SC-CAMLR-X

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

REPORT OF THE TENTH MEETING

OF THE SCIENTIFIC COMMITTEE

**HOBART, AUSTRALIA
21 – 25 OCTOBER, 1991**

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Abstract

This document presents the adopted record of the Tenth Meeting of the Scientific Committee for the Conservation of Antarctic Marine Living Resources held in Hobart, Australia, from 21 to 25 October 1991. Major topics discussed at this meeting include: krill resources, fish resources, other resources, ecosystem monitoring and management, marine mammal and bird populations, assessment of incidental mortality, development of approaches to conservation of Antarctic marine living resources, CCAMLR Scheme of International Scientific Observation and cooperation with other organisations. 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.

TABLE OF CONTENTS

Page

OPENING OF THE MEETING
Adoption of the Agenda
Report of the Chairman

RULES OF PROCEDURE FOR THE PARTICIPATION OF OBSERVERS

KRILL RESOURCES
Fishery Status and Trends
Report of the Working Group on Krill
Review of Fisheries Activities
Information Necessary for the Management of Krill Resources
Survey Method and Biomass Estimations
Review of Subgroup on Survey Design's Work
Prey Surveys for CEMP
Survey for Direct Abundance Estimation
Future Work on Krill Survey Design
Krill Biomass Estimation
Acoustic Target Strength
Estimation of Yield and Production
Distribution and Movement
Demographic Parameters
Advice to WG-CEMP
Development of Approaches to Managing the Krill Fishery
Operational Definitions of Article II
Possible Approaches to Managing the Krill Fishery and their Development
Precautionary Limits on Krill Catches
New and Developing Fisheries
CCAMLR Scheme of International Scientific Observation
Data Requirements
Future Work of WG-Krill
Advice to the Commission
General Advice
Specific Advice on the Status of Krill Stocks

FISH RESOURCES
Report of the Working Group on Fish Stock Assessment
New and Developing Fisheries
Interactions of Other Components of the Ecosystem (e.g., Birds and Mammals) with Fisheries
Prey Requirements of Predators
By-Catch of Young and Larval Fish in the Krill Fishery
Review of Material for the Meeting
Fisheries Status and Trends
Assessments
Notothenia rossii, Notothenia squamifrons, Patagonotothen guntheri,

Pseudochaenichthys georgianus and *Chaenocephalus aceratus* (Subarea 48.3)
Champsocephalus gunnari (Subarea 48.3)
Management Advice
Dissostichus eleginoides (Subarea 48.3)
Management Advice
Notothenia gibberifrons (Subarea 48.3)
Management Advice
General Considerations on the Re-Opening of a Directed Fishery and the Application of TACs to 'By-Catch' Species in Subarea 48.3
Management Advice
Electrona carlsbergi (Subarea 48.3)
Management Advice
South Orkney Subarea (48.2)
Management Advice
Antarctic Peninsula Subarea (48.1)
Management Advice
Statistical Area 58
Division 58.5.1 (Kerguelen)
Management Advice
Champsocephalus gunnari (Division 58.5.1)
Management Advice
Division 58.5.2 (Heard Island)
Management Advice
Subarea 58.4
Data Requirements
Workshop on Survey Design
Working Group Convener

OTHER RESOURCES
Squid
Crabs

ECOSYSTEM MONITORING AND MANAGEMENT
Predator Monitoring
Prey Monitoring
Environmental Monitoring
Ecosystem Assessment
Prey Requirements for Krill Predators
Other Matters
Collaboration and Awareness of CEMP
CCAMLR/IWC Workshop on the Feeding Ecology of Southern Baleen Whales
CCAMLR System of Observation
New and Developing Fisheries
Future Work of WG-CEMP
Management Plans for CEMP Sites
Advice to the Commission

MARINE MAMMAL AND BIRD POPULATIONS

Status and Trends of Populations
Workshop on Southern Elephant Seals
Pack Ice Seal Censuses

ASSESSMENT OF INCIDENTAL MORTALITY
Incidental Mortality in Longline Fisheries
Advice to the Commission
Incidental Mortality in Trawl Fisheries
Management Advice
Impact of Bottom Trawling
Marine Debris
Driftnet Fisheries
General Matters

DEVELOPMENT OF APPROACHES TO CONSERVATION
New Fisheries
General

CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION

COOPERATION WITH OTHER ORGANIZATIONS

REVIEW AND PLANNING OF THE PROGRAM OF WORK OF THE SCIENTIFIC COMMITTEE

BUDGET FOR 1992 AND FORECAST BUDGET FOR 1993

ELECTION OF VICE-CHAIRMEN OF THE SCIENTIFIC COMMITTEE

NEXT MEETING

OTHER BUSINESS

ADOPTION OF THE REPORT

CLOSE OF THE MEETING

ANNEX 1: List of Participants

ANNEX 2: List of Documents

ANNEX 3: Agenda for the Tenth Meeting of the Scientific Committee

ANNEX 4: Proposed Amendments and Additions to Part X of the Scientific Committee Rules of Procedure

ANNEX 5: Report of the Third Meeting of the Working Group on Krill

ANNEX 6: Report of the Working Group on Fish Stock Assessment

ANNEX 7: Report of the Working Group for the CCAMLR Ecosystem Monitoring Program

ANNEX 8: CCAMLR Scheme of International Scientific Observation

ANNEX 9: Scientific Committee Budget for 1992 and Forecast Budget for 1993

REPORT OF THE TENTH MEETING
OF THE SCIENTIFIC COMMITTEE
(Hobart, Australia, 21 to 25 October 1991)

OPENING OF THE MEETING

1.1[*] The Scientific Committee for the Conservation of Antarctic Marine Living Resources met under the Chairmanship of Mr O. Østvedt (Norway) from 21 to 25 October 1991 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, India, Italy, Japan, Republic of Korea, New Zealand, Norway, Poland, South Africa, Spain, Sweden, Union of Soviet Socialist Republics, United Kingdom and United States of America.

1.3 The Chairman extended a special welcome to Dr G. Duhamel, a Vice-Chairman of the Scientific Committee, who was unable to attend the last meeting. Best wishes were extended to Prof. T. Lubimova (USSR) the other Vice-Chairman of the Scientific Committee, who was unable to attend, having retired in 1991.

1.4 The Chairman commemorated two colleagues, Dr Dick Hennemuth (USA) and Sr Jeronimo Bravo de Laguna (Spain). Both had contributed substantially to the program of work of CCAMLR. Dick Hennemuth was the first Convener of the *Ad Hoc* Working Group on Fish Stock Assessment and died in February 1991. Jeronimo Bravo de Laguna was Chairman of the Standing Committee on Inspection in 1989 and died in June 1991.

1.5 Observers from the Netherlands, Uruguay, the Intergovernmental Oceanographic Commission (IOC), the International Whaling Commission (IWC) and the Scientific Committee on Antarctic Research (SCAR) were welcomed and encouraged to participate as appropriate, in discussion of Agenda Items 2 to 11.

1.6 In 1990, the Scientific Committee considered whether ASOC (Antarctic and Southern Ocean Coalition) should be invited to attend as an observer (SC-CAMLR-IX, paragraph 9.9).

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* The first part of the number relates to the appropriate item of the Agenda (Annex 3).

1.7 At the 1990 meeting, all delegations except Japan accepted that ASOC could be invited so long as the following conditions were contained in any letter of invitation to ASOC (SC-CAMLR-IX, paragraph 9.13):

- the observer nominated should possess a suitable scientific qualification;
- the invitation would only apply to the the meeting stipulated in the letter;
- until such time as the Rules of Procedure of the Scientific Committee were amended, ASOC's participation would be in accordance with the conditions set down in Rules 32 to 34 of the Commission's Rules of Procedure; and
- that the absolute confidentiality of data and results discussed in the meeting of the Scientific Committee be observed where these were not subsequently published in the report of the meeting of the Scientific Committee.

