area would be greatly enhanced by undertaking CEMP activities at more sites along the north coasts of the South Shetland Islands near the main fishing grounds north of Livingston Island (e.g., Cape Shirreff).

6.54 It was recognised that some of these points, particularly the fourth, may be especially challenging to address by research in the near future. The Working Group agreed, however, that undertaking research on these topics is essential if progress is to be made in understanding the factors affecting krill availability to predators, and that Members should be encouraged to proceed with such research as a matter of priority.

6.55 The Working Group emphasised that understanding the nature of potential competition between krill predators and the krill fishery is far more complicated than a comparison of the biomass of krill present in a particular zone with the biomass of krill eaten by predators would show.

² Woehler, E.J. (Compiler). 1993. *The Distribution and Abundance of Antarctic and Sub-Antarctic Penguins*. Scientific Committee on Antarctic Research (SCAR), Cambridge: 76 pp.

Indeed, there are at least four topics which need to be considered in evaluating potential predator/fishery competition:

- (i) spatial overlaps, accounting for the locations of predator foraging areas and commercial fishing grounds;
- (ii) temporal overlaps, accounting for the timing and seasonal changes of predators' localised foraging activities and the scheduling of fleet operations;
- (iii) behavioural interactions, pertaining to the types and characteristics of krill aggregations needed by predators for efficient foraging (e.g., size and density of krill patches) and the effects of trawling activities on krill aggregation patterns; and
- (iv) prey biomass and predator energetic needs, accounting for the actual levels of krill biomass present in and moving through particular localised areas, and the amount of krill biomass needed to meet the energetic needs of predators and their offspring.

6.56 It was noted that several of the papers considered at the present and past meetings had contributed to these topics. For example, papers by the Secretariat had addressed the spatial and temporal scales of the fishery within 50 and 100 km of predator colonies (WG-CEMP-91/9, WG-Krill-92/19 and 10). Similarly, the analysis of the spatial and temporal distributions of prey consumption by predators (WG-Krill-93/7) represents a valuable advancement at this stage.

Consequences of Potential Precautionary Measures

6.57 In 1991 a dialogue was initiated to explore the consequences of various types of conservation measures associated with a precautionary approach to management (SC-CAMLR-XI, Annex 4, paragraphs 5.1 to 5.35). It was agreed that this dialogue had been very useful, and there was a feeling that it should be continued (SC-CAMLR-XI, paragraphs 5.39 and 5.40).

6.58 To facilitate this dialogue, the Scientific Committee requested that the Secretariat conduct a simulation study to explore more fully the potential consequences of different extents and locations of closed areas (SC-CAMLR-XI, paragraph 5.41). The Data Manager completed such a simulation model and presented the results in WG-Krill-93/14.

6.59 In WG-Krill-93/14, the behaviour of the krill fishery in a portion of Subarea 48.1 was modelled using input parameters derived from Chilean CPUE and fishing distribution data, under several

alternative management strategies. These strategies included unrestricted fishing, closing waters within 50 km of the South Shetland Islands, closing an area within 100 km of either Livingston or Elephant Island, and closing areas within 100 km of both Livingston and Elephant Islands.

6.60 Under unrestricted fishing, the model predicted a catch level and distribution of catches similar to that seen in the present fishery. Under a closure of the waters within 50 km of the South Shetland Islands, the catch dropped by 24%. Closing the Livingston Island area resulted in a 39% increase and closing the Elephant Island area resulted in a 15% decrease in catches from the unrestricted level, while closing both areas simultaneously resulted in a 71% decrease in catches. A further discussion of the simulation's results can be found in the 1993 Report of WG-Krill (SC-CAMLR-XII/4, paragraphs 5.34, 5.35 and 5.37).

6.61 WG-CEMP welcomed this paper and commended the Secretariat and Data Manager for producing the analysis in a timely and well-presented manner.

6.62 The Working Group noted the advantage at this stage of the simplicity of the model and that it reproduced, in at least a general way, the magnitude and distribution of the catch. There was considerable discussion about how the model could be made more realistic, though it was agreed that only a few of the suggestions would be feasible to incorporate in the near future.

6.63 The Working Group recommended that the Secretariat be asked to refine the model on the following basis:

- (i) as feasible, incorporate suggested improvements to the model, but maintain the model's general structure at present;
- (ii) Members engaged in krill fishing should be encouraged to provide input as to whether there are features that could be added in a simple fashion to the model that would remove some of the concerns about its realism. These might include, for example, consideration of the lost value of the catch from management strategies that affect the fishery's ability to target particular qualities of krill (e.g., WG-Krill-93/38), and the different fishing gear used and fishery strategies employed by the fleets of different fishing countries; and
- (iii) this work might be facilitated by a direct dialogue between the Data Manager and scientists from fishing countries.

6.64 In summary, WG-CEMP agreed that the model in WG-Krill-93/14 served the purpose of demonstrating the utility of such an analysis for investigating the effects of potential precautionary measures. The Working Group emphasised that the model results or continued efforts to further refine the model should not be interpreted as a basis for implementing precautionary measures. Rather, the intention was for the model to assist with the continued dialogue to explore various options and possible consequences of strategies for a precautionary approach to the issue of potential impacts of localised fisheries on predator populations (SC-CAMLR-XI, paragraphs 5.39 and 5.40).

6.65 As another aspect of this dialogue, Members engaged in krill fishing were invited at the 1992 Scientific Committee meeting to consider and report on what potential measures or combination of measures would be acceptable for application within Subareas 48.1 and 48.2 in order to address the problem of providing some precautionary protection for land-based krill predators foraging within 100 km of breeding colonies between December and March inclusive (SC-CAMLR-XI, paragraph 5.40).

6.66 Dr H. Hatanaka (Japan) informed the Working Group that a discussion among Japanese krill fishermen, in consideration of WG-Krill-93/7, had concluded that there is no need to impose any kind of restrictions on the fishery and, therefore, that no fruitful results will come from further dialogue to identify the options for potential measures for protection. Dr Hatanaka also indicated he felt that recent developments, such as the adjustment in FIBEX biomass estimates and the recent decline in total krill catch, support the conclusions of the fishermen.

6.67 Most participants noted that the developments cited by Dr Hatanaka as evidence for a lack of the necessity for a precautionary approach did not bear directly upon whether or not it is appropriate to discuss a range of options for potential precautionary measures.

6.68 Many participants noted that there is still substantial uncertainty regarding the true implications of competition between predators and the fishery. Such uncertainty was a primary factor for the recognition by the Scientific Committee of the importance of continuing a dialogue on the consequences to krill fishing countries and to predator populations resulting from implementing various precautionary measures.

6.69 In light of the preceding discussion, the Working Group agreed unanimously that it would be helpful for scientists from both fishing and non-fishing countries to continue their discussion exploring potential options for measures supporting a precautionary approach to the issue of potential impacts of localised fishing activity. In doing so, the Working Group drew a clear distinction between discussions of the options or types of potential precautionary measures and the need to implement

specific measures. It was emphasised that the current discussion should focus on potential options for precautionary measures. The possible need for implementing measures should be considered separately.

ESTIMATES OF PREY REQUIREMENTS FOR KRILL PREDATORS

Krill Consumption by Predators

7.1 Last year WG-CEMP made considerable progress on this topic (SC-CAMLR-XI, Annex 7, paragraphs 7.2 to 7.9) by:

- (i) noting the existence of the most recent summaries for the South Georgia ISR and providing a new summary in respect of energy budgets for Antarctic fur seals;
- (ii) providing new summaries with respect to penguins and fur seals for the Antarctic Peninsula ISR;
- (iii) providing the first synthesis of energy and prey consumption budgets for crabeater seals; and
- (iv) providing a full synthesis of relevant data for the Prydz Bay ISR.

7.2 In reviewing priorities in 1992, WG-CEMP had concluded that further work on this topic was of a lower priority than other tasks relating to predator-prey-fishery interactions currently being undertaken by WG-CEMP (SC-CAMLR-XI, Annex 7, paragraph 7.12).

7.3 Some Members of the Scientific Committee had indicated a strong interest in obtaining estimates of krill consumption by selected predators in Subareas 48.1 and 48.2 (SC-CAMLR-XI, paragraph 5.58).

7.4 WG-CEMP noted that the data assembled last year provided all the information necessary for estimating the krill consumption of a range of predators for most conceivable purposes.

7.5 Members who require yet more detailed information or who need to adapt the information provided for more specialised purposes should contact those responsible for the appropriate data compilations.

7.6 In order to maintain up-to-date references on population size, diet and energy consumption of predators, Members were urged to table copies of relevant publications at WG-CEMP meetings. No such documents had been tabled at the present meeting.

7.7 In respect of a suggestion by WG-FSA in 1991 (SC-CAMLR-X, paragraphs 6.55 to 6.56) that krill predation by fish might be incorporated into WG-CEMP's estimates of prey consumption, WG-CEMP noted that WG-FSA was better placed to summarise available data on krill consumption and energy budgets of fish. However, a continuing dialogue on this topic between WG-FSA and WG-CEMP would be valuable.

Predator Performance and Krill Availability

7.8 An approach to understanding functional relationships between krill availability and predator performance was initiated at the Joint Meeting of WG-Krill and WG-CEMP in 1992 (SC-CAMLR-XI, Annex 8) and is described in detail in paragraph 2 and the Appendix of that Annex.

7.9 It was advised that models should be developed for several different predator species and that the information required for each would be:

- (i) adult average annual survival rate;
- (ii) age-at-first breeding; and
- (iii) from the viewpoint of the predator, a division of years into good, poor and bad, these categories nominally corresponding to circumstances in which, respectively, breeding success and adult survival are good, breeding success is poor but adult survival unaffected and both breeding success and adult survival are poor.

Additional data on the timing of the breeding season of the predator were requested.

7.10 The tasks of providing these data were allocated by SC-CAMLR-XI, Annex 7, paragraph 7.18. Data were contributed by Dr Trivelpiece (Adélie penguin), Drs Croxall and Boyd (black-browed albatross and Antarctic fur seal) and Drs Boveng and Bengtson (crabeater seal). These data were circulated in SC CIRC 92/13 (with a revised version in SC CIRC 93/18).

7.11 Analysis of these data according to the methods developed in SC-CAMLR-XI, Annex 8, Appendix 1 was carried out by Drs D.S. Butterworth and R.B. Thomson (South Africa) and

reported in WG-Krill-93/43. Dr Butterworth presented a review of the main findings of his paper to WG-CEMP.

7.12 A brief description of some of the main features of the analyses conducted and problems encountered is reported in SC-CAMLR-XII/4, paragraphs 5.12 to 5.21. An important general conclusion was that variability in the annual recruitment of krill results in predator populations having less resilience to krill harvesting than deterministic evaluations would suggest. However, quantitative descriptions of these effects and of acceptable levels of fishing intensity could not be undertaken until uncertainties over the validity of some of the data provided for the predators (particularly on adult survival) had been resolved.

7.13 Dr Butterworth was thanked for his clear presentation to WG-CEMP of WG-Krill-93/43 and he and his co-author were thanked for undertaking such a comprehensive analysis so promptly.

7.14 In reviewing the predator data as submitted and interpreted, Members noted that a number of problems had arisen, in part through insufficiently clear explanation of the exact nature of the data required and in part through lack of time for dialogue between Members submitting data and those undertaking the analysis.

7.15 Specifically, most of the submitted data on proportions of years in different categories were based on subjective assessment and, even where objective criteria were specified, the categories tended to reflect good, average (rather than poor) and bad years. In respect of values for adult survival, those submitted were mainly mean rather than maximum values. In addition, those for Adélie penguins and Antarctic fur seals were also underestimates, in that no allowance had been made for band/tag loss and related problems.

7.16 To clarify the sources and nature of the predator data, as well as to provide information in response to the questions posed by WG-Krill (paragraph 5.20), the data submitted and the methods used to collect them were reviewed for each parameter and follow as paragraphs 7.17 to 7.28.

Adult Survival

Adélie Penguin

7.17 The study populations at Admiralty Bay, King George Island, South Shetland Islands were built up by flipper-banding 200 pairs of adult birds each year. The survival value reported derived

from the re-sighting data for the birds from each group observed one year later. Although these data are entirely comparable across years, they will consistently under-estimate adult survival because of:

- (i) Deferred breeding (i.e., birds breeding in years n and $n + 2$ but being unrecorded in year $n + 1$). This is thought to be a small effect and could be corrected for by examining the records of birds seen in year $n + 2$;
- (ii) Band loss. A study using double-banded birds indicated a rate of band loss of 4 to 5%, (i.e., under-estimating annual survival by this amount). However, double-banding significantly increased mortality rate so a subsequent study, comparing single-banded and transponder-implanted birds, is in place and results should be available in December 1993;
- (iii) Band-induced mortality. Even applying single bands may decrease annual survival; the above study will contribute to assessing the magnitude of this effect; and
- (iv) Emigration from the study area. This is not believed to be a significant factor in Adélie penguin populations and no reports of breeding Adélies banded at Admiralty Bay have been received from other investigators working in nearby colonies on King George Island.