1.8 The Japanese Delegation (SC-CAMLR-IX, paragraph 9.15) expressed the views that:

(i) the Rules of Procedure of the Scientific Committee are not adequate concerning the attendance of observers;

(ii) ASOC's attendance at the Scientific Committee would undermine the confidentiality of data; and

(iii) as ASOC is a 'movement', the Scientific Committee would not benefit from the presence of an ASOC observer at the Committee.

1.9 At the present meeting, the Japanese Delegation accepted that ASOC could be invited to attend the Tenth Meeting of the Scientific Committee, so long as the conditions laid out in SC-CAMLR-IX, paragraph 9.13 (paragraph 1.7 above) were met, and that additionally it was clearly stated in the letter that:

(i) one representative will be designated and only that representative will attend the meeting;

(ii) the representative will attend only the plenary sessions of the Scientific Committee;

(iii) the confidentiality of discussions at the plenary meeting will be observed; and

(iv) this invitation will apply only to this meeting of the Scientific Committee.

1.10 The Executive Secretary was asked to write to ASOC inviting them to attend under the conditions given in SC-CAMLR-IX, paragraph 9.13 and paragraph 1.9 above.

1.11 ASOC subsequently accepted the invitation under these conditions and was represented at the meeting as an observer.

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

1.13 Responsibility for the preparation of the Scientific Committee's Report was assigned to the following Rapporteurs: Mr D. Miller (South Africa), Krill Resources; Prof. J. Beddington and Dr I. Everson (UK), Fish Resources; Dr A. Constable (Australia), Other Resources, and Developments of Approaches to Conservation of Antarctic Marine Living Resources; Dr J. Croxall (UK), Ecosystem Monitoring and Management; Dr J. Bengtson (USA), Marine Mammal and Bird Populations and Assessment of Incidental Mortality; Mr P. Heyward (Australia), CCAMLR Scheme of International Scientific Observation; and Dr D. Agnew (Secretariat) all other items.

Adoption of the Agenda

1.14 The Provisional Agenda for the meeting had been circulated to Members in accordance with the Rules of Procedure. No amendments to the Provisional Agenda were proposed and the Agenda was adopted (Annex 3).

Report of the Chairman

1.15 During the intersessional period, Members participated in a number of meetings. The Chairman expressed the thanks of the Scientific Committee to all those who contributed to the success of the meetings under CCAMLR, Conveners, Rapporteurs, the Secretariat and last but not least, the countries hosting the meetings.

1.16 In this regard, the Chairman thanked the Delegations of the USSR and Spain for hosting the Working Group on Krill (WG-Krill) and the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP) respectively.

1.17 The Third Meeting of WG-Krill, chaired by the Convener Mr Miller, was held in Yalta, USSR, from 22 to 30 July 1991. The report of this meeting was distributed as SC-CAMLR-X/4.

1.18 The Sixth Meeting of WG-CEMP was held at the Instituto Español de Oceanografía, Santa Cruz de Tenerife, from 5 to 13 August 1991. The meeting was chaired by the Convener, Dr Bengtson. The report of this meeting was distributed as SC-CAMLR-X/6.

1.19 The Working Group on Fish Stock Assessment (WG-FSA) met in Hobart, Australia, from 8 to 17 October, 1991 and was chaired by the Convener, Dr K.-H. Kock (Germany). The report of this meeting was distributed as SC-CAMLR-X/5.

1.20 Other major events this year were the BIOMASS Colloquium held in Bremerhaven from 18 to 21 September followed by the SCAR Conference: Antarctic Science - Global Concern, in Bremen from 23 to 27 September. CCAMLR was represented at this Conference by Dr E. Sabourenkov (Science Officer) who presented a poster on CCAMLR's objectives and research program.

RULES OF PROCEDURE FOR THE PARTICIPATION OF OBSERVERS

2.1 The draft amendment to the Rules of Procedure (SC-CAMLR-IX, Annex 8), distributed as SC-CAMLR-X/3, was considered.

2.2 After some discussion, an amended version of this draft was agreed and the Scientific Committee recommended that the Commission approve this amendment to the Rules of Procedure (Annex 4).

2.3 Concerning Rule 20(a), the Executive Secretary was urged to use facsimile when notifying Argentina of the draft agenda for meetings.

KRILL RESOURCES

Fishery Status and Trends

3.1 The krill catch for the 1990/91 season was 4.6% less than in 1989/90 and totalled 357 538 tonnes (Table 3.1).

Table 3.1: National krill landings (in tonnes) since 1983/84.

Member	Split-Year*							
	1984	1985	1986	1987	1988	1989	1990	1991
Chile	1 649	2 598	3 264	4 063	5 938	5 329	4 501	3 679
Germany	0	50	0	0	0	0	396	0
Japan	49 531	38 274	61 074	78 360	73 112	78 928	62 187	67 582
Republic of Korea	5 314	0	0	1 527	1 525	1 779	4 040	1 211**
Poland	0	0	2 065	1 726	5 215	6 997	1 275	9 571
Spain	0	0	0	379	0	0	0	0
USSR	74 381	150 538	379 270	290 401	284 873	301 498	302 376	275 495
Total	130 875	191 460	445 673	376 456	370 663	394 531	374 775	357 538

* 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).

** From catch data tabled during the meeting.

3.2 The total krill catch by subarea since 1973 is illustrated in Figure 3.1.

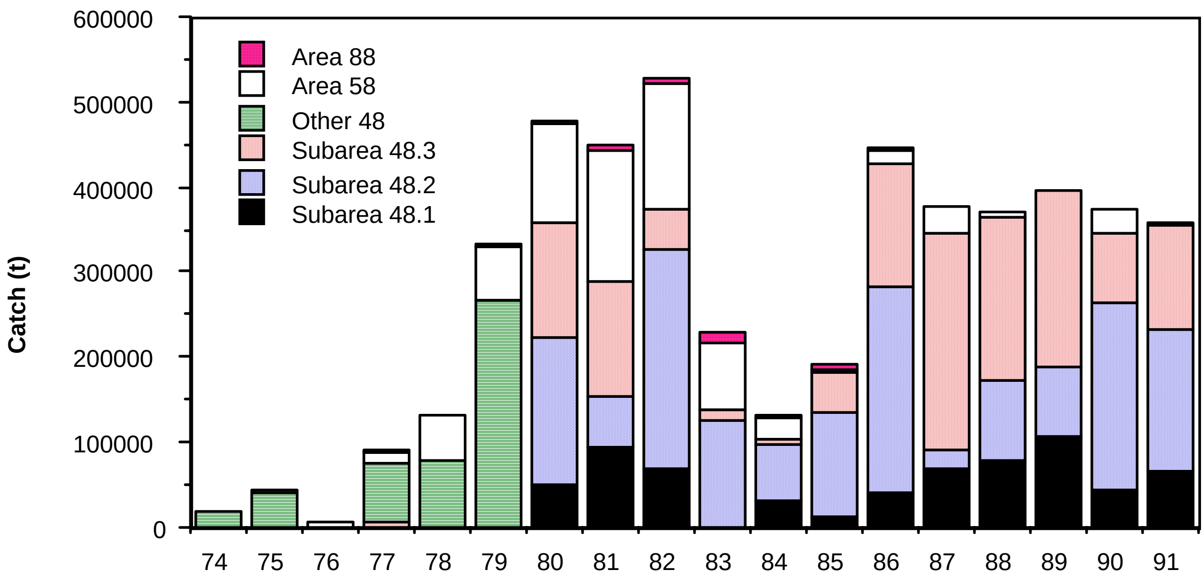

Figure 3.1: Total krill catches by subarea from 1973 to 1991. ('Other 48' refers to catches from Statistical Area 48 not allocated in Subareas 48.1, 48.2 or 48.3).

3.3 An analysis of the 1990/91 landings by area and subarea indicated a slight decrease in total catch from Statistical Area 48 compared with the previous two years. In this regard, Soviet catches in Subarea 48.2 decreased by approximately 61 000 tonnes compared with 1989/90, while in Subareas 48.1 and 48.3 they increased by 4 721 and 31 017 tonnes respectively.

3.4 In contrast to the above, there was a decrease in the overall catch in Subarea 58.4 (29 753 to 1 329 tonnes) and a slight increase in Statistical Area 88 (658 to 749 tonnes).

3.5 The total catch taken by the USSR was some 8% less than that taken in 1989/90 while catches by Japan were 8.7% greater. The latter was still some 9 000 tonnes below the 1988/89 level.

3.6 The total krill catch in 1990/91 by area and country is shown in Table 3.2

Table 3.2: Total krill catch in 1990/91 by area and country. The catch for 1989/90 is indicated in brackets.

	Chile	Germany	Japan	Korea	Poland	USSR
Subarea 48.1	3679 (4501)		54720 (33936)	1211 (4040)	310	4721
Subarea 48.2			1924 (1)		6020	159313 (220517)
Subarea 48.3		0 (396)	9606		3241 (1275)	110715 (79698)
Subarea 58.4			1329 (28250)			(1503)
Statistical Area 88			3			746 (658)
TOTAL	3679 (4501)	0 (396)	67582 (62187)	1211 (4040)	9571 (1275)	275495 (302376)

3.7 Dr M. Naganobu (Japan) indicated that the Japanese krill fishery is likely to be around the current level during the forthcoming year. During the 1990/91 season, only six vessels (five in the Scotia Sea and one off Wilkes Land) operated in the Convention Area compared with eight vessels in 1989/90.

3.8 Dr J. Lee (Korea) reported that the Korean catch in 1990/91 of some 1 211 tonnes was taken by one vessel and included 846 tonnes of krill which had been discarded. In reply to questions from a number of Scientific Committee Members, Dr Lee explained that the high level of discarded krill was a unique event which could be attributed to a freezer breakdown aboard the vessel concerned and was unlikely to occur in future years. The Korean catch in the forthcoming 1991/92 season was also unlikely to increase dramatically from mean levels (± 2 000 tonnes) taken over the past few years.

3.9 Dr V. Marín (Chile) reported that the Chilean fishery had caught some 19% less in 1990/91 than in 1989/90 of which 251 tonnes were processed into meal and 1 265 tonnes into frozen krill. Based on current information, catch levels in 1991/92 were unlikely to change substantially.

3.10 In reporting the above, Dr Marín drew the Scientific Committee's attention to a paper he had tabled at the meeting of WG-Krill in Yalta in which haul-by-haul data from the Chilean krill fishery during the 1990/91 season had been analysed (see WG-Krill-91/39 and paragraph 3.20 below).

3.11 Dr K. Shust (USSR) indicated that Soviet catches were unlikely to increase in 1991/92, although slight fluctuations in overall catch levels could be expected as a result of variations in krill catchability and economic demands.

3.12 The Scientific Committee was informed that an application from an Australian company to harvest up to 80 000 tonnes of krill annually is currently under consideration by the Australian Government.

3.13 As emphasised at its Ninth Meeting (SC-CAMLR-IX, paragraph 2.11), the Scientific Committee once again reiterated the utility of reviewing Members' intended commercial krill fishing activities for the forthcoming season (see also paragraph 3.20 below).

3.14 Papers distributed at the meeting and relevant to the krill agenda item dealt with a proposal for a project aimed at modelling krill aggregation dynamics (SC-CAMLR-X/9), precautionary catch limits for krill (SC-CAMLR-X/10), krill catches and consumption by land-based predators (SC-CAMLR-X/BG/7), catch-per-unit effort and krill body length from the Japanese fishery in Subarea 48.1 (SC-CAMLR-X/BG/10), the consumption of krill by fish in Division 58.4.2 (SC-CAMLR-X/BG/11) and proposals for the format of observations to be made on commercial fishing vessels in the Convention Area (SC-CAMLR-X/8).

Report of the Working Group on Krill

3.15 The Third Meeting of the Working Group on Krill (WG-Krill) was held in Yalta, USSR from 22 to 30 July 1991. This meeting, which was attended by 39 participants from 15 Member countries, was preceded by a meeting of WG-Krill's Subgroup on Survey Design between 18 and 20 July 1991. The latter meeting was convened by Dr I. Everson (United Kingdom).

3.16 Having briefly outlined the objectives of both WG-Krill’s (SC-CAMLR-IX, paragraphs 2.59 to 2.61; CCAMLR-IX, paragraphs 8.1 to 8.14) and the Subgroup’s (SC-CAMLR-IX, Annex 4, paragraph 97) meetings, the Convener of WG-Krill, Mr D. Miller (South Africa), presented the reports of both meetings (SC-CAMLR-X/4).

3.17 The Working Group’s and Subgroup’s reports are attached in Annex 5.

3.18 In reviewing the reports, the Scientific Committee thanked the Conveners and all the participants for their input. There were some 75 background papers presented to the Working Group (43 papers) and Subgroup (32 papers) and the relevant lists of documents are given in Annex 5, Appendix C and Appendix D, Attachment 2 respectively.

3.19 The Scientific Committee endorsed both WG-Krill’s and the Subgroup’s reports and made use of their findings as a basis for discussion. In the interests of brevity and to avoid unnecessary duplication, only a brief summary of the two reports is given below. Wherever paragraphs of either the Working Group or Subgroup report were accepted with little or only minor revision, the reader is referred to the relevant paragraphs of Annex 5. Consequently, the following summary should be read in conjunction with the two reports.

Review of Fisheries Activities (Annex 5, paragraphs 3.1 to 3.14)

3.20 The Scientific Committee noted that WG-Krill had endorsed the principle that Members fishing for krill should provide the Commission with information on the number of fishery vessels expected to be operational during the forthcoming season along with their catching capacity (see also paragraph 3.13 above). Both items of information were seen as being helpful in the determination of likely levels of fishing effort being deployed in the Convention Area (Annex 5, paragraph 3.6).

3.21 The value of haul-by-haul data from the krill fishery, particularly in the vicinity of land-based predator colonies, as well as information from scientific observers based on Soviet commercial vessels was also noted (Annex 5, paragraphs 3.7 to 3.9). In this connection, the Scientific Committee agreed that the collection of biological and other data from commercial krill fishing vessels remains a top priority in WG-Krill’s work. It was also acknowledged that only scientific observers will collect such data.

3.22 The Scientific Committee noted that despite this call for an investigation of the by-catch of young fish in the krill fishery (SC-CAMLR-IX, paragraph 3.19) only one paper had been tabled at WG-Krill and that no new data are yet available on the by-catch of larval fish in that fishery. Consequently, it reiterated its call for further investigation of the problem.

3.23 Finally, the Scientific Committee agreed that there is a critical need for work on the mortality of krill not retained in krill trawls if the impact of the fishery is ever to be fully assessed (Annex 5, paragraphs 3.11 and 3.12).

Information Necessary for Management of Krill Resources (Annex 5, paragraphs 4.1 to 4.14)

Survey Method and Biomass Estimations

Review of Subgroup on Survey Design's Work

3.24 The Scientific Committee noted that the Working Group had emphasised that simulation studies would have particular application in the development of specific survey designs which involve geostatistical analysis, particularly since they would also provide some indication of the robustness of various estimators. Further work on the application of geostatistics in the analysis of krill survey data and associated simulation studies were therefore encouraged (Annex 5, Appendix D, paragraph 4.7).