The study population has fluctuated considerably over the study years 1977 to 1993 but there is no statistically significant overall trend. However, the population has not yet recovered from the significant declines following the 1989 and 1990 winters and currently is at its historically lowest level.

Black-browed Albatross

7.18 The sources and methods used to derive these data are described in WG-CEMP-93/6 for the study at Bird Island, South Georgia. All birds breeding in selected study colonies are double-banded (with Monel metal and Darvic plastic leg bands). Almost every bird breeding in these colonies is recaptured annually and survival is calculated taking into account birds that defer breeding for one or more years. The value provided is the average, for both sexes combined, of the mean values calculated for each of the 15 years for which estimates are available. There is no emigration of breeding birds, no band loss and no band-induced mortality, so the survival estimates are likely to be of high accuracy. The study populations have declined at between 0.5% to 2.0%

annually over the study period (1976 to 1991), though without any statistically significant decrease in adult survival; however, the latter has been declining markedly since 1988.

Crabeater Seal

7.19 The methods used are described in detail in WG-CEMP-93/4. Basically the value submitted is the weighted average age-specific survival rate (estimated using a five parameter survivorship model) derived from catch-at-age data on 2852 seals collected in the Antarctic Peninsula area between 1964 and 1990. The value, of 0.93, is therefore averaged across some 44 years of varying characteristics; to the extent that some years would be less than good, this value is an under-estimate. However, conditions in the 1950s to 1970s may have been particularly favourable for this species. Data on the actual population trends in crabeater seals are incomplete; census data from 1983 indicated lower seal densities than had been observed in the late 1960s and early 1970s (Erickson and Hanson, 1990³), but it is at present unknown whether this is a result of a decline in population abundance or other factors such as a change in distributions.

Antarctic Fur Seal

7.20 The adult survival rate estimate submitted (0.79) is the average of annual estimates based on re-sightings of tagged adult female seals from 1987/88 to 1991/92 at the main study site on Bird Island, South Georgia. It will be an under-estimate due to:

- (i) Tag loss. This is a significant problem (though substantially less than with tagged pups) but difficult to quantify. Some data for double-tagged animals are available and these will be analysed to adjust the adult survival estimate; and
- (ii) Emigration. Female fur seals at Bird Island show considerable site fidelity (Lunn and Boyd, 1991⁴) and tagged animals on other Bird Island beaches would readily be recognised so this is likely to be of negligible significance. Deferred breeding is allowed for in the estimate, and tag-induced mortality is believed to be negligible. Following very rapid expansion over the past 30 years (initially around 17% per annum, decreasing to 10% p.a.), the rate of increase of the population of breeding

³ Erickson, A.W. and M.B. Hanson. 1990. Continental estimates and population trends of Antarctic ice seals. In: Kerry, K.R. and G. Hempel (Eds). *Antarctic Ecosystems. Ecological Change and Conservation*. Springer-Verlag, Berlin: 254-264.

⁴ Lunn, N.J. and I.L. Boyd. 1991. Pupping site fidelity of Antarctic fur seals at Bird Island, South Georgia. *Journal of Mammalogy*, 72: 202-206.

females at Bird Island has been less than 1% p.a. over the last five years. The South Georgia population as a whole, however, is still increasing at around 10% p.a. (Boyd, 1993⁵).

Age-at-First-Breeding

Adélie Penguin

7.21 The value submitted is the mean of ages at which tagged female chicks were first observed to breed in the years 1981 to 1987. Recruitment is highly variable between years (though without systematic trend) and the value will therefore be somewhat biased (probably downward) by the contribution of large numbers of birds recruiting in good years.

Black-browed Albatross

7.22 The data used to give the modal value are the average for both sexes combined (no significant difference between sexes) of the relatively small number of known-age birds which has been recruited in recent years (see WG-CEMP-93/6). There may be a bias similar to that for Adélie penguins but it will be less than 0.1 year. There is no indication of any trend in age of recruitment (unlike the situation in the wandering albatross).

Crabeater Seal

7.23 Data on age-at-sexual maturity (first ovulation) from counts of *corpora* in females aged by counts of tooth annuli were used to derive annual estimates for all seals in the collection referred to above (see WG-CEMP-93/4 for further details). There is a trend to increasing age of sexual maturity from 3.0 in the mid-1960s to nearly 5.0 in the late 1980s. The value proposed, of 3.8 years, is the mid-point of the whole data set; current values would be about one year greater. Butterworth and Thomson (WG-Krill-93/43) used a value of 5 years for age at first parturition. There may be some biases due to differential recruitment in good years but the large range of years should minimise this effect.

⁵ Boyd, I.L. 1993. Pup production and distribution of breeding Antarctic fur seals *Arctocephalus gazella* at South Georgia. *Antarctic Science*, 5:17-24.

Antarctic Fur Seal

7.24 Data are based on the observed average age-at-first parturition of seals tagged as pups for the years 1983/84 to 1991/92. For their analysis, Butterworth and Thomson erroneously added one year to the estimate provided of 3.5 years. There is no evidence of any significant change in this parameter over the past decade (Boyd *et al.*, 1990⁶).

Interannual Variation

Adélie Penguin

7.25 These proportions were based on the variation in breeding success (proportion of chicks surviving to creche stage) for the years 1977 to 1992 (Trivelpiece *et al.*, 1990⁷ and unpublished data).

Black-browed Albatross

7.26 The proportions provided were based on the variation in breeding success (proportion of chicks fledged from eggs laid) or of annual adult survival for the years 1975-76 to 1990-91 (WG-CEMP-93/6, Tables 5 and 10).

Crabeater Seal

7.27 The proportions were based on frequency data of estimated strength of cohorts from 1945 to 1988 (Testa *et al.*, 1991⁸; Boveng, 1993⁹) divided into thirds as described in WG-CEMP-93/4.

⁶ Boyd, I.L., N.J. Lunn, P. Rothery and J.P. Croxall. 1990. Age distribution of breeding female Antarctic fur seals in relation to changes in population growth rate. *Canadian Journal of Zoology*, 68: 2209-2213.

⁷ Trivelpiece, W.Z., S.G. Trivelpiece, G.R. Geupel, J. Kjelson and N.J. Volkman. 1990. Adélie and chinstrap penguins: their potential as monitors of the Southern Ocean ecosystem. In: Kerry, K.R. and G. Hempel (Eds). *Antarctic Ecosystems. Ecological Change and Conservation*. Springer-Verlag, Berlin Heidelberg: 191-202.

⁸ Testa, J.W., G. Oehlert, D.G. Ainley, J.L. Bengtson, D.B. Siniff, R.M. Laws and D. Rounsevell. 1991. Temporal variability in Antarctic marine ecosystems: periodic fluctuations in the phocid seals. *Can. Journ. of Fisheries and Aquatic Sciences*, 48: 631-639.

⁹ Boveng, P.L. 1993. Variability in a crabeater seal population and the marine ecosystem near the Antarctic Peninsula. Ph.D. Thesis. Montana State University, Bozeman, Montana, USA.

Antarctic Fur Seal

7.28 The proportions were based on variation in average values of foraging trip duration, pup mortality and male and female pup growth rates for the years 1983/84 to 1991/92 (WG-CEMP-93/9 and 10; Lunn, 1993¹⁰). The submitted data were somewhat subjectively assessed overall as good/average/bad in the proportions 1:6:2. More objective assessment would have produced ratios of 3:4:2 (foraging trips), 2:5:2 (pup mortality) and 3:5:1 (growth rates).

Further Discussion on the Modelling Exercise

7.29 This review indicates that some quite substantial modifications to the data submitted and to the analyses based thereon are required.

7.30 In particular, those contributing the original data (i.e., Adélie penguin, Dr Trivelpiece; black-browed albatross and Antarctic fur seal, Drs Croxall and Boyd; crabeater seal, Drs Bengtson and Boveng) were asked to supply as much information as possible in terms of year-specific values, so that the actual distributions of data values (rather than some more or less arbitrary classifications of these) can be used in the analysis.

7.31 In addition, contributors were asked to submit information for the original datasets and sites that were used in the model concerning:

- (i) the magnitude of under-estimates of adult survival, where appropriate (Adélie penguin, Antarctic fur seal);
- (ii) maximum rates of population increase recorded for closed populations of each predator species;
- (iii) observed rates of change in population size (together with statistical significance and likely reasons) for the population used to derive the submitted data over the study period; and
- (iv) quantitative data on diet, indicating the degree of dependence on krill of each predator species.

¹⁰ Lunn, N.J. 1993. The reproductive ecology of female Antarctic fur seals *Arctocephalus gazella* during lactation. Ph.D. Thesis, Open University: xv+201 pp.

These responses should take care of all but the last of the queries from WG-Krill (SC-CAMLR-XII/4, paragraph 5.20).

7.32 In respect of identifying other krill-dependent populations for which equivalent data are available (SC-CAMLR-XII/4, paragraph 5.20), WG-CEMP suggested that Adélie penguins at other sites, e.g. Béchervaise Island (see WG-CEMP-93/19) and the gentoo penguins at Bird Island, South Georgia, for which data have been provided in WG-CEMP-93/8, would be suitable.

7.33 All data requested in paragraphs 7.30 and 7.31 to undertake this re-analysis would be transmitted to the Convener of WG-CEMP by 31 December 1993. He would be responsible for their collation and transmission to the CCAMLR Secretariat for circulation to all Members and to all attendees at the 1992 and 1993 meetings of WG-Krill and WG-CEMP.

7.34 Some general discussion followed on the topic of assessing functional relationships between predators and prey through the type of model being used above.

7.35 Japanese scientists pointed out that factors other than krill availability contributed to the observed variation in survival, breeding success, reproductive performance and cohort strength from which the distributions of interannual variation were derived.

7.36 The Working Group noted that:

- (i) the analyses being undertaken are still preliminary and can be refined further when relevant quantitative data on the influence of other environmental factors are available;
- (ii) the evidence for breeding success, foraging trip duration, offspring growth and other reproductive performance variables being directly affected by food availability was many times stronger than any evidence of direct effects of ice, weather, etc. in the species and situations under consideration. However, it was recognised that survival rate can be affected by ice and weather conditions, especially in winter. Any years where poor survival and reproductive performance could be attributed to ice or weather should be clearly identified by contributors when submitting data;
- (iii) krill availability to predators within their foraging range while rearing offspring, rather than krill biomass in some larger areas, is the most appropriate variable for assessing functional relationships;

- (iv) krill availability to predators is affected not only by krill biomass and distribution, but also by aspects such as its aggregation patterns in relation to predators' foraging behaviour; and
- (v) all analyses in WG-Krill-93/43 need repeating using the corrected data.

7.37 However, it was recognised that the present modelling initiatives were being undertaken because there were no suitable empirical data with which to derive functional relationships. Members were again encouraged to acquire appropriate data on relationships between estimates of krill biomass and krill availability to predators in order to enable realistic functional relationships to be assessed empirically.

7.38 It is unlikely that this can be done quickly. In the meantime, WG-CEMP agreed that models such as those developed in WG-Krill-93/43 offered a good starting point for examining these important relationships. Indeed, it was emphasised that the predator data being used in these models were among the best available for marine mammals and birds anywhere.

7.39 Members were encouraged to undertake their own analyses of the newly-submitted data so that more than one set of evaluations could be available for consideration.

LIAISON WITH WG-KRILL AND WG-FSA

8.1 The Working Group noted that numerous topics of common interest with WG-Krill and WG-FSA had been discussed under agenda items 4 to 7 (see paragraphs 4.30, 5.30 to 5.33, 6.52 to 6.58 and 7.7 to 7.39). In particular, efforts to model the functional relationships between predator performance and krill availability were cited as a good example of a productive collaboration between WG-CEMP and WG-Krill.

8.2 Last year, the Scientific Committee had agreed that it would be important to try to hold a joint meeting of WG-CEMP and WG-Krill in 1994 (SC-CAMLR-XI, paragraph 6.15). The Working Group recommended that every effort should be made to arrange such a meeting.

8.3 Last year, dialogue between WG-CEMP and WG-FSA was initiated to try to incorporate relevant data from certain fish species in the assessments forming part of SC-CAMLR-XI, Annex 7, Table 4 (Table 5, this Report). WG-FSA had noted that it would take time to refine the type of parameters to be included and to evaluate the applicability of the approach as a whole. It had invited submissions on this topic for its 1993 meeting.

OTHER BUSINESS

IUCN Assessment of Marine Protected Areas

9.1 At its 1992 meeting, the Working Group was informed of the IUCN initiative to assess the World's marine protected areas and identify priority areas for conserving global marine biodiversity. If funds were to be made available from the World Bank to help support conservation of global marine diversity, then providing some type of financial support to CEMP might be an effective way for the Global Environment Facility to achieve some of its objectives (SC-CAMLR-XI, Annex 7, paragraphs 9.4 and 9.5).

9.2 The Convener had been asked to investigate this matter further (SC-CAMLR-XI, Annex 7, paragraph 9.6) , to determine:

- (i) whether these programs' goals corresponded to those of CCAMLR and the work of WG-CEMP;
- (ii) the prospects and circumstances under which funding may be made available for this initiative by the World Bank;
- (iii) whether or not WG-CEMP should consider recommending to the Scientific Committee that a proposal be developed requesting that the World Bank provide funds in support of CEMP.

9.3 He reported that he had been unable to make further progress with his investigation. The Working Group gratefully accepted an offer from Drs Bengtson and Penhale to pursue this matter further and report back to WG-CEMP at its next meeting.

Sixth SCAR Symposium on Antarctic Biology

9.4 Dr S. Focardi (Italy) reminded the Working Group that the Sixth SCAR Symposium on Antarctic Biology will be held from 30 May to 3 June 1994 in Venice, Italy. The deadline for notifying the Symposium organisers of an intention to submit a verbal or poster presentation is 1 October 1993. The themes of the Symposium will be Antarctic Biodiversity, Life History Strategies and Environmental Change and Human Impact. Meetings of the SCAR Subcommittee on Bird Biology and the SCAR Group of Specialists on Seals will immediately precede the Symposium.

9.5 The report of a meeting of Conveners of CCAMLR Working Groups, held in November 1992 and available to the Working Group as SC-CAMLR-XII/BG/12, contained a recommendation that the Science Officer present a poster describing the aims and achievements of CCAMLR to the Symposium.

9.6 The Working Group recommended that the Scientific Committee endorse this suggestion and in the meantime encouraged the Chairman of the Scientific Committee, Dr K.-H. Kock, to ask the Science Officer to submit a preliminary proposal for a poster to the Symposium organisers prior to the 1 October 1993 deadline.

SO-GLOBEC

9.7 The Working Group noted that information on the aims and organisation of SO-GLOBEC had been presented to WG-Krill (SC-CAMLR-XII/4, paragraphs 7.4 to 7.6).

9.8 Dr Croxall introduced WG-CEMP-93/29 which contained the draft report of the meeting of the SO-GLOBEC Top Predator Group. He emphasised that the development by this Group of a research program into the nature of interactions between zooplankton and higher predators was still at an early stage, and that the coordination with other groups working in the Antarctic (CCAMLR Working Groups, Scientific Committee and SCAR) was essential to identify areas of common interest and avoid duplication of effort. For this reason, the SO-GLOBEC Group had suggested that the topic of SO-GLOBEC should be placed on the agenda of both WG-Krill and WG-CEMP.

9.9 There was a particular requirement for SO-GLOBEC to develop a more detailed program for top predators (because this has hitherto received less attention than the zooplankton research program) and the assistance of CCAMLR and SCAR had been specifically invited in this regard. A workshop to consider this topic will be held, probably at Cambridge, UK, in 1994.

9.10 At its initial implementation meeting, the Top Predator Group had identified a number of target predator species, research objectives and candidate experimental sites which were in general more broadly defined than those of CEMP. Although the objectives of SO-GLOBEC and some of the scientific initiatives of CCAMLR may be similar, there are differences in time scales and specific aims between the two groups (in particular, SO-GLOBEC will run for a limited period of five to eight years). It is expected that SO-GLOBEC will emphasise the use of new technology and techniques, including extensive modelling, which may be of utility to CCAMLR in the future development of its research programs.

9.11 Concern was expressed that there would be potential for competition for finances between SO-GLOBEC and CEMP since there were some areas of similar research objectives. The involvement of CCAMLR and SCAR at this early stage in the planning of SO-GLOBEC should minimise these risks. In some areas of research, such as zooplankton ecology, the existence of the SO-GLOBEC program may make available data and resources not currently accessible to CCAMLR.

9.12 The Working Group endorsed the recommendation of WG-Krill that the Scientific Committee should consider nominating an observer to the SO-GLOBEC program (SC-CAMLR-XII/4, paragraph 7.10) and that the liaison between SO-GLOBEC and the Scientific Committee and its Working Groups should continue.

SCAR Antarctic Pack-ice Seals (APIS) Program

9.13 The Convener introduced a draft prospectus describing a new international research initiative on pack-ice seals, coordinated by the SCAR Group of Specialists on Seals (WG-CEMP-93/22). This draft prospectus, for the Antarctic Pack-ice Seals (APIS) Program, was produced at a workshop held in May, 1993, sponsored in part by CCAMLR (SC-CAMLR-XI, paragraph 7.18).

9.14 The APIS Program is being developed to address several research topics of direct relevance to CCAMLR, and especially to the work of WG-CEMP. For example, although crabeater seals have been selected as a CEMP monitoring species, implementation of CEMP activities in the pack-ice zone has been modest because of the limited availability of logistic and financial support. It is expected that the pack-ice seal research outlined in the APIS Program will represent a major contribution to CEMP.

9.15 Priority field research activities in this program are planned over the five-year period from 1995/96 to 1999/2000. Three of the five APIS operations areas fall within CEMP ISRs (Antarctic Peninsula/South Shetland Islands, Bellingshausen Sea, and Prydz Bay). Funding for these studies will primarily be sought from national programs.

9.16 The Working Group welcomed this new initiative, noting that both the APIS Program and CEMP would be able to contribute significantly to each other's work. The Working Group recommended that the APIS Program's development should be brought to the Scientific Committee's attention, and that efforts should be made to ensure that close coordination and effective communication are developed and maintained between these two programs.

Exploratory Fisheries

9.17 The Working Group noted the discussions of WG-Krill on exploratory fisheries (SC-CAMLR-XII/4, paragraphs 7.1 to 7.3), and considered a draft document prepared by the US Delegation outlining a possible approach to developing a procedure for evaluating fisheries during their exploratory phase (CCAMLR-XII/5). The Working Group agreed that the draft document provided a good basis for considering this issue. Suggestions on improving the draft were made to the authors, who indicated their intention to submit a revised version to WG-FSA, the Scientific Committee and the Commission.

SUMMARY OF RECOMMENDATIONS AND ADVICE

10.1 The Working Group made the following recommendations to the Scientific Committee:

- (i) that a short newsletter, describing major results and conclusions of WG-CEMP, be prepared and distributed annually following the completion of the Scientific Committee meeting (paragraph 3.6);
- (ii) that the draft Management Plan for the protection of Cape Shirreff and San Telmo Islands, South Shetland Islands be considered by the Scientific Committee (paragraph 4.1);
- (iii) that Members maintain national registers of electronic tags and associated banding data (paragraph 4.27);
- (iv) that funds be considered for supporting a workshop on at-sea behaviour methodology, tentatively proposed for 1995 (paragraph 4.20);
- (v) that the Secretariat be asked to continue to receive and process JIC data on sea-ice distribution (paragraph 4.38);
- (vi) that Members be strongly encouraged to submit to the CCAMLR Data Centre all available predator data collected in accordance with CEMP Standard Methods (paragraph 5.2);
- (vii) that the Secretariat be asked to refine its model of krill fishery behaviour (paragraph 6.63);

- (viii) that every effort should be made to arrange a joint meeting of WG-Krill and WG-CEMP in 1994 (paragraph 8.2);
- (ix) that the recommendation of the meeting of Conveners of CCAMLR Working Groups (November 1992) for the Science Officer to participate in the Sixth SCAR Symposium on Antarctic Biology and to present a poster describing the aims and achievements of CCAMLR, be endorsed (paragraph 9.6);
- (x) that the recommendation of WG-Krill of nominating an observer to the SO-GLOBEC program be supported (paragraph 9.12); and
- (xi) that close coordination and effective communication be developed between CEMP and SCAR's Antarctic Pack-ice Seals (APIS) Program (paragraph 9.16).

ADOPTION OF THE REPORT
AND CLOSE OF THE MEETING

11.1 The Report of the Meeting was adopted.

11.2 In closing the meeting the Convener thanked participants, rapporteurs, subgroups and the Secretariat for their work and assistance during the meeting. He noted that many CCAMLR Members had been actively involved in CEMP activities during the past year, and that these efforts and the papers presented at the meeting had contributed significantly to the meeting's success.

11.3 The Convener stated that, in his view, the work and challenges being addressed by CEMP reflected a fundamental tenet of the ecosystem approach embodied in the Convention. He congratulated the members of WG-CEMP for their excellent progress over the past nine years in developing a sound scientific program, which is serving as a pioneering effort to help incorporate an ecosystem perspective into considerations of conservation and management issues in Antarctica.

11.4 The Working Group expressed its gratitude to the Government of the Republic of Korea, the Polar Research Center of the Korea Ocean Research and Development Institute, and the Seoul National University for hosting the meeting. The Working Group further expressed its thanks to all those who assisted with the organisation of the meeting and for their warm hospitality.

Table 1: Summary of Members' CEMP activities on monitoring approved predator parameters.

Parameter		Species ¹	Country	Site Name/ Integrated Study Region/ Network Site	Year Started ²	Data Submitted ²	Being Prepared ²
Penguins							
A1	Weight on arrival at breeding colonies	A	Australia	Magnetic Is Prydz Bay	1984		1990-91
		A	Australia	Béchervaise Is		1992-93	
		A	Argentina	Stranger Point/ King George Is	1988	1988-90	1991
		A	Argentina	Laurie Is	1988	1988-90	1991
			Argentina	S. Orkney Is			
		A	Germany	Esperanza St. Ardley Is/ S. Shetlands	1991 1991	1991	
		M	UK	Bird Is/ South Georgia	1990	1990-93	
A2	Length of the first incubation shift	A	Australia	Magnetic Is Prydz Bay	1984		1989-91
		A	Australia	Béchervaise Is/ Mawson	1991	1991-93	
		A	Argentina	Stranger Point King George Is	1988		1990-91
			Argentina	Esperanza St.	1991		1991
		A	Germany	Ardley Is/ S. Shetlands	1991		
A3	Annual trends in breeding population size	A	Australia	Magnetic Is Prydz Bay	1984		1990-91
		A	Australia	Béchervaise Is		1992-93	
		A	Argentina	Stranger Point/ King George Is	1988		1990-91
			Argentina	Esperanza St.	1991		1991
		M,C	Brazil	Elephant Is S. Shetlands	1986	1992	
		A,C	Chile	Ardley Is S. Shetlands	1982		1989-92
		A	Japan	Syowa Station/ Network site	1970		1989-91

Table 1 (continued)

Parameter	Species ¹	Country	Site Name/ Integrated Study Region/ Network Site	Year Started ²	Data Submitted ²	Being Prepared ²
A3 continued	M,G	UK	Bird Is/ South Georgia	1976	1990-93	
	A,C,G	UK	Signy Is/ Network site	1979	1990-93	
	A	USA	Anvers Is	1992	1993	
	A	Germany	Ardley Is/ S. Shetlands	1991		
A4	C	Chile	Ardley Is S. Shetlands	1982		1989-92
	M,C	Brazil	Elephant Is S. Shetlands	1986	1989-92	1989-92 ³
	M,C	USA	Seal Is S. Shetlands	1988		1990-93 ³
	A	USA	Anvers Is Palmer Station	1988		1989-93 ³
A5	A	Australia	Magnetic Is Prydz Bay	1984		1990-91
	C	USA	Béchervaise Is Seal Is S. Shetlands	1992 1988	1988-93	
	A	USA	Anvers Is Palmer Station	1990	1990-93	
	M	USA	Seal Is		1990	
A6	A	Australia	Magnetic Is Prydz Bay	1984		1989-91
	A	Australia	Béchervaise Is	1992	1992-93	
	A	Argentina	Stranger Point/ King George Is Laurie Is/ Esperanza St.	1988		1990-91
	M,C	Brazil	Elephant Is S. Shetlands	1991 1986	1990-92	1991
	C	Chile	Ardley Is S. Shetlands	1982		1989-92
	C,G	Korea	Barton Pen., King George Is	1992		1992-93
	M,G	UK	Bird Is/ South Georgia	1976	1990-93	