3.25 The spatial scales (micro - a few to 10s km, meso - 10s to 100s of km, and macro - 100s to 1 000s km) of application of the analytical techniques discussed by the Subgroup (Annex 5, Appendix D, paragraphs 48 and 56) were accepted by the Scientific Committee in their application to the monitoring of prey in relation to data from CEMP monitoring of predators.

Prey Surveys for CEMP (Annex 5, paragraphs 4.9 to 4.15)

3.26 In considering prey surveys for CEMP, the Subgroup developed a design applicable to prey information in the context of predator parameter A5 (Penguin Foraging Trip Duration) in the Antarctic Peninsula Integrated CEMP Study Region.

3.27 This survey design (Annex 5, Appendix D, Attachment 4) was accepted by the Scientific Committee. Although different in layout to the guidelines recommended last year (SC-CAMLR-IX, paragraph 2.47 and SC-CAMLR-IX, Annex 4, paragraph 100), it was agreed that if offered significant advantages in terms of standing stock estimation and the determination of krill distribution within a given area (Annex 5, paragraphs 4.11 to 4.13).

3.28 The Scientific Committee noted that WG-Krill had requested WG-CEMP to provide an indication of the types of information on krill distribution and aggregation likely to be important in improving understanding of predator/prey interactions.

Survey for Direct Abundance Estimation (Annex 5, paragraphs 4.16 to 4.20)

3.29 The Scientific Committee endorsed the deliberations and guidance of the Subgroup and WG-Krill concerning the conduct of krill abundance surveys in the southwest Atlantic (Annex 5, Appendix D, Attachment 4, Survey Designs 2, 3 and 4).

Future Work on Krill Survey Design (Annex 5, paragraphs 4.21 to 4.23)

3.30 The Scientific Committee endorsed WG-Krill's proposals on further work to be directed at developing general principles and specific details to be used in the design of krill abundance surveys (Annex 5, paragraph 4.21).

3.31 In this connection, a Soviet proposal outlining the construction of a model on which to base simulation studies using real acoustic survey data to develop survey designs and analytical procedures was considered (SC-CAMLR-X/9).

3.32 The Scientific Committee agreed that this was a useful proposal and encouraged further development of the projects. However, the Scientific Committee did not see its way clear to provide a financial contribution to support the Soviet proposal at this time.

Krill Biomass Estimation (Annex 5, paragraphs 4.24 to 4.31)

Acoustic Target Strength

3.33 In keeping with the priority that it had afforded to this topic at its last meeting (SC-CAMLR-IX, paragraph 2.32 and 2.33), the Scientific Committee noted the considerable progress in the refinement and re-assessment of krill acoustic target strength (Annex 5, paragraphs 4.24 to 4.30).

3.34 The Scientific Committee endorsed the conclusion of WG-Krill that the BIOMASS function for krill target strength at 120 kHz should not be used to convert measurements of volume backscattering strength to biomass. Pending a more formal review of the problem, the Scientific Committee recommended that the following definition, derived from Green *et a1*. (1991: *Nature 349*: 110) should be used:

$$\text{TS (dB)} = -127.45 + 34.85 \text{ X } \text{Log}_{10} \text{ (length in mm)}.$$

3.35 The Scientific Committee also endorsed the suggestions concerning additional measurements of krill target strength (Annex 5, paragraph 4.30(ii)).

Estimation of Yield and Production (Annex 5, paragraphs 4.32 to 4.51)

3.36 Refinement of estimates of krill yield and production were afforded high priority by the Scientific Committee at its last meeting (SC-CAMLR-IX, paragraphs 2.21 to 2.28 and 2.40).

3.37 The Scientific Committee therefore noted WG-Krill's attempts to produce such estimates (Annex 5, paragraphs 4.32 to 4.42) and endorsed its conclusion that further work is necessary to investigate the sensitivity of λ (the numerical factor relating potential yield to unexploited biomass and natural mortality) to various factors.

3.38 The urgent need for length frequency data from commercial krill catches was re-emphasised in the context of refining estimates of age-at-first-capture, one of the factors likely to affect λ.

3.39 In general, there was agreement that the approach followed by WG-Krill in the estimation of krill potential yield emphasises the need for the refinement of important input parameter values, particularly natural mortality (**M**) and recruitment variability.

3.40 Once again major problems associated with estimating emigration and immigration rates in the calculation of $\mathbf{B_0}$, initial biomass, were noted. The Scientific Committee agreed that further calculations should be undertaken for WG-Krill's next meeting along the lines set out in Appendix E of WG-Krill's report.

3.41 Dr M. Mangel (USA) stated that he considered the approach outlined above to provide a useful basis for addressing a difficult problem. He shared the Working Group's reservations concerning the compensatory nature (Annex 5, paragraph 4.38) of some of the assumptions underlying the model considered by the Working Group, the need to improve allowance for local predator demands (Annex 5, paragraph 4.39) as well as to take more specific account of all components of the krill stock (i.e., other than spawning animals) and the strong need for length frequency data from the fishery (Annex 5, paragraph 4.21).

Distribution and Movement (Annex 5, paragraphs 4.52 to 4.82)

3.42 The Scientific Committee took particular note of WG-Krill's deliberations on the effects of water movement on the distribution of krill.

3.43 The Scientific Committee recognised that the direct estimation of the krill biomass effectively available on a given fishing ground or in a subarea could require synoptic surveys over much larger areas. Alternatively, krill movements (i.e., fluxes) could be investigated directly which would require knowledge of krill input, export and residence times in a particular area or region.

3.44 The Scientific Committee therefore agreed that the various hypotheses developed by WG-Krill (Annex 5, paragraph 4.74) provide a useful framework for further development of analyses aimed at understanding the dynamics of krill fluxes between subareas of the Scotia Sea. Consequently, Members were urged to prepare submissions to WG-Krill's next meeting on the potential magnitude of key fluxes in this region, particularly in the context that such information is crucial to further assessment of krill potential yield in the subareas concerned.

3.45 The Scientific Committee emphasised that any reports or publications from surveys aimed at assessing the role of movement of krill should provide full details of survey techniques and analyses. Details on the statistical (i.e., coefficients of variation, etc.) and operational (survey design criteria and coefficients of variation, etc.) constraints of such surveys should also be provided in survey reports.

3.46 Furthermore, the influence of krill flux on the distribution of specific components of the krill population (e.g. length and/or maturity stages) and the estimation of yield in certain subareas should be explored. The role of vertical migration should also be considered.

Demographic Parameters (Annex 5, paragraphs 4.83 to 4.94)

3.47 The three tables of published krill demographic parameter values produced by the Working Group were noted by the Scientific Committee (Annex 5, Tables 2 to 4). The Scientific Committee also acknowledged that WG-Krill had not had sufficient time to thoroughly examine these values or the way in which they had been derived. It was agreed that this should be undertaken at the Working Group's next meeting and that a review of length/weight relationships for various sized animals be included.

3.48 The Scientific Committee urged Members who have additional information on krill demographic parameters to submit these to the next meeting of WG-Krill.

Advice to WG-CEMP (Annex 5, paragraphs 5.1 to 5.15)

3.49 Having already considered matters relevant to krill (prey) survey design (see paragraphs 3.26 to 3.28 above), the Scientific Committee endorsed WG-Krill's requests to WG-CEMP (Annex 5, paragraph 5.9) for additional information concerning krill's role as a prey item for various predators. WG-CEMP's response to this request was considered in more detail under Agenda Item 6 (see paragraphs 6.53 to 6.57 below).