Table 1 (continued)

Parameter	Species ¹	Country	Site Name/ Integrated Study Region/ Network Site	Year Started ²	Data Submitted ²	Being Prepared ²
A6 continued	A,C,G	UK	Signy Is/ Network site	1979	1990-93	
A7	Fledging weight	M,C	USA Seal Is S. Shetlands	1988	1988-93	1990-91
		A	USA Anvers Is Palmer Station	1988	1990-93	
		A	Germany Ardley Is	1991		
		A	Australia Magnetic Is Prydz Bay	1984		
		A	Australia Béchervaise Is	1992	1993	
		M	Brazil Elephant Is S. Shetlands	1986	1992	
		C	Brazil Elephant Is S. Shetlands	1986	1990-92	
		M,G	UK Bird Is/ South Georgia	1989	1990-93	
		C	USA Seal Is S. Shetland Is	1988	1988-92	
		A	USA Anvers Is Palmer Station	1988	1990-93	
A8	Chick diet	M	USA Seal Is		1990	1992
		A	Germany Ardley Is	1991		
		G	Korea Barton Pen., King George Is	1992		
		A	Australia Magnetic Is Prydz Bay	1984		
		A	Australia Béchervaise Is Mawson	1991	1991-92	
		M,C	Brazil Elephant Is S. Shetlands	1986	1992	
		C	Chile Ardley Is S. Shetland Is	1982		
		M	UK Bird Is/ South Georgia	1986	1990-93	
		G	UK Bird Is/ South Georgia	1986	1990-93	
		C	USA Seal Is S. Shetlands	1988	1988-91	

Table 1 (continued)

Parameter		Species ¹	Country	Site Name/ Integrated Study Region/ Network Site	Year Started ²	Data Submitted ²	Being Prepared ²
A8 continued		A	USA	Anvers Is Palmer Station	1988	1990-93	
A9	Breeding chronology	A	Germany	Ardley Is	1991		
		A	Australia	Magnetic Is Prydz Bay	1984		
		A	Australia	Béchervaise Is/ Mawson	1991		1991-93
		C,M	USA	Seal Is S. Shetland Is	1988	1988-93	
		A	USA	Anvers Is	1988	1990-93	
Flying birds							
B1	Breeding population size	B	UK	Bird Is/ South Georgia	1977	1977-93	
B2	Breeding success	B	UK	Bird Is/ South Georgia	1977	1977-93	
B3	Age-specific annual survival and recruitment	B	UK	Bird Is/ South Georgia	1977	1977-91	
Seals							
C1	Cow foraging/ attendance cycles	F	Chile	Cape Shirreff	1988	1988	
		F	UK	Bird Is/ South Georgia	1979	1990-93	
		F	USA	Seal Is S. Shetland Is	1988	1988-93	
C2	Pup growth	F	Chile	Cape Shirreff/ Ant. Peninsula	1985	1984-85 1990-92	
		F	UK	Bird Is/ South Georgia	1973 1978	1990-93	
		F	USA	Seal Is S. Shetland Is/	1988	1988-93	

¹ A - Adélie penguin, M - Macaroni penguin, C - Chinstrap penguin, G - Gentoo penguin, B-Black-browed albatross, F - Fur seal

² All years referred to are split-years

³ At present these data are not requested for submission to the CCAMLR Data Centre

Table 2: Directed research programs required to evaluate the utility of potential predator parameters.

Parameter	Member (species, area or site ^b)	Data Collected (years)	Data Analysed (years)	Reference to Published Results ^c	Research to be Continued (years)	Principal Scientists, Institution
Penguins^a						
Weight prior to moult						
At-sea diving behaviour and activity pattern	Australia (A-18)	1992-93	1992-93	Kerry <i>et al.</i> , 1993; Kerry <i>et al.</i> , (in prep.)	1994	K. Kerry, Aust. Antarc. Div.
	Germany (A,G-11)	1987-88	1989-90	Culik, 1993; Culik & Wilson, 1993; Culik <i>et al.</i> , 1992, 1993; Cooper <i>et al.</i> , 1993; Pütz, 1993; Weimerskirch & Wilson, 1992; Wilson, 1992; Wilson & Culik, 1992; Wilson <i>et al.</i> , 1992, 1993a, 1993b	1993-94	
	Germany (A,C,G-2)	1991-92	1992-93	Culik, 1993; Culik & Wilson, 1993; Culik <i>et al.</i> , 1992, 1993; Cooper <i>et al.</i> , 1993; Pütz, 1993; Weimerskirch & Wilson, 1992; Wilson, 1992; Wilson & Culik, 1992; Wilson <i>et al.</i> , 1992c, 1993a, 1993b		
	Japan, Australia (A-6)	1992-93				
	NZ (A-1)	1985-90	1985-90	Davis <i>et al.</i> , 1988; Davis & Miller, 1993; Sadlier & Lay, 1990	1993-94	L. Davis, Univ. of Otago
	UK (G,M-4)	1989-93 1989	1989-90 1989	Williams <i>et al.</i> , 1992a; Williams <i>et al.</i> , 1992b Croxall <i>et al.</i> , 1993	1994	J. Croxall, BAS (1991-93) P. Butler, Univ. B'ham)
	USA (C,M-2)	1988-1993	1989-1991	Bengtson & Eberhardt, 1989; Bengtson <i>et al.</i> , 1990; Bengtson <i>et al.</i> , 1991a; Bengtson <i>et al.</i> , 1991b; Croll <i>et al.</i> , 1991; Croll <i>et al.</i> , 1992; Bengtson <i>et al.</i> , 1993; Croll <i>et al.</i> , (in prep.)	continuing	J. Bengtson, NMML
	USA (A,G,C-2)	1989-92	In progress		1994	W. Trivelpiece, Montana State Univ.
Weight recovery during incubation	Australia (A-18)	1991-93	1991-92	Kerry <i>et al.</i> , 1993	1994-96	K. Kerry, Aust. Antarc. Div.
	NZ (A-1)	1987-89	1987-89	Davis & Miller, 1993		L. Davis, Univ. of Otago
	USA (A, C-2)	1984-85, 1988	1984-85, 1988	Trivelpiece & Trivelpiece, 1990	1994	W. Trivelpiece, Montana State Univ.
	USA (A-11)	1993		Trivelpiece & Trivelpiece, 1990	1994	W. Trivelpiece, Montana State Univ.

Parameter	Member (species, area or site ^b)	Data Collected (years)	Data Analysed (years)	Reference to Published Results ^c	Research to be Continued (years)	Principal Scientists, Institution
Penguins (continued)						
Survival	Australia (A-18)	1991-93	1991-93	Clarke, (in prep.)	1994-95	K. Kerry, Aust. Antarc. Div.
	NZ (A-1)	1977, 1984	1977, 1984	Davis & McCaffrey, 1986		L. Davis, Univ. of Otago
	UK (G, M-4)	1987-91	1987-90	Williams & Rodwell, 1992	1994	J. Croxall, BAS
	USA (C-2)	1988-93			continuing	J. Bengtson, NMML
	USA (A-11)	1988-93				W. Trivelpiece, Montana State Univ.
Chick growth rate	Chile (A, G-2)	1982-93	1982-93		1994	J. Valencia, Univers. de Chile
	Japan, Australia (A-6)	1992-93			1993-94	Y. Watanuki, Nat. Inst. of Polar Res.; G. Robertson, Aust. Antarc. Div.
	Korea (C, G-2)	1992-93				S. Kim, Polar Res. Center, KORDI
	NZ (A-1)	1977, 1984	1977, 1984	Davis & McCaffrey, 1989		L. Davis, Univ. of Otago
	Norway (M,C-17)	1989-90				E. Røskaft, Univ. of Trondheim
	UK (G-4)	1977, 1980, 1987-90	1977, 1980, 1987-90	Williams & Croxall, 1990; Williams & Croxall, 1991		J. Croxall, BAS
	USA (C-2)	1988-93			continuing	J. Bengtson, NMML
Bioenergetics	Australia (A-18)	1991-93	1991-92	Kerry <i>et al.</i> , 1993	1994-95	K. Kerry, Aust. Antarc. Div.
	Germany (A,C,G-11)	1987-88, 1989-90	1988-91	Bannasch & Fiebig, 1992; Culik, 1992a, b, c, d; Culik & Wilson, 1992; Wilson <i>et al.</i> , 1992a, b; Wilson & Culik, 1993		
	Germany (A,C,G-2)	1991-92	1992-93	Bannasch & Fiebig, 1992; Culik, 1992a, b, c, d; Culik & Wilson, 1992; Wilson <i>et al.</i> , 1992a, b; Wilson & Culik, 1993		
	NZ (A-1)	1984-85	1984-85	Green & Gales, 1990		B. Green, CSIRO, L. Davis, Univ. of Otago
	UK (G-4)	1991-93	Some	None		P. Butler, Univ. B'ham
Reproductive strategies	Japan, Australia (A-6)	1992-93			1993-94	Y. Watanuki, Nat. Inst. of Polar Res; G. Robertson, Antarc. Div.
	NZ (A-1)	1984-90	1984-90	Davis, 1991; Davis & Spiers, 1990	1993-94	L. Davis, Univ. of Otago

Parameter	Member (species, area or site ^b)	Data Collected (years)	Data Analysed (years)	Reference to Published Results ^c	Research to be Continued (years)	Principal Scientists, Institution
Penguins (continued)						
Reproductive strategies (cont.)	Norway (M,C-17)	1989-90				E. Røskaft, Univ. of Trondheim
Flighted seabirds^a						
Breeding population size	Norway (Cp-16)	1985				F. Mehlum, Norw. Polar Inst. (NPI)
	Norway (Cp, Ss-16)	1990		Haftorn <i>et al.</i> , 1991; Mehlum <i>et al.</i> , 1988; Røv, 1991		N. Røv, Norw. Inst. Nature Research (NINA)
	Norway (Cp, Ss-16)	1992	1991-92			S. Lorentsen, NINA
	Norway (Cp-16)	1993			1997	B. Sæther, NINA
Breeding success	Norway (Cp, Ss-16)	1990		Haftorn <i>et al.</i> , 1991; Mehlum <i>et al.</i> , 1988; Røv, 1990		N. Røv, NINA
	Norway (Cp, Ss-16)	1992	1992			S. Lorentsen, NINA
	Norway (Cp-16)	1993			1997	B. Sæther, NINA
Chick weight at fledging	Norway (Cp,Sp-16)	1990		Haftorn <i>et al.</i> , 1991; Mehlum <i>et al.</i> , 1988; Røv, 1990		N. Røv, NINA
	Norway (Cp,Sp-16)	1992	1991-92		1996	S. Lorentsen, NINA
	UK (Ba-4)	1989-93	1989-91	None	indefinitely	J. Croxall, P. Prince, BAS
	USA (Cp-2)	1990-1993			continuing	J. Bengtson, NMML
Duration of foraging trips	Norway (Cp-16)	1985				F. Mehlum, NPI
	Norway (Cp,Sp-16)	1990		Haftorn <i>et al.</i> , 1991; Mehlum <i>et al.</i> , 1988; Røv, 1990		N. Røv, NINA
	Norway (Cp,Sp-16)	1992	1991-92			S. Lorentsen, NINA
	Norway (Cp-16)	1993			1997	B. Sæther, NINA
	UK (Ba-4)	1989-93	Some	None	1994	J. Croxall, P. Prince, BAS
Activity budget at sea	UK (Ba-4)	1990-93	Some	None	1994	J. Croxall, P. Prince, BAS
Prey characteristics (diet)	Norway (Cp-16)	1990/92			1997	B. Sæther, NINA
	UK (Ba-4)	1976-77, 1980, 1986	1976-77, 1986	Croxall <i>et al.</i> , 1988	1994	J. Croxall, P. Prince, BAS
Meal size	UK (Ba-4)	1976-78, 1980, 1986, 1991-93	1976-78, 1980, 1986	Croxall <i>et al.</i> , 1988	1994	J. Croxall, P. Prince, BAS