3.50 Particular note was taken of WG-Krill's concern with obtaining realistic estimates of krill eaten by predators in various geographic areas, especially as these may relate to estimating the potential yield of krill stocks and in the calculation of the required krill escapement from the fishery. In this context, the Scientific Committee noted the need for an on-going dialogue between WG-Krill and WG-CEMP concerning the need for operational definitions of Article II with respect to krill fishing and predator monitoring (SC-CAMLR-IX, paragraph 2.19) (see also paragraphs 6.34 to 6.39, 6.60 and 12.4 below).

3.51 The Scientific Committee agreed that that there is a need for closer evaluation of the potential impact of highly-localised commercial krill catches on land-based predators. Also, since the variability in the ratio between krill consumption by predators and commercial krill catch levels is unknown, this should be taken into account when assessing interactions between the fishery and other krill consumers (see also paragraphs 3.66 to 3.68).

Development of Approaches to Managing the Krill Fishery (Annex 5, paragraphs 6.1 to 6.30).

Operational Definitions of Article II (Annex 5, paragraphs 6.1 to 6.7)

3.52 Despite requests from the Scientific Committee and Commission in 1990 (SC-CAMLR-IX, paragraph 2.19 and CCAMLR-IX, paragraph 4.17), it was noted that no further operational definitions of Article II had been received by WG-Krill since its last meeting (SC-CAMLR-IX, Annex 4, paragraph 61).

3.53 The Scientific Committee agreed that this matter requires further attention and that it should be considered in the context of (a) particular management procedure(s) and the associated mechanisms for monitoring the krill resource.

Possible Approaches to Managing the Krill Fishery and their Development (Annex 5, paragraphs 6.4 to 6.30)

3.54 The Scientific Committee noted that WG-Krill had continued to develop approaches to management of the fishery in keeping with the former’s request (SC-CAMLR-IX, paragraph 2.60).

3.55 WG-Krill had set out the various advantages and disadvantages for seven management approaches which may be applicable to the krill fishery, namely: reactive management (Annex 5, paragraphs 6.5 to 6.10); predictive management (Annex 5, paragraphs 6.11 to 6.15); open and closed areas (Annex 5, paragraphs 6.16 to 6.19); indicator species (or other indirect methods (Annex 5, paragraphs 6.20 to 6.24)); pulse fishing (Annex 5, paragraphs 6.25 and 6.26); and feedback management (Annex 5, paragraphs 6.27 to 6.29).

3.56 The Scientific Committee agreed that reactive management does not constitute a viable long-term strategy for management of the krill fishery and that the development of a feedback management procedure for krill should be a long-term aim. In the meantime, the various other approaches discussed by WG-Krill provide the basis for the formulation of advice on precautionary measures for the krill fishery that had been requested by the Commission (CCAMLR-IX, paragraphs 8.1 to 8.14 and paragraphs 6.27 to 6.29 below).

3.57 The Delegations of Chile and Spain stated that it would be desirable to develop studies concerning the inter-relations of krill and the fishing fleet, with the idea of incorporating the principle of management based upon controlling the fishing effort.

Precautionary Limits on Krill Catches
(Annex 5, paragraphs 6.56 to 6.66)

3.58 The Scientific Committee noted that in dealing with the Commission's request for an indication of the best estimate of a precautionary limit for krill in various statistical areas and an identification of the various options on which such a limit could be established (CCAMLR-IX, paragraph 8.5), WG-Krill had taken cognisance (Annex 5, paragraphs 6.31 and 6.32) of reservations expressed last year by the USSR, Japan and Korea (CCAMLR-IX, paragraph 8.7).

3.59 Nevertheless, the Working Group had recognised that the rationale underlying the consideration of precautionary measures is the prevention of an inordinate expansion of the fishery at a time when information available for predicting potential yield is limited. The Scientific Committee agreed that such measures should be considered as short-term, require regular review and should only be applied on an interim basis to be superseded as soon as improved information on which to base management decisions becomes available (Annex 5, paragraph 6.34).

3.60 The Scientific Committee also agreed with WG-Krill that initially the provision of estimates for precautionary limits should be expressed in the form of catches (Annex 5, paragraph 6.33). It recognised, however, that such limits could be formulated in different terms (e.g. closed areas or effort controls) to achieve similar aims.

3.61 The inherent difference between precautionary measures based on whole statistical areas as opposed to individual subareas was recognised (Annex 5, paragraphs 6.35 and 6.36).

3.62 WG-Krill had considered two alternative bases for specifying precautionary limits in Statistical Area 48. Briefly, these were based on historical catches (Annex 5, paragraphs 6.38

to 6.41) and estimates of potential yield (Annex 5, paragraphs 6.42 to 6.55) derived via the formula $Y = \lambda MB_o$. The Working Group also used a model-based approach to derive an appropriate level of fishing effort in relation to the available krill stock and to the demands of associated predators (Annex 5, paragraphs 6.56 to 6.59).

3.63 With respect to the general approach based on historical catches in Statistical Area 48, the Scientific Committee noted the following objections raised during the Working Group's meeting (Annex 5, paragraph 6.41):

(i) there is little scientific basis in relation to assessment of the stock;

(ii) the limits could be unnecessarily restrictive if the stock is capable of yielding much greater amounts of krill than have been taken historically; and

(iii) it takes no account of changes in fishing effort due to economic and other factors.

3.64 Some Members noted that the use of historical catches is a mechanistic approach and therefore has less empirical justification than an approach based on stock assessment.

3.65 A number of Scientific Committee Members felt that despite the above limitations, historical catches did indeed provide a useful basis on which to develop precautionary measures since *inter alia*:

(i) there is no evidence thus far to suggest that historical catch levels in Statistical Area 48 had significantly impacted either on krill stocks or on associated predators dependent on these stocks for food;

(ii) historical catch levels did in fact provide some indication of economic trends and/or possible operational variability in the fishery; and

(iii) given the uncertainties associated with the derivation of precautionary limits based on estimates of krill potential yield (see paragraphs 3.66 to 3.70 below), historical catches offer a conservative approach to the setting of such limits.

3.66 In estimating a precautionary limit in Statistical Area 48 based on the yield approach (Annex 5, paragraphs 6.42 to 6.55), the Working Group noted that the resultant figure would be higher than appropriate for such a limit on krill catches since:

(i) the precautionary limit should be below the possible ultimate level for the fishery, since later growth of the fishery as it approached such a limit should take place under an improved management procedure (e.g. feedback control would be exercised); and

(ii) allowance should be made for uncertainty in the estimates of the parameters used in the $Y = \lambda MB_0$ calculation.

3.67 For these reasons, WG-Krill had attempted to introduce a discount factor **d** into the above formula. A component of this factor would take account of the escapement of krill from the fishery necessary to meet predator demands, although such demands would to some extent be implicitly assumed in the estimate of **M** (Annex 5, paragraphs 6.43 to 6.49).

3.68 The Scientific Committee acknowledged that there is uncertainty associated with the estimation of an appropriate discount factor, especially in relation to the need to take explicit account of predator demands. However, this is not the only, or necessarily the most appropriate means of taking into account predator requirements. For example, closed areas and seasons may be more effective in reducing the possible impact of fishing close to predator colonies.

3.69 The Scientific Committee also noted WG-Krill's efforts to take account of possible flux effects when using localised surveys of krill biomass to derive precautionary limits by subarea (Annex 5, paragraphs 6.51 to 6.53). Consequently, it endorsed the Working Group's preferred basis for calculation of a precautionary limit in Statistical Area 48 which, being based on a direct estimate of biomass (i.e., of $\mathbf{B_o}$) in the area as a whole during FIBEX, exhibited little necessity for a flux adjustment (Annex 5, paragraph 6.54).