Parameter	Member (species, area or site ^b)	Data Collected (years)	Data Analysed (years)	Reference to Published Results ^c	Research to be Continued (years)	Principal Scientists, Institution
Flighted seabirds (continued) Adult mortality/ survival	Norway (Cp,Ss-16)	1992/93			1997	B. Sæther, NINA
Fur seals Reproductive success	Chile (2)	1987, 1990-93	1987	Oliva <i>et al.</i> , 1987		D. Torres, INACH
	UK (4)	1979, 1981-93	1979, 1981-86, 1984-92	Croxall <i>et al.</i> , 1988 Lunn & Boyd, 1993; Lunn <i>et al.</i> , 1993; Lunn <i>et al.</i> , (submitted)	indefinitely	I. Boyd, BAS
	USA (2)	1987-1993			continuing	J. Bengtson, NMML
Prey characteristics (diet)	UK (4)	1989-93	1989-90	Boyd <i>et al.</i> , 1991	indefinitely	I. Boyd, BAS
	USA (2)	1988-1993			continuing	J. Bengtson, NMML
At-sea diving behaviour and activity pattern	UK (4)	1983, 1989-93	1983, 1989-90, 1989-93	Croxall <i>et al.</i> , 1985 Boyd & Croxall, 1992 Boyd <i>et al.</i> , (submitted)	1994-96	I. Boyd, BAS
	USA (2)	1987-1993	1989-1991	Bengtson & Eberhardt, 1989; Bengtson <i>et al.</i> , 1990; Bengtson <i>et al.</i> , 1991a; Bengtson <i>et al.</i> , 1991b; Boveng <i>et al.</i> , 1991	continuing	J. Bengtson, NMML
Bioenergetics	UK (4)	1988-89, 1991-93	1988-89 Some	Boyd & Duck, 1991 None	1994-96	I. Boyd, BAS, P. Butler, Univ. B'ham (1991- 93)
Indices of physiological condition	UK (4)	1991-93	None	None	-	J. Arnold, I.L. Boyd, BAS
Fine structure of teeth	UK (4)	1973-93 1962-81	1973-89 1962-81	Boyd & Roberts, 1993 Bengtson, 1988	indefinitely	I. Boyd, BAS, J. Bengtson, NMML (1962-81)
	USA (4)	1983	1983	Bengtson, 1988		J. Bengtson, NMML
Population size	Norway (17)	1989-90		Bakken, 1991		V. Bakken, NPI
Crabeater seal Reproductive success	Norway (12)	1964	1964	Øritsland, 1970		T. Øritsland, Inst. Marine Research (IMR)
	USA (11,12)	1978-1990	1978	Bengtson & Sinniff, 1981	continuing	J. Bengtson, NMML

Parameter	Member (species, area or site ^b)	Data Collected (years)	Data Analysed (years)	Reference to Published Results ^c	Research to be Continued (years)	Principal Scientists, Institution
Crabeater seal (continued)						
Age at sexual maturity	Norway (12)	1964	1964	Øritsland, 1970		T. Øritsland, IMR
	USA (11,12)	1978-1990	1978-1983	Bengtson & Sinniff, 1981; Bengtson & Laws, 1985	continuing	J. Bengtson, NMML
Cohort strength	USA (11,12)	1978-1990	1978-1990	Bengtson & Laws, 1985; Testa <i>et al.</i> , 1991; Boveng, 1993	continuing	J. Bengtson, NMML
Indices of physiological condition	USA (11,12)	1982-1990	1982-1990	Bengtson <i>et al.</i> , 1992	continuing	J. Bengtson, NMML
Instantaneous growth rates						
Prey characteristics (diet)	Norway (12)	1964	1964	Øritsland, 1977		T. Øritsland, IMR
At-sea diving behaviour and activity pattern	USA (11,12)	1986-1990	1986-1990	Bengtson & Stewart, 1992; Bengtson <i>et al.</i> , 1993	continuing	J. Bengtson, NMML
Seasonal movements and habitat use	Norway (12)	1993				A. Blix, Univ. of Tromsø
	USA (11,12)	1986-1990	1986-1990	Bengtson <i>et al.</i> , 1993	continuing	J. Bengtson, NMML
Minke whales All parameters ^d	Japan (1,13)	? - 1992/93			continuing	H. Kato, Nat. Res. Instit. of Far Seas Fish.

a Penguins: A - Adélie; C - Chinstrap; M - Macaroni/Royal; G - Gentoo
 Flighted birds: Ba - Black-browed albatross; Cp - Antarctic/Cape petrel; Sp - Snow petrel; Ss - South polar skua

b Areas:

- | | | | |
|----------------------|-------------------------|---|--------------------|
| 1. Ross Sea | 6. Davis Station | 11. Antarctic Peninsula | 16. Svarthammaren, |
| 2. South Shetland Is | 7. Syowa Station | 12. Weddell Sea | Queen Maud Land |
| 3. South Orkney Is | 8. Dumont d'Urville Sea | 13. Mainly from the Indian Ocean (IWC Areas III and IV) | 17. Bouvet Is |
| 4. South Georgia Is | 9. Crozet Is | 14. Marion Is | 18. Mawson Station |
| 5. Macquarie Is | 10. Balleny Is | 15. Kerguelen Is | |

c The complete list of references is given below.

d The following parameters are studied in Minke whales: Reproductive rate; Age of sexual maturity; Cohort strength; Feeding activity pattern; Diet; School size and distribution.

Table 2 References:

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Table 3: Summary of Members' research required to provide essential background information needed to interpret changes in monitored predator parameters.

Research Topic	Countries Proposing Directed Research	
	Programs Currently Underway	Programs Proposed to Commence (season of initiation)
<p>PENGUINS</p> <ul style="list-style-type: none"> - Foraging areas - Energy requirements - Seasonal movements - Relationships between monitored parameters and physical environment (e.g., distribution and structure of sea-ice and frontal systems) 	<p>Japan, USA, South Africa, Australia</p> <p>USA, UK, Germany</p> <p>South Africa</p> <p>Chile, Australia, UK/USSR, USA, South Africa (frontal systems)</p>	
<p>FUR SEALS</p> <ul style="list-style-type: none"> - Local abundance/population structure - Energy requirements/life history - Foraging areas - Relationships between monitored parameters and physical environment (e.g., distribution and structure of sea-ice and frontal systems) 	<p>Argentina, Chile, UK, USA</p> <p>UK, USA</p> <p>USA, UK, Japan (1990/91, with USA)</p> <p>Chile (partial), USA, UK/USSR</p>	<p>Brazil</p>
<p>CRABEATER SEALS</p> <ul style="list-style-type: none"> - Foraging areas - Energy requirements/life history - Stock discreteness/seasonal movements - Relationships between monitored parameters and physical environment (e.g., distribution and structure of sea-ice and frontal systems) - Abundance/population structure 	<p>USA, Sweden</p> <p>USA, Sweden</p> <p>USA, Sweden</p> <p>USA</p>	<p>USA (1993/94)</p>

Table 4: Most recent krill biomass estimates from areas within CEMP Integrated Study Regions (ISRs). These estimates are not applicable to the entire ISRs, but only for the portions of the ISRs for which survey data are available. Figure 1 indicates the zones within the ISRs for which these biomass estimates apply (shown as shaded area).

ISR	Survey Type	Year	Status	Area ('000 km ²)	Density (g.m ⁻²)	Biomass (10 ⁶ tonnes)	Reference
South Georgia	Acoustic	1981	recalculated from FIBEX data	25	59.7	1.51	WG-Krill-92/20
Antarctic Peninsula	Acoustic	1981	recalculated from FIBEX data	129	105.8	13.6	SC-CAMLR-XII/4, Table 4
Prydz Bay	Acoustic	1992	Australian survey	268	7.4	1.98	WG-Krill-92/23

Table 5: Assessment of predator and prey studies, 1988 to 1993. Predator parameters were obtained from WG-CEMP-92/8 and 12 unless otherwise referenced in the tables. Data are given qualitative rankings High, Medium, Low, Very Low (H, M, L, VL). The symbols +, 0, - indicate temporal changes in parameters. Foraging duration is expressed as relative length of foraging trips to sea (S = short, M = medium, L = long). Data changed since 1992 are indicated by an *. Columns under “Krill” have been left blank (paragraphs 6.39 and 6.40).

5.1 Site: Anvers Is, Subarea 48.1

Year	Adélie		Krill				Environment		
	Breeding Population Size/Change	Breeding Success	Catch		CPUE	Biomass	Snow	Sea-Ice	Ocean
			100 km radius	Subarea					
1988		-							
1989		-							
1990		M							
1991		L							
1992	(First census)	H							
1993	M -	H							

5.2 Site: Cape Shirreff, Livingston Is, Subarea 48.1

Year	Antarctic Fur Seal ¹		Chinstrap ²		Krill				Environment			
	Breeding Population Size/Change		Breeding Success	Breeding Population Size/Change		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						L*			

¹ WG-CEMP-92/53

² *Boletín Antártico Chileno*, Vol. 11 (1): 12-14.

5.3 Site: Admiralty Bay, King George Is, Subarea 48.1¹

Year	Gentoo		Adélie		Chinstrap		Krill				Environment			
	Breeding Population Size/Change		Breeding Success	Breeding Population Size/Change		Breeding Success		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					

(This summary table was constructed without benefit of reviewing the actual data and may contain source errors)

5.4 Site: Ardley Island and Stranger Point combined, King George Island, Subarea 48.1. Esperanza data used for 1991 for Stranger Point.

Year	Adélie ¹ - Ardley		Chinstrap ² - Ardley		Adélie ³ - Stranger			Krill				Environment		
	Breeding Population Size/Change	Breeding Success	Breeding Population Size/Change	Breeding Success	Breeding Population Size/Change	Breeding Success	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		+	?							

¹ WG-Krill-92/21; WG-CEMP-92/54

² WG-CEMP-92/54

³ WG-CEMP-92/6; WG-CEMP-92/45

Note: Esperanza data for 1991; Stranger Point not available

5.5 Site: Seal Island, Elephant Island, Subarea 48.1

Year	Chinstrap ¹				Antarctic Fur Seal ²					Krill			Environment		
	Breeding Population Size/Change	Breeding Success	Fledging Weight	Foraging Duration	Pups Born Number/Change	Foraging Duration	Pup Growth Rate	Weight at Age	Catch		CPUE	Biomass	Snow	Sea-Ice	Ocean
									100 km radius	Subarea					
1988	M	?	M	H	S	M	+	M	M	H					
1989	L	-	L	H	M	VL	-	?	H	L					
1990	H	+	H	M	L	M	+	M	L	L					
1991	M	-	L	L	S	L	-	L	H	L					
1992	H	+	M	M	M	M	+	M	M	H					
1993	H	-	M	M	S	M	0	L	M	?					

¹ Data are from the CCAMLR Data Centre and documents WG-CEMP-90/21, 91/11, 91/33, 92/17 and 93/27

² Data are from the CCAMLR Data Centre and documents WG-CEMP-89/21, 90/34, 90/41, 91/11, 92/17 and 93/27

5.6 Site: Signy Is, South Orkneys, Subarea 48.2

Year	Adélie		Chinstrap		Gentoo		Krill			Environment			
	Breeding Population Size/Change	Breeding Success	Breeding Population Size/Change	Breeding Success	Breeding Population Size/Change	Breeding Success	Catch		CPUE	Biomass	Snow	Sea-Ice ¹	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	H -	M						M	
1992	M* +	H	L-M +	H	M -	H						H	
1993	M 0	H	M +	H	H +	M						?	