3.70 The above estimate for a precautionary limit on the krill catch in Statistical Area 48 was comparable to those obtained by the Working Group using other methods. Such methods attempted to account for fluxes (paragraph 3.69) or were derived via various approaches (Annex 5, paragraph 6.56 to 6.59).

3.71 Based on all the approaches considered by WG-Krill, the Scientific Committee noted that its best estimate for a precautionary catch limit on krill in Statistical Area 48 stands at 1.5 million tonnes which corresponds to a potential yield in the order of 2.2 million tonnes and a $\mathbf{B_0}$ of 15 million tonnes.

3.72 The resultant estimate for a precautionary limit on the krill catch in Statistical Area 48 derived by the latter method, was comparable to those obtained whereby specific allowances were made for fluxes (paragraph 3.70) as well as those derived via a number of other approaches (Annex 5, paragraphs 6.56 to 6.59).

3.73 The Scientific Committee acknowledged the Soviet and Japanese views with respect to the limit in paragraph 3.71. These views are contained in Annex 5, paragraphs 6.63 and 6.65 to 6.66 respectively.

3.74 There was general agreement within the Scientific Committee that the limit referred to above would not necessarily constitute a conservative catch limit since some account would also need to be taken of total krill mortality arising from fishing (see paragraph 3.23 above).

3.75 The Scientific Committee appreciated that a shortage of time had precluded the Working Group undertaking similar precautionary limit calculations for other areas and recommended that these calculations should be performed as soon as possible.

3.76 The Scientific Committee agreed that the above estimate for Statistical Area 48 should be divided on a subarea basis so as to allow for the possibility of separate krill stocks in subareas.

3.77 The division referred to in paragraph 3.75 may be achieved in a number of different ways. Results contained in paper SC-CAMLR-X/10 represented an attempt to calculate limits for individual subareas within Statistical Area 48 based on *pro-rata* division of FIBEX data. Some Members expressed reservations concerning results of the analysis in this paper, however, other Members regarded these results as a useful first attempt to break down the areal precautionary limit on a subarea basis.

3.78 The Scientific Committee recognised that in order to refine precautionary limits by subareas of Statistical Area 48, it is essential that the FIBEX data be re-analysed taking into consideration the appropriate re-definition of the survey strata which would be applicable at subarea level. This task was afforded high priority.

3.79 Dr Naganobu indicated that in his view any subareal division in the calculation of precautionary limits is premature at this stage. In his opinion, this is because the available scientific information on which to base any subarea divisions is still subject to considerable uncertainty. He agreed, however, that further research was needed and drew the Scientific

Committee's attention to the following topics which had been identified by WG-Krill (Annex 5, paragraph 7.16) and which he considered should be addressed in this regard.

(i) Investigations of flux in areas and subareas.

(ii) Estimation of total effective biomass in areas and subareas.

(iii) Refinement of calculation of potential yield including further evaluation of the underlying population models and demographic parameters used in such calculation.

He added that more surveys are necessary to address these problems and to collect the data required.

3.80 The need to consider even finer spatial breakdowns than statistical subareas was emphasised as important in the context of containing the potential impact of localised fishing within restricted predator foraging areas.

3.81 One way of limiting the possible localised impact of the fishery would be to use historical fine-scale catch data in combination with predator foraging range information to identify areas of potential overlap in space and time between the fishery and predators feeding on krill. In these areas, some level of historical catch (i.e., lowest, mean or highest) could then be applied in the setting of finer-scale precautionary limits.

3.82 The further definition of regions where potential overlap between fisheries and foraging predators may occur was thus seen as a priority task for the future calculation and division of precautionary krill limits at scales finer than that of a statistical subarea.

3.83 The potential impact of localised fishing can also be addressed by applying an approach which combines the precautionary limit for Statistical Area 48 derived from the estimate of yield with the approach based on historical catches. This entails limiting krill catches from existing fishing grounds near land-based predator colonies to the highest catches ever taken on these grounds. Thus the potential impact on local predators would be contained close to historic levels.

3.84 Alternatively, a combination of procedures could be applied. For example, closure of specific areas where the fishery and predators are found could be implemented for specific periods or in a variable manner. With respect to the latter, there may be some benefit in ensuring that detailed information is obtained on fishing carried out in close proximity to some predator colonies in an attempt to determine functional relationships between the fishery, krill stock and predator stock concerned. Also, closure of specific areas to fishing where predator monitoring studies are underway would allow monitoring of predator stocks remote from any possible fishery effects.

3.85 In all instances, the application of any precautionary limit based on catch limitations will necessitate a complementary catch reporting system at a spatial and temporal scale appropriate to that to which the limit is being applied.

3.86 With respect to re-assessment of the so-called 'krill-surplus' perception raised at WG-Krill (Annex 5, paragraph 8.3), the Scientific Committee noted the views of WG-CEMP (Annex 7, paragraph 7.19). After some discussion, the Scientific Committee was unable to provide WG-Krill with specific guidelines as to the most effective way to pursue this matter further.

New and Developing Fisheries (Annex 5, paragraphs 7.5 to 7.9)

3.87 The Scientific Committee endorsed WG-Krill's comments on this matter and agreed that the definition suggested by the Secretariat should be expanded for assessment purposes (see also discussions under Agenda Item 9, Development of Approaches to Conservation of Antarctic Marine Living Resources).

CCAMLR Scheme of International Scientific Observation (Annex 5, paragraphs 7.10 to 7.12)

3.88 The Scientific Committee noted WG-Krill's deliberations on this matter and endorsed the observer forms which the Working Group has developed (see also discussions under Agenda Item 10, CCAMLR Scheme of International Scientific Observation).

Data Requirements

3.89 In view of the continued shortage of much of the information requested at its last meeting (SC-CAMLR-IX, paragraphs 2.63 to 2.68) and highlighted by the Working Group (Annex 5, Table 6), the Scientific Committee reiterated its request for such information in view of the continued need to monitor the krill fishery. In particular, it endorsed WG-Krill's request that:

(i) length frequency data from fine-scale reporting areas should be submitted to the Secretariat, even though the collection of such data may, to a large extent, only be possible by specially trained personnel; and

(ii) haul-by-haul data from the commercial fishery should be collected and submitted to the Secretariat. It was recognised that the collection and submission of such data may, on occasion, be problematic.

3.90 In this respect, Chilean fisheries have been able to provide haul-by-haul data, while USSR fisheries have experienced technical difficulties with the implementation of this requirement, and the Japanese and Korean Delegations have indicated that they are unable to report haul-by-haul data as a result of legislation in their countries.

3.91 Dr R. Holt (USA) indicated that in his view the continued lack of submitted length frequency and haul-by-haul data (paragraphs 3.89(i) and (ii)) constituted an unfortunate cycle of events based on the assertion that the collection of such data was too expensive or too hard. In this connection, the Scientific Committee agreed that some indication of the cost incurred by fishing operators in the collection of such data would be useful.

Future Work of WG-Krill

3.92 The Scientific Committee noted that the work of WG-Krill has progressed well. In particular, the specification of prey survey designs, the refinement of potential yield estimates (including investigation of krill fluxes between subareas within Statistical Area 48), the estimation of precautionary limits and discussions on the development of various management approaches, were seen as being particularly important achievements.

3.93 The Scientific Committee thus endorsed the following topics as having the highest priority for the Working Group's work in the forthcoming year:

- investigations of flux in Statistical Area 48 and other areas;

- estimation of total effective biomass in Statistical Area 48 and other areas;

- refinement of calculations of potential yield and precautionary limits, including further evaluation of the pertinent population models and demographic parameters used in such calculations; and

- further estimation of precautionary limits in various statistical areas and subareas.

3.94 The Working Group should continue to address problems associated with survey design, development of approaches to management and continued liaison with WG-CEMP on matters of concern.

3.95 In order to address these 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 1992.

3.96 This meeting is scheduled for 4 to 12 August 1992 and an offer by Chile to host it in Punta Arenas was gratefully accepted.

Advice to the Commission

General Advice

3.97 WG-Krill should hold an intersessional meeting during 1992 in order to continue review of commercial fishing activities, further refine estimates of potential yield and precautionary limits and sustain momentum in the development of approaches to structuring advice on krill resources.

3.98 The krill length-acoustic target strength relationship contained in paragraph 3.34 should be endorsed, as should the guidelines from the conduct of krill (prey) surveys in paragraph 3.27.

3.99 The collection of haul-by-haul data from the fishery should continue and wherever possible should be submitted to the Secretariat as a matter of priority. Similarly, the submission of length frequency data from the fine-scale reporting areas should also be encouraged.

3.100 Current estimates of krill potential yield based on the $Y = \lambda MB_0$ approach should be refined with respect to investigation of the sensitivity of the vital numerical parameter λ.

3.101 In an attempt to refine subarea estimates of precautionary limits for krill and catches in Statistical Area 48, re-analysis of the basic FIBEX data should be undertaken as soon as possible. The involvement of the BIOMASS Data Centre and the subsequent costs likely to be incurred as a result should be formally acknowledged.

3.102 Estimates of precautionary limits for krill should be carried out for other statistical areas as a matter of urgent priority.

Specific Advice on the Status of Krill Stocks

3.103 The Scientific Committee agreed that reactive management - the practice of taking management action only when the need for it has become apparent - is not a viable long-term strategy for the krill fishery. Some form of feedback management, which involves the continuous adjustment of management measures in response to information, is to be preferred as a long-term strategy. In the interim, a precautionary approach is desirable and in particular, a precautionary limit on annual catches should be considered.

3.104 The Scientific Committee considered that for Statistical Area 48, an annual catch limit of 1.5 million tonnes based on estimates of potential yield is the best available.

3.105 There are important caveats associated with this catch limit.

- First, the limit needs to be divided into subareas to allow for the possible interactions between krill populations in these subareas.

- Second, it may need to be supplemented by other management measures to ensure that the catch is not entirely concentrated in the foraging range of colonies of vulnerable land breeding predators. Currently much of the krill catch in Statistical Area 48 is taken in such areas (SC-CAMLR-X/BG/7 and WG-Krill-91/39).

- Third, the limit has not involved an allowance for possible unreported mortality of krill associated with fishing operations (although there was very limited information on the matter).

3.106 Some Members of the Scientific Committee proposed an alternative approach to setting a precautionary catch limit which was aimed at meeting the caveats as presented in paragraph 3.105. This is to set a precautionary limit based on historical catches.

3.107 Two such options were reviewed. One was based on the maximum catch in the area as a whole in any one year: 425 900 tonnes. The second was based on summing the maximum catch in each subarea: 619 500 tonnes.

3.108 A further approach was proposed which would combine the precautionary limit of 1.5 million tonnes for Statistical Area 48, with the highest historic catches in the subareas. The latter would be used to provide an upper limit to catches on the existing fishing grounds near predator colonies.

3.109 Other Members were opposed to setting a precautionary TAC on historical catches. They did not believe such a method had any scientific basis (paragraphs 3.63 and 3.64).

FISH RESOURCES

Report of the Working Group on Fish Stock Assessment

4.1 The Convener of the Working Group on Fish Stock Assessment (WG-FSA), Dr K.-H. Kock (Germany), presented a report of the meeting which had been held in Hobart at the offices of the Secretariat from 8 to 17 October 1991.

4.2 The Report of WG-FSA is attached in Annex 6.

4.3 The Convener noted that the start of the meeting had been delayed for one day to allow Soviet colleagues, Drs Shust and Gasiukov, time to arrive. They had experienced unforeseen travel problems and did not arrive at the meeting until 14 October when all the assessments were in their final stage of preparation. WG-FSA had tried to consider objectively all the papers submitted by Soviet scientists in the preparation of the assessments. Soviet scientists requested that a large number of their comments on the assessments prepared by Members and within the Working Group be included in the report. WG-FSA decided to accept these comments into the report to avoid a lengthy debate during Scientific Committee. These additional comments had made the report of WG-FSA somewhat lengthy and somewhat disjointed.

4.4 Prof. Beddington considered that the report was disjointed in its presentation because of the large number of individual comments that had been included at the request of the Soviet scientists. He was concerned that equal weight in the presentation of the report had been given to papers that had been correctly tabled and discussed, and a paper that was only available in summary form.

4.5 Dr Shust apologised for the late arrival of himself and Dr Gasiukov. He noted that copies of papers had been mailed to the Secretariat in August but these had failed to arrive. Complementary copies of some of these papers had been sent to the Convener in advance of the meeting, arriving in good time, and these had been tabled.

4.6 Dr Shust further noted that some aspects of assessments including those performed by both himself and Dr Gasiukov were presented in a way that they considered to be unacceptable.

4.7 In reviewing the report, the Scientific Committee thanked the Convener and the participants for all their hard work. A large number of background papers had been presented to the WG-FSA meeting, a list of these documents is given in Annex 6 (WG-FSA report), Appendix C.

New and Developing Fisheries (Annex 6, paragraphs 5.1 to 5.6)

4.8 The Scientific Committee endorsed the comments made by WG-FSA. Further discussion was taken under Scientific Committee Agenda Item 9 (Development of Approaches to Conservation of Antarctic Marine Living Resources).

Interactions of Other Components of the Ecosystem
(e.g. Birds and Mammals) with Fisheries
(Annex 6, paragraphs 5.7 to 5.11)

4.9 The Scientific Committee endorsed the comments made by WG-FSA. Further discussion was taken under Scientific Committee Agenda Item 8 (Assessment of Incidental Mortality).

Prey Requirements of Predators
(Annex 6, paragraphs 5.12 to 5.16)

4.10 The Scientific Committee endorsed the comments made by WG-FSA.

By-Catch of Young and Larval Fish in the Krill Fishery
(Annex 6 paragraphs 5.17 to 5.20)

4.11 The Scientific Committee endorsed the comments made by WG-FSA.

Review of Material for the Meeting (Annex 6, paragraphs 6.1 to 6.17)

4.12 The work of WG-FSA has always been hampered by incomplete submissions of data. Various data, requested by WG-FSA, were not submitted. The problem is most serious for data relating to the commercial fisheries. A comparison of data requested compared to data submitted is given in Annex 6, Appendix E.

4.13 This problem had been highlighted last year by the Commission (CCAMLR-IX, paragraphs 4.3 and 4.5 to 4.8). The most serious example of information not being submitted to CCAMLR was haul-by-haul and length frequency data on *Dissostichus eleginoides* in Subarea 48.3 in accordance with Conservation Measure 26/IX. No haul-by-haul data were available and length compositions had only been submitted for some months, but not the entire season.

4.14 The Scientific Committee requests the Commission to take urgent steps to ensure complete and timely data submission. Failure to address this perennial problem adequately in the past has degraded the quality of advice that Scientific Committee is able to offer and furthermore increases the uncertainty associated with the assessments.

4.15 The Scientific Committee endorsed without comment the views expressed on other topics in this section of the report.

Fisheries Status and Trends

4.16 In the Atlantic sector, commercial fishing for finfish is prohibited in Subareas 48.1 and 48.2 but is permitted in Subarea 48.3, South Georgia. The total reported catch of all species was 82 423 tonnes, twice the amount reported for the 1989/90 season. The increase was primarily due to a threefold increase in the reported catch of *Electrona carlsbergi* to 78 488 tonnes.