¹ Murphy, *et al.*, unpublished data *

5.7 Site: Bird Island, South Georgia, Subarea 48.3

Year	Gentoo				Macaroni				Black-browed Albatross				Krill			Environment		
	Breeding Population Size/Change	Breeding Success	Krill in Diet	Meal Size	Breeding Population	Breeding Success	Krill in Diet	Meal Size	Breeding Population Size/Change	Breeding Success	Growth Rate ¹	Catch		CPUE	Biomass	Snow ²	Sea-Ice ^{3*}	Ocean
												100 km radius	Subarea					
1988	M -	M	M*	H*	M -	L	-	-	L ---	VL	-					H	H	
1989	H ++	M	H	M-H*	H* +	H	M	M*	M ++	M	H					M	M	
1990	H -	L-M	M*	M*	M -	H	M	M*	M 0	M	L					M	L	
1991	L --	VL	L	L	L -	H	L	L	L-M -	VL	M					M	L	
1992	M +	H	M*	M	M +	M	H	H	L *-	M	H					H	M-H	
1993	M 0	H	H	M-L	M 0	M-H	H	M	L +	H	H					M	L-M	

¹ P.A. Prince, unpublished data

² Black-browed albatross only

³ Lunn *et al.* (WG-CEMP-93/10)

5.8 Site: Bird Island, South Georgia, Subarea 48.3

Year	Antarctic Fur Seal ¹								Krill				Environment		
	Pups Born No/Change ¹	Birth Mass ²	Perinatal Period ²	Foraging Trip	Growth Rate	Wean Mass ²	Breeding Success ³	Catch		CPUE	Biomass	Snow	Sea- Ice ^{1*}	Ocean	
								100 km radius	Subarea						
1988	H	0	H	M	S	M*	M	M					H		
1989	H	-	H	M	M	M*	H	M					M		
1990	H	+	H	M	S*	M	M	M*					L		
1991	L	--	L	S	VL*	M*	L	H*					L		
1992	M	+	M	M	M	M*	M	L*					M-L		
1993	H	+	M	M	M-L	M-L	M	M					M-L		

¹ Lunn *et al.*, in press (WG-CEMP-93/10)

² Data from Lunn and Boyd, in press (WG-CEMP-92/41), Lunn *et al.*, in press (WG-CEMP-93/9), Boyd, unpublished data

³ Boyd, unpublished data

5.9 Site: Béchervaise Island, Mawson, Division 58.4.2

Year	Adélie			Krill	Environment		
	Breeding Population Size/Change	Breeding Success ³	Krill in Diet*	Biomass ¹	Snow	Sea-Ice	Ocean
1991	Start year	Start year*	Start*		L*	M*	
1992	+2*	0*	0*		L*	M*	
1993	0	0	0		Ma	M	

¹ WG-Krill-92/23

² *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
(Seoul, Republic of Korea, 16 to 23 August 1993)

1. Opening of the Meeting
2. Adoption of the Agenda
3. Review of Members' Activities
 - (i) Recent Studies
 - (ii) Plans for Future Work
4. Monitoring Procedures
 - (i) Predator Monitoring
 - (a) Sites and Species
 - (b) Field Research Procedures
 - (c) Procedures for Calculating Indices and Trends
 - (ii) Prey Monitoring
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12. Close of the Meeting.

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(Seoul, Republic of Korea, 16 to 23 August 1993)

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REPORTS OF MEMBERS' ACTIVITIES WITH REGARD TO CEMP

This appendix contains descriptions of Members' activities in relation to CEMP that were submitted to this meeting by participants (Argentina, Australia, Chile, Germany, Italy, Japan, the Republic of Korea, Russia, South Africa, Sweden, UK and USA).

2. Argentina carried out the Ecosystem Monitoring Program in three places: King George Island (Stranger Point), Antarctic Peninsula (Hope Bay) and the South Orkneys (Mossman Peninsula) under the direction of Dr Daniel F. Vergani and Lic. Zulma Stanganelli. The main work was conducted on Adélie penguins; population trends and breeding success were the principal parameters measured.

3. Directed research on prey started with studies on fish in the South Shetland Islands. This investigation was carried out through observation of diet of blue-eyed shags (*Phalacrocorax atriceps*) to see variation of food suitability. This survey was directed by Lic. E. Barrera-Oro and Lic. R. Casaux.

4. During the 1992/93 austral summer Australia continued with its CEMP monitoring program and associated Adélie penguin research at Béchervaise Island near Mawson Base. CEMP Standard Methods for parameters A1, A2, A3, A6 and A7 have been carried out and analysed using both manual and automated methods. In addition, dietary samples for A8 have been collected and data from satellite trackers, time-depth recorders and the automated weighbridge system pertaining to parameters A4 and A5 are presently being analysed.

5. Australia's weighing and identification system was operational on the island throughout the season, assisting in the collection of data for CEMP. This system will continue to be used for a number of years into the future and it is planned to install a second of these at Magnetic Island near Davis during the 1993/94 summer. A third system will also be set up in the future at an undisturbed site, the location of which is yet to be determined.

6. In 1992/93 Chile conducted censuses and pup growth studies on fur seals at Cape Shirreff and the San Telmo Islands. These data complement census data collected since 1965/66. Population sizes of fur seals were 50 (1966), 1 741 (1973), 8 929 (1987), 10 768 (1992) and 13 242 (1993) for Cape Shirreff and the San Telmo Islands combined. Additional data on environmental parameters, and population censuses of Weddell and southern elephant seals were

also collected at Cape Shirreff, and a marine debris survey was conducted there. Studies will continue in 1993/94 with the introduction of monitoring following CEMP Standard Methods.

7. On Ardley Island, studies of seabird populations were carried out in 1992/93 and will be continued in 1993/94. Observation of penguins' early nesting period was conducted in October 1992. These studies were directed by Dr José Valencia, of Universidad de Chile, with the support of the Instituto Antártico Chileno. The penguin census, and observation of birds during the early nesting period, will continue in 1993/94.

8. Germany has no program monitoring predator species in any of the Integrated Study Regions. German CEMP-related research focuses on the at-sea behaviour of Adélie penguins including swimming speed, directions, foraging range, diving depth and feeding activity. In order to obtain more information on prey ingestion and meal size at different diving depths, a unit was developed to record stomach temperature following ingestion of prey organisms. These investigations are part of an ongoing program which started in 1984. They are conducted at Ardley Island by a group of researchers from the Institute of Marine Science at Kiel (Drs B. Culik and R. Wilson).

9. Italy continues to study the ecological genetics and the evolutionary biology of Antarctic and sub-Antarctic crustaceans. The levels of genetic polymorphism were evaluated in populations of Amphipods, Isopods and Euphausiids. Genetics similarity indexes were calculated for Amphipods of the genus *Paramoera* from Terranova Bay. DNA sequence analysis of mitochondrial genes was studied in *Euphausia superba* by means of PCR and direct sequencing.

10. Italy also studies physiological and toxicological aspects and biochemical responses to heavy metals and xenobiotics contamination in Antarctic organisms. Biomarkers are used to evaluate the exposure level and their ecological effects on the Antarctic ecosystem; attention is focused on the upper trophic levels of the marine food chain.

11. Italy is planning to commence work from its station at Terranova Bay in cooperation with Australia; it is hoped to install an automated penguin monitoring system (APMS), developed by Australia, and it will be fully operational in the 1994/95 season. In addition, at the site of the APMS, manual observations according to CEMP Standard Methods will be carried out.

12. Japan continues to monitor the annual trends in breeding population size of Adélie penguins near Syowa Station. Studies on Adélie penguins will be conducted in the Indian Ocean sector in cooperation with Australia in 1993/94.

13. Japan continues to investigate the biology and population size of minke whales through selective catching in the Southern Ocean. Studies of krill ecology in relation to hydrological parameters as well as survey design will also continue. Japan intends to continue cooperative work on CEMP monitoring.

14. The monitoring program for chinstrap and gentoo penguins by KARP (Korea Antarctic Research Program) is being initiated in the rookery at Barton Peninsula, King George Island. Because of the late observation, only fledgling measurements were taken during the 1991/92 breeding season. In the 1992/93 breeding season, however, a preliminary survey on breeding chronology, breeding success, and chick growth and chick banding was conducted. It is reported in WG-CEMP-93/23. The program will be continued in the 1993/94 breeding season. It is part of a land-based marine ecology program which includes micro-organism, coastal fish population, benthic animal and macroalgae.

15. CEMP-related studies conducted by the Russian Federation have been recently concentrated on the prey-species Antarctic krill. During the last two years, available historical fine-scale data from krill fisheries in Subareas 48.1, 48.2 and 48.3 (1974 to 1987) have been processed to study location of catches. The first results of the study were submitted to WG-CEMP last year (WG-CEMP-92/30). This study will be continued.

16. Krill distribution and biology studies have been planned for the 1993/94 season as a part of the Russian Antarctic Expedition (RAE-39). These studies will be conducted in the coastal area of the Bellingshausen Sea.

17. South Africa's CEMP-related activities have suffered in recent years from irregular funding and a lack of clarity concerning national priorities. This situation has now changed and three major areas of research of interest to CEMP have been allocated funds for the immediate future. These are:

- (i) continuation of monitoring at the Prince Edward Islands of gentoo/macaroni penguins (including CEMP parameters) and seals (elephant and fur);
- (ii) initiation of a study of biogenic fluxes at the Robertskollen Nunatak (a breeding site for snow petrels) in 1994/95; and
- (iii) commencement of studies at various frontal zones and other ecoclines (e.g., oceanic islands and the ice edge) in the Southern Ocean. This includes a planned krill aggregation study at South Georgia in 1993/94; and a cooperative study with UK scientists.

18. Sweden has no monitoring activity according to CEMP. Basic research on king penguins and elephant seals is undertaken in cooperation with BAS (UK); research on crabeater seals is in cooperation with USA.

19. 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 1993 were identical to those recorded in 1992 (SC-CAMLR XI, Annex 7, Appendix D, paragraph 20).

20. 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.

21. Additional directed research 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; 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.

22. Of papers listed in 1992, WG-CEMP-91/23 is now published (*Can. J. Zool.* (1992) 70: 919-928). Of papers tabled last year WG-CEMP-92/37 (*Auk.* (1992) 109: 223-234), WG-CEMP-92/38 (*J. Zool.* (1993) 230: 31-47), WG-CEMP-92/39 (*Antarcti. Sci.* (1993) 5: 17-24), WG-CEMP-92/40 (*J. Zool.* (1993) 229: 55-67), and WG-CEMP-92/42 (*Phil. Trans. Roy. Soc. Lond. B.* (1992) 338: 319-328) were published. WG-CEMP-92/41 is still in press (*Symp. Zool. Soc. Lond.*).

23. Nine papers involving predators are tabled this year. WG-CEMP-93/6 reviews 17 years' data from population studies on black-browed and grey-headed albatrosses at South Georgia, including annual data on breeding population size, adult and juvenile survival rates, breeding frequency and success. The paper, which also includes relevant methodological data (as requested in support of the existing Standard Method B3 for black-browed albatrosses), documents significant population declines (especially in grey-headed albatrosses), mainly due to substantial decreases in juvenile survival in recent years. The specification of the device used to record at-sea activity budget data for albatrosses is described (together with sample results) in WG-CEMP-93/7. WG-CEMP-93/8 reviews inter-annual variation in population size and breeding success in gentoo penguins over 16 years at South Georgia. It documents the significant effect that a relatively small number of years of very poor reproductive performance (and subsequent deferred breeding and reduced adult survival) can

have on the overall trends and fluctuations in the population. For Antarctic fur seals, WG-CEMP-93/9 reviews interannual variation in pup growth rates at South Georgia over nine years; WG-CEMP-93/10 reviews reproductive performance over the same years. Of particular interest to WG-CEMP is the use of foraging trip duration as an index of prey availability in models partitioning variance in reproductive success due to differences in age, experience, year and the effect of physical and biological environment. WG-CEMP-93/11 demonstrates the considerable potential of using data from fine-scale examination of sectioned teeth to provide information on inter-annual variation in body growth as index of environmental conditions. There are correlations between years of known poor reproductive performance and indices of ENSO effects. On the topic of predator-prey interactions, WG-CEMP-93/12 and 13 both deal with relationships between distribution of top predators and krill from simultaneous visual and acoustic surveys around Bird Island, South Georgia. Non-random distribution of predators was very evident as was the strong influence of the distribution of krill swarms. Although Antarctic fur seals and macaroni penguins were especially aggregated at krill swarms, correlations were found over a wide variety of spatial scales, but particularly at 10 to 100 km.

24. Finally, WG-CEMP-93/14 deals with aspects of the collection of diving data with time-depth recorders that may have important implications for data analysis. This contributes directly to WG-CEMP interest on this topic (SC-CAMLR-XI, Annex 7, paragraph 4.18).

25. No krill surveys were carried out in 1992/93. A research cruise, to investigate predator-krill interactions in detail, will be carried out in 1993/94. This will include krill surveys, mainly at meso and fine scales.

26. United States activities in 1992/93 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, ecology and behaviour.

Preliminary reports on these activities are provided in the AMLR field season report (WG-CEMP-93/27).

27. At Seal Island, directed research and monitoring activities were conducted on fur seals, chinstrap penguins, macaroni penguins and Cape petrels. The following Standard Methods parameters were monitored: A5, A6a and c, A7, A8, A9, C1 and C2. In addition, directed research on foraging ecology and chick growth rates was continued, and efforts were initiated to develop an automated land-based tracking system of penguins and seals to determine foraging locations. At Palmer Station, Standard Methods parameters A3, A5, A6a, b and c, A7, A8 and A9 were monitored for Adélie penguins. This was conducted in conjunction with the long-term ecological research (LTER) program of the National Science Foundation (NSF).