4.17 A total of 1 518 tonnes of 'Lanternfish' (Myctophidae) was reported in CCAMLR-X/MA/8 as being taken from Subarea 48.2 although no STATLANT data were submitted. Dr Shust thought that the location of these catches may be incorrect and agreed to provide clarification on this before the next meeting of WG-FSA.

4.18 The reported catches by species over the past 22 years are set out in Table 1 of Annex 6.

4.19 Despite a TAC of 26 000 tonnes there had been virtually no commercial fishing on *Champsocephalus gunnari*. A reported catch by USSR of 48 tonnes was thought by WG-FSA to be a result of research fishing in April and May 1991. USSR STATLANT returns report a zero catch for this period but include 49 tonnes for November 1991, the latter tonnage was not available to WG-FSA. The total catch, therefore, was unknown.

4.20 Reported catches of *D. eleginoides* totalled 3 641 tonnes, slightly less than that allowed under Conservation Measure 24/IX.

4.21 The fishery in the Indian Ocean sector was confined to waters around Kerguelen Islands (Division 58.5.1) and on the Ob and Lena Banks (Division 58.4.4).

4.22 The reported catches by species over the past 20 years are set out in Table 19 of Annex 6.

4.23 The main species reported from the Kerguelen fishery was *C. gunnari*, of which 13 283 tonnes were taken, mainly by Soviet trawlers. 1 944 tonnes of *D. eleginoides* were caught mainly by one French trawler. A Soviet longliner, which had previously worked around South Georgia, carried out exploratory fishing on *D. eleginoides*.

4.24 The Soviet fishery on Ob and Lena Banks reported 575 tonnes of *Notothenia squamifrons*, a total within the TAC set by the Commission.

Assessments

4.25 Assessment summaries have been prepared and are included in Annex 6, Appendix J.

Notothenia rossii, *Notothenia squamifrons*, *Patagonotothen guntheri*, *Pseudochaenichthys georgianus* and *Chaenocephalus aceratus* (Subarea 48.3)
(Annex 6, paragraphs 7.10, 7.14 to 7.15, 7.18, 7.185 to 7.188)

4.26 The Scientific Committee endorsed the recommendations of the Working Group.

4.27 The Scientific Committee recommends that all conservation measures which were in force with respect to the above species should be extended for a further year. Dr Shust added the reservation that he had recommended an increase in by-catch of *C. aceratus* and *P. georgianus* to 500 tonnes each (Annex 6, paragraph 7.188).

Champsocephalus gunnari (Subarea 48.3)
(Annex 6, paragraphs 7.19 to 7.85)

4.28 Four conservation measures were in force for the 1990/91 season:

(i) from 1 November 1991, mesh size limitation of 90 mm (Conservation Measure 19/IX);

(ii) a prohibition of a directed fishery between 1 April 1991 and 4 November 1991 (Conservation Measure 21/IX);

(iii) a catch reporting system for the 1990/91 season (Conservation Measure 25/IX); and

(iv) a TAC of 26 000 tonnes (Conservation Measure 20/IX).

4.29 The TAC of 26 000 tonnes had been set by the Commission following advice from the Scientific Committee that the possible range of TACs was 44 000 to 64 000 tonnes. This lower figure had been chosen following a warning from the Scientific Committee that there was a high degree of uncertainty associated with their estimation, and, if a high TAC was set a significant by-catch of *Notothenia gibberifrons* was possible.

4.30 The total reported catch of this species during the season was thought to be little more than 93 tonnes. No commercial concentrations of the species were found and in consequence, the fishing fleet had moved to other areas in search of krill and *E. carlsbergi*.

4.31 The estimates of TAC in 1990 had been calculated using results of a UK survey and two surveys by the USSR.

4.32 Results from standing stock surveys in recent seasons are summarised in Annex 6, Table 3. There were two surveys in 1991. One by the *Falklands Protector* (UK/Germany/Poland), which is documented in WG-FSA-91/14, indicated a stock of 26 204 tonnes. The other by the *Atlantida* (USSR) had been available to the Working Group only in summary form (WG-FSA-91/23). Accordingly, the Working Group had been unable to examine the methods used in this survey nor to substantiate the results. This survey indicated a substantial stock of 192 225 tonnes.

4.33 Prof. Beddington recalled that in 1990 he had pointed out to the Scientific Committee substantial unexplained differences in the results of the UK and USSR surveys which he believed were due to differences in methodology and operation. In the light of the results of the last two years, he now found it impossible to place any credibility whatsoever on the results of the various USSR surveys. For the South Georgia region in 1990, two remarkably consistent estimates were available from USSR surveys, 878 000 tonnes (*Akademik Knipovich*) and 887 000 tonnes (*Anchar*). In normal conditions, stock size in 1991 would be predicted to be in excess of 1 million tonnes. Such results were not credible in the light of a minute commercial catch, and a complete absence of commercial concentrations of fish.

4.34 Dr Shust noted that substantial differences in the survey methodology in 1990 were only evident between vessels *Hill Cove* and *Anchar,* whereas there were no such differences between those carried out by *Akademik Knipovich* and *Hill Cove*. Furthermore, several biomass estimates obtained by *Akademik Knipovich* were submitted to the Working Group in 1990. Of these estimates, the one Prof. Beddington mentioned above was one of the highest (SC-CAMLR-IX, Annex 5).

4.35 Dr Shust accepted that there were problems in reconciling the standing stock estimates from recent surveys. He reminded the Scientific Committee that the standing stock estimate from the *Atlantida* survey was very close to the VPA projection.

4.36 There were indications from both surveys that there had been a substantial decline (77 to 80%) in the stock since 1990 in the absence of fishing. There were two possible biological explanations: increased mortality or emigration (Annex 6, paragraph 7.26).

4.37 There was indirect evidence from a number of surveys that krill predators in the area were suffering from a shortage of krill. The survey by the *Falklands Protector* had indicated that krill, the preferred prey of *C. gunnari*, was in short supply and individuals were found to be eating food of a lower calorific value.

4.38 WG-FSA-91/7 indicated that the reproductive condition of individuals sampled by the *Falklands Protector* was poor.

4.39 Two VPA assessments were presented to the meeting (paragraphs 7.37 to 7.52).

4.40 The first (WG-FSA-91/15) used standard methodology based on a VPA tuned to the bottom trawl surveys. It indicated a stock of low size with declines in spawning stock abundance and recruitment in recent years. Predicted catch levels for 1991/92 based on $\mathbf{F_{0.1}}$ were in the range of 8 000 to 14 000 tonnes.

4.41 The second assessment was based on tuning a VPA on trawl surveys and the commercial USSR catch and effort data for a time series from 1984 to 1990, there were of course no commercial catches for 1991. This indicated a substantially larger stock size in 1991. The paper recommended a TAC level for 1991/92 based on the analysis of 59 400 tonnes.

4.42 Two assessments were made during the Working Group meeting. Although these assessments were different in some technical details from the originals submitted to the Group, the methodologies and results of the Working Group assessments were essentially the same as the two originals.

4.43 Assessment 1 indicated a stock size in 1989/90 of around 27 000 tonnes and a catch level based on $\mathbf{F_{0.1}}$ of 9 672 tonnes.

4.44 Assessment 2 indicated a stock size in 1989/90 of around 196 000 tonnes and a catch level based on $\mathbf{F_{0.1}}$ of 61 870 tonnes.

4.45 There was substantial discussion of these assessments in the Working Group (Annex 6, paragraphs 7.53 to 7.78). Dr P. Gasiukov (USSR) made a number of critical comments on both assessments presented to and performed