28. Two 30-day cruises were conducted aboard the NOAA Ship *Surveyor* from mid-January to mid-March, 1993 in the vicinity of the Seal Island CEMP site and Elephant Island. Chlorophyll *a* concentrations, primary production rates, organic carbon concentrations, phytoplankton species compositions, nutrient concentrations, and solar irradiance were measured and mapped. In addition, the distribution and abundance of krill were measured using sampling nets and acoustic instrumentation.

29. Analyses of crabeater seal demographic and ecological data were completed, incorporating data collected over the past several decades. One element of this analysis involved calculating adult survival rates, age at sexual maturity, and cohort strengths; these estimates were provided for the modelling exercise on functional relationships being conducted by WG-Krill and WG-CEMP.

30. In addition to the AMLR CEMP studies, a joint NSF/AMLR study of predator/prey interactions was conducted during June, 1993, aboard the NSF Ship *Nathaniel B. Palmer* in the waters surrounding South Georgia. NSF-sponsored scientists conducted research investigating the distribution and abundance of sea birds while AMLR scientists collected similar data on krill.

31. Finally, in support of the NSF's LTER program, three oceanographic cruises were conducted by the NSF Ships *Polar Duke* and *Nathaniel B. Palmer* in November 1992 and January and May 1993. 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.

32. Anticipated CEMP-related field work in 1993/94 will include penguin and fur seal monitoring and directed research at Seal Island and penguin monitoring at Palmer Station. Shipboard surveys of hydrographic conditions, phytoplankton production, krill distribution and abundance, krill demography will be conducted around Elephant Island. In addition, the LTER Program will conduct research similar to that conducted this year. Pending the availability of logistic support, investigations

of pack-ice seal distribution and abundance, habitat use and seasonal movements, and foraging ecology are also planned.

33. During the Norwegian Antarctic Research Expedition 1992/93, studies were continued on Antarctic petrels and south polar skuas at Svarthammaren, Queen Maud Land by the Institute of Nature Research, Trondheim. A total of 1 200 individually-marked Antarctic petrels (adults and chicks) in four study sites were weighed at regular intervals, and the breeding success of all pairs recorded. Heavy snowfall and subsequent high temperatures caused high mortalities of chicks. Two experiments involving increased energetic costs were carried out to study relationships between adult body size and parental investment in chicks. South polar skua studies included mapping of territories and marking (including satellite marking of four individuals) to investigate social structure and migrations.

34. Crabeater seal studies (carried out by the Department of Arctic Biology, University of Tromsø) included investigations of the digestibility of krill using the Mn-marker method (digestible energy of 83.8 ± 2.2 was lower than that of *Thysanoessa* sp. in North Atlantic minke whales 92.2 ± 2.8). Eight moulted crabeater seals were equipped with satellite PTTs with TDRs. Seals stayed in the pack-ice zone, moving along the edge of the shelf with about 150 dives per day during the first few weeks. In late April and May most seals migrated into deep waters in the north, reaching as far as 63°S before returning to the South in early June. Diving frequencies were maintained at a high level, indicating active feeding. Maximum distances covered and diving depths reached were 3 875 km and between 232 and 528 m, although most dives were for less than 2 minutes and 50 m depth.

35. Tentative plans to initiate a monitoring program for Antarctic fur seals and chinstrap and macaroni penguins on Bouvet Island could be carried out during NARE 1993/94.

MINUTES OF THE MEETING OF THE EDITORIAL BOARD

MINUTES OF THE MEETING OF THE EDITORIAL BOARD

The Editorial Board meeting was held from 16 to 27 October and on 5 November 1993. The following members of the Editorial Board were present: Dr K.-H. Kock (Chairman of the Board), Drs E. Balguerías, M. Basson, J. Bengtson, I. Everson, R. Holt, T. Ichii, K. Kerry, C. Moreno, S. Nicol, Mr D. Miller as well as Drs D. Agnew and E. Sabourenkov (Secretariat).

2. The Agenda of the meeting comprised the following items:
 - Structure of the Editorial Board;
 - Publication of *Scientific Abstracts*;
 - Proposal for a peer-reviewed journal; and
 - Selection of papers for publication.

3. The list of documents prepared by the Secretariat and considered by the Board, is appended (Appendix 1).

STRUCTURE OF THE EDITORIAL BOARD

4. The Board agreed on the following membership:
 - Chairman of the Board: Chairman of the Scientific Committee;
 - Members:
 - the two Vice-Chairmen of the Scientific Committee;
 - the Conveners of the Working Groups;
 - experts representing diverse disciplines nominated by the Working Groups; and
 - the Data Manager and Science Officer (Secretariat).

5. The following experts were nominated by the Working Groups to be members of the Board until the end of the CCAMLR meeting in 1995:

WG-Krill - Drs M. Basson (UK) and S. Nicol (Australia);
WG-CEMP - Drs T. Ichii (Japan) and K. Kerry (Australia); and
WG-FSA - Drs C. Moreno (Chile) and K. Sullivan (New Zealand).

PUBLICATION OF *SCIENTIFIC ABSTRACTS*

6. The Board approved the first issue of the *Scientific Abstracts* published in April 1993, and recommended their annual publication.

PROPOSAL FOR A PEER-REVIEWED JOURNAL

7. The Board considered a set of documents prepared by the Secretariat (SC-CAMLR-XII/7), describing a publication procedure for the proposed Journal. The Board adopted the publication procedure contained in these documents and recommended it to the Scientific Committee for approval.

8. The Board recommended that the Scientific Committee approve publication of the new peer-reviewed Journal with the first issue to be published in 1994. The Science Officer will be the Editor-in-Chief of the new Journal. The Journal will be published in English with abstracts and captions to tables and figures in all official CCAMLR languages.

9. The Board recommended that the Journal be named *CCAMLR Science* with the subtitle “Selected papers of the Commission and the Scientific Committee for the Conservation of the Antarctic Marine Living Resources”. The Board also proposed that a cover page design for the Journal should reflect patterns and colours already used on the cover page for the *CCAMLR Scientific Abstracts*.

10. The Secretariat was asked, during the intersessional period, to design the cover and to distribute it to members of the Editorial Board for approval. It was recommended that the Journal be printed on A4 standard size paper.

11. The question of processing papers for publication in *CCAMLR Science* submitted in languages other than English (French, Spanish, Russian) was discussed in detail. The Board recommended that the following policy be adopted:

For discussions at CCAMLR meetings, papers are accepted in any of the official CCAMLR languages: English, French, Russian and Spanish. However, if the author wishes his/her paper to be considered for publication in the *CCAMLR Science* Journal, the paper should be submitted in English. If only a copy in English is submitted, it is the responsibility of the author to ensure that the language is of a high standard. In order not to

discourage any author whose native language is one of the other official CCAMLR languages and in order to assist in the review of the English version, a copy in the other language is also helpful.

12. The Board considered an assessment of costs of publication of the Journal. The Board found that the new edition would require A\$15 400 more than the cost of the current publication of *Selected Scientific Papers* (250 copies), of which A\$11 100 would be budgeted for ongoing costs and A\$4 300 for the cost of setting up the Journal in its first year.

13. The Board recommended that the first issue of *CCAMLR Science* be published next year, preferably by 1 September 1994. In order to meet this deadline, final manuscripts should be received by the Secretariat by 1 July 1994. Papers received after 1 July will be published in the 1995 edition of the Journal.

14. The Secretariat was asked to prepare, for a wide distribution, a flier leaflet explaining the objectives of the new Journal, its layout and contents of the first issue, and containing an invitation for subscription aimed at interested scientists, libraries and organisations. It was also suggested that in order to promote public awareness of this new CCAMLR scientific publication, the Secretariat should contact publishers of *ASFA* concerning inclusion in that publication of abstracts of papers appearing in *CCAMLR Science*.

SELECTION OF PAPERS FOR PUBLICATION

15. The Board considered papers which have been recommended by Working Groups for publication. The list of papers selected for publication, subject to results of a peer-review process, is given in Appendix 2.

LIST OF DOCUMENTS

EdBoard-XII/Rev.1	Editorial Board Agenda (annotated)
EdBoard-XII/2	CCAMLR Scientific Abstracts
EdBoard-XII/3 Rev. 2	List of Documents Recommended for Consideration for Publication
EdBoard-XII/4 Rev. 1	List of Reviewers Suggested by Members
EdBoard-XII/5	Minutes of the Editorial Board Meeting, 5 November 1992
SC-CAMLR-XII/7 (Draft)	Publication Policy - <i>CCAMLR Science</i> Journal

**LIST OF DOCUMENTS SELECTED FOR PUBLICATION,
SUBJECT TO PEER-REVIEW, IN THE CCAMLR SCIENCE JOURNAL**

WG-Krill

- | | |
|----------------|---|
| WG-KRILL-93/7 | AN ASSESSMENT OF THE IMPACT OF KRILL FISHERY ON PENGUINS IN THE SOUTH SHETLANDS
T. Ichii, M. Naganobu and T. Ogishima (Japan) |
| WG-KRILL-93/8 | STATUS OF THE KRILL STOCK AROUND ELEPHANT ISLAND IN 1991/92 AND 1992/93
V. Loeb (USA) and V. Siegel (Germany) |
| WG-KRILL-93/12 | ESTIMATING KRILL RECRUITMENT AND ITS VARIABILITY
W. de la Mare (Australia) |
| WG-KRILL-93/13 | MODELLING KRILL RECRUITMENT
W. de la Mare (Australia) |
| WG-KRILL-93/14 | PRELIMINARY MODEL OF KRILL FISHERY BEHAVIOUR IN SUBAREA 48.1
D.J. Agnew (Secretariat) |
| WG-KRILL-93/20 | REPORT OF AN EXAMINATION OF THE ACOUSTIC DATA FROM RV <i>EDUARDO L. HOLMBERG</i> COLLECTED DURING THE FIBEX STUDY
Inigo Everson (UK) and Adrian O. Madirolas (Argentina) |
| WG-KRILL-93/31 | STATUS OF THE FIBEX ACOUSTIC DATA FROM THE WEST ATLANTIC
P.N. Trathan and I. Everson (UK) |
| 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) |
| WG-KRILL-93/43 | POSSIBLE EFFECTS OF DIFFERENT LEVELS OF FISHING ON KRILL ON PREDATORS - SOME INITIAL MODELLING ATTEMPTS
D.S. Butterworth and R.B. Thomson (South Africa) |
| WG-KRILL-93/44 | NATURAL MORTALITY RATES OF THE ANTARCTIC KRILL <i>EUPHAUSIA SUPERBA</i> DANA IN THE INDIAN SECTOR OF THE SOUTHERN OCEAN
E.A. Pakhomov (Ukraine) |

WG-KRILL-93/45 ANTARCTIC KRILL, *EUPHAUSIA SUPERBA* DANA, DEMOGRAPHY
STUDIES IN THE SEAS OF SODRUZHESTVA AND COSMONAUTS
(INDIAN OCEAN SECTOR OF ANTARCTICA)
E.A. Pakhomov (Ukraine)

WG-KRILL-93/48 BIAS IN ACOUSTIC BIOMASS ESTIMATES OF *EUPHAUSIA SUPERBA*
DANA TO DIEL VERTICAL MIGRATION
David A. Demer and Roger P. Hewitt (USA)

WG-KRILL-93/49 ACOUSTIC ESTIMATES OF KRILL BIOMASS IN THE ELEPHANT ISLAND
AREA: 1981-1993
David A. Demer and Roger P. Hewitt (USA)

WG-CEMP

WG-CEMP-93/19 THE EFFECT OF CEMP MONITORING PROCEDURES ON ADELIE PENGUIN
COLONIES
J. Clark, K. Kerry (Australia)

WG-FSA

WG-FSA-93/8 Rev. 1 BY-CATCH OF JUVENILE ANTARCTIC FISH FROM KRILL (*EUPHAUSIA*
SUPERBA DANA) FISHERIES IN THE SOUTH GEORGIA AREA, IN 1992
E.A. Pakhomov and S.A. Pankratov (Ukraine)

WG-FSA-93/17 ON THE STATUS OF MESOPELAGIC FISH (MYCTOPHIDAE) IN THE
SOUTHERN OCEAN ECOSYSTEM
A.N. Kozlov (Russia)

WG-FSA-93/18 THE MIGRATION PATTERNS OF *ELECTRONA CARLSBERGI* (TÅNING,
1932)
A.N. Kozlov (Russia)

WG-FSA-93/20 ESTIMATING CONFIDENCE INTERVALS FOR FISH STOCK ABUNDANCE
ESTIMATES FROM TRAWL SURVEYS
William K. de la Mare (Australia)

WG-FSA-93/23 USING PRODUCTION MODELS TO ASSESS THE STOCK OF *PARALOMIS*
SPINOSISSIMA AROUND SOUTH GEORGIA ISLAND
George Watters (USA)

Workshop on the Management of the Antarctic Crab Fishery

- WS-CRAB-93/5 MANAGEMENT AND ASSESSMENT OPTIONS FOR THE CRAB FISHERY
AROUND SOUTH GEORGIA
M. Basson and D.D. Hoggarth (UK)
- WS-CRAB-93/7 A PRELIMINARY INVESTIGATION OF THE POSSIBLE EFFECTS OF
RHIZOCEPHALAN PARASITISM ON THE MANAGEMENT OF THE CRAB
FISHERY AROUND SOUTH GEORGIA
M. Basson (UK)
- WS-CRAB-93/19 NOTA SOBRE LA PRESENCIA DE *PARALOMIS SPINOSISSIMA* Y
PARALOMIS FORMOSA EN LAS CAPTURAS DE LA CAMPAÑA
“ANTARTIDA 8611”
L.J. López Abellán and E. Balguerías (Spain)
- WS-CRAB-93/29 A PRELIMINARY REPORT ON RESEARCH CONDUCTED DURING
EXPERIMENTAL CRAB FISHING IN THE ANTARCTIC DURING 1992
(CCAMLR AREA 48)
Robert. S. Otto and Richardson A. Macintosh (USA)

Scientific Committee

- SC-CAMLR-XII/BG/8 Rev. 1 SEABIRD INTERACTIONS WITH LONG-LINING OPERATIONS DURING
AN EXPLORATORY FISHING CRUISE FOR *DISSOSTICHUS ELEGINOIDES*
TO SOUTH SANDWICH ISLANDS, ANTARCTICA
J. R. Ashford, J. P. Croxall. P.S. Rubilar and C. A. Moreno

**HISTORY AND TERMS OF REFERENCE
OF CCAMLR WORKING GROUPS**

HISTORY AND TERMS OF REFERENCE OF CCAMLR WORKING GROUPS

FORMATION OF WORKING GROUPS

The Second Meeting of the Scientific Committee in 1983 recognised the need for the formation of Working Groups when it established terms of reference for an *Ad Hoc* Working Group on Data Collection and Handling (Table 1) which met for two years. During the Third Meeting of the Scientific Committee, the terms of reference for an *Ad Hoc* Working Group on Fish Stock Assessment and an *Ad Hoc* Working Group on Ecosystem Monitoring were established. In addition, the Third Meeting also established an *Ad Hoc* Working Group on Krill research priorities which only met for one year.

2. At the Fourth Meeting of the Scientific Committee in 1985, terms of reference were developed for a permanent Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP). Although the *Ad Hoc* Working Group on Fish Stock Assessment was vital to the management of CCAMLR fisheries and met every year, it was not until the Sixth Meeting of the Scientific Committee in 1987 that terms of reference were established for a formal Working Group on Fish Stock Assessment (WG-FSA).

3. The Sixth Meeting in 1987 also established terms of reference for an *Ad Hoc* Working Group on Krill. These terms of reference were modified during the Scientific Committee's Seventh Meeting to establish a formal Working Group on Krill (WG-Krill).

WORKING GROUP TERMS OF REFERENCE

4. The terms of reference established for the three Working Groups are:

WG-FSA Terms of Reference (SC-CAMLR-VI, paragraph 5.71):

- (a) apply and develop methodologies for fish stock assessment, including:
 - (i) procedures for monitoring fish stock abundance and population structure;
 - (ii) protocols for the collection and analysis of fishery-related data including the relevant operations of the CCAMLR database;

- (iii) analytical procedures for the estimation of projections of fish stock population trajectories;
- (b) review and conduct assessments of the status and potential yield of fish stocks in the Convention Area;
- (c) evaluate the actual and potential impact of fish stocks and fisheries on the past, present and possible future management actions.

WG-CEMP Terms of Reference (SC-CAMLR-IV, paragraph 7.14):

- (a) to plan, recommend, coordinate and ensure the continuity of a multinational CCAMLR Ecosystem Monitoring Program within the Convention Area;
- (b) to identify and recommend research including theoretical investigations to facilitate design and evaluation of the recommended ecosystem monitoring program;
- (c) to develop and recommend methods for the collection and storage and analysis of data including data formats for submission to CCAMLR;
- (d) to facilitate the analysis of data, their interpretation and to identify management implications;
- (e) to report progress to each meeting of the Scientific Committee with recommendations for further work.

WG-Krill Terms of Reference (SC-CAMLR-VII, paragraph 2.26):

- (a) review and evaluate methods and techniques for estimating krill abundance, taking note of the effects of patchiness and the influences of the physical environment;
- (b) review and evaluate information concerning the size, distribution and composition of the commercial krill catches, including likely future trends in these catches;
- (c) liaise with the Working Group for the CCAMLR Ecosystem Monitoring Program for assessing any impact of changes in krill abundance and distribution on dependent and related species;

- (d) evaluate the impact on krill stocks and krill fisheries of current and possible future patterns of harvesting, including changes brought about through management action, in order that the Scientific Committee may formulate appropriate scientific advice on krill to the Commission;
- (e) report to the Scientific Committee on information and data, required from commercial krill catches.

Table 1:

Year	Location	Convener	Action
83/II	Hobart	-	Scientific Committee established terms of reference for <i>Ad Hoc</i> Working Group on Data Collection and Handling
84/III	Woods Hole	Hennemuth	Meeting of <i>Ad Hoc</i> Working Group on Data Collection and Handling
	Hobart	Hennemuth	Meeting and establishment of terms of reference for <i>Ad Hoc</i> Working Group on Fish Stock Assessment
	Hobart	Kerry	Scientific Committee established terms of reference for <i>Ad Hoc</i> Working Group on Ecosystem Monitoring
	Hobart	Beddington	Scientific Committee established <i>Ad Hoc</i> Working Group on Krill research priorities
85/IV	Hobart	Ranke	Meeting of <i>Ad Hoc</i> Workshop on Krill CPUE
	Hobart	Hennemuth	Meeting of <i>Ad Hoc</i> Working Group on Fish Stock Assessment
	Seattle	Kerry	Meeting of <i>Ad Hoc</i> Working Group on Ecosystem Monitoring
	Hobart	-	Scientific Committee established terms of reference and Working Group for the CCAMLR Ecosystem Monitoring Program
86/V	Hobart	Hennemuth	Meeting of <i>Ad Hoc</i> Working Group on Fish Stock Assessment
	Hamburg	Kerry	Meeting of Working Group for the CCAMLR Ecosystem Monitoring Program
87/VI	Hobart	Kock	Meeting of <i>Ad Hoc</i> Working Group on Fish Stock Assessment
	Dammarie les Lys	Kerry	Meeting of Working Group for the CCAMLR Ecosystem Monitoring Program
	Hobart	-	Scientific Committee established terms of reference and <i>Ad Hoc</i> Working Group on Krill
	Hobart	-	Scientific Committee established terms of reference and Working Group on Fish Stock Assessment
88/VII	Hobart	Kock	Meeting of Working Group on Fish Stock Assessment
	Hobart	-	Scientific Committee established terms of reference for Working Group on Krill No meetings of WG-Krill and WG-CEMP

From 1989 to 1993 all three Working Groups have met each year:

- WG-Krill in La Jolla (USA), Leningrad (Russia), Yalta (Ukraine), Punta Arenas (Chile) and Tokyo (Japan);
- WG-CEMP in Mar del Plata (Argentina), Stockholm (Sweden), Santa Cruz de Tenerife (Spain), Viña del Mar (Chile) and Seoul (Korea); and
- WG-FSA always in Hobart.

Table 2:

	Year	Number of Participants	Number of Meeting Documents	Number of Other Working Group Documents	Number of Other Documents	Number of Overlap Topics
WG-FSA	1992	21	32	1	7	2
	1993	21	29	4	6	6
WG-KRILL	1992	25	33	3	1	9
	1993	34	50	2	3	6
WG-CEMP	1992	17	55	15	2	18
	1993	28	29	21	3	28

**SCIENTIFIC COMMITTEE BUDGET FOR 1994
AND FORECAST BUDGET FOR 1995**

**SCIENTIFIC COMMITTEE BUDGET FOR 1994
AND FORECAST BUDGET FOR 1995**

This paper describes the suggested draft budget of the Scientific Committee as drawn up by the Scientific Committee Chairman and the Secretariat.

2. The budget includes major provision for supporting the Working Groups and *ad hoc* workshops. Items are also included for specific projects requested of the Secretariat by the Scientific Committee or its Working Groups, and representation of the Scientific Committee at meetings other than those of CCAMLR by the Secretariat.

WORKING GROUP ON KRILL

3. The Working Group on Krill (WG-Krill) has advised that a meeting of WG-Krill will be needed in 1994, shorter than that held in 1993. In addition a joint Krill/CEMP meeting will be held. The costs under this item are for secretarial support and report typing/translation for the Krill meeting and for a share of the joint meeting.

WORKING GROUP ON FISH STOCK ASSESSMENT

4. The Working Group on Fish Stock Assessment (WG-FSA) has the responsibility to provide expert advice to the Scientific Committee on the status of finfish stocks in the Convention Area. A meeting of WG-FSA will be needed in 1994.

ECOSYSTEM MONITORING PROGRAM

5. The Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP) has advised that there will be a need for a meeting of WG-CEMP in 1994, shorter than that held in 1993. In addition a joint Krill/CEMP meeting will be held. The costs under this item are for secretarial support and report typing/translation for the WG-CEMP meeting and for a share of the joint meeting.

6. In 1993 the Secretariat, under instruction from the Scientific Committee (SC-CAMLR-XI, paragraphs 5.9, 5.72 and 13.3), began a database of sea-ice changes around selected CEMP sites. The Scientific Committee also required that this database include data from previous years. The

estimate of A\$7 100 represents the cost of recording and processing data for 1994 and for three earlier years (see SC-CAMLR-XII/8).

TRAVEL FOR SCIENTIFIC COMMITTEE PROGRAM

7. As a result of a decision taken at the Fifth Meeting of the Commission, travel for Secretariat staff associated with the Scientific Committee program is included in the Scientific Committee budget. The amount provides for travel by staff members to give necessary support to WG-Krill and WG-CEMP. The meeting of WG-FSA will take place in Hobart in 1994.

KRILL FLUX ANALYSIS WORKSHOP

8. The amount of A\$8 000 is required to support the attendance of two invited experts to the Krill Flux Analysis Workshop which is to be held immediately before the 1994 meeting of WG-Krill.

REPRESENTATION AT SCAR SYMPOSIUM

9. The Scientific Committee considers it necessary for the Secretariat to improve its working relationship with SCAR and has recommended that the Science Officer attend the SCAR Symposium on Antarctic Biology. Such representation is expected to cost A\$5 500. The Secretariat has also suggested that the Scientific Committee might wish to be represented at a meeting of the SCAR/COMNAP *Ad Hoc* Working Group on Antarctic Data Management in 1994.

ALLOCATION FROM THE NORWEGIAN CONTRIBUTION SPECIAL FUND

10. The balance of this Fund will be fully used in 1993.

<u>1993</u>		<u>1994</u>	<u>1995</u>
	Working Groups:		
20 600	WG-Krill meeting	17 200	21 500
3 000	BIOMASS database activation	0	0
20 100	WG-CEMP meeting	16 700	21 000
5 500	Sea-ice Monitoring	7 100	3 000
2 000	Sea-ice Seals Planning Workshop	0	0
0	Joint Meeting on Functional Approaches	8 000	0
27 200	WG-FSA meeting	27 200	28 000
7 400	Crab Workshop	0	0
	Workshops:		
0	At-sea Monitoring Workshop	0	4 000
34 500	Travel for Scientific Committee Program	27 600	34 000
	Secretariat Representation at Meetings:		
3 900	ICES and CWP	0	4 000
0	SCAR Symposium	5 500	0
0	SCAR/COMNAP Antarctic Data Meeting	4 000	0
3 000	Contingency	5 900	6 000
0	Krill Flux Analysis Workshop	8 000	0
<u>127 200</u>	Sub Total	<u>127 200</u>	<u>121 500</u>
8 100	Less allocation from the Norwegian Contribution Special Fund	0	0
A\$119 100	Total from Commission Budget	A\$127 200	A\$121 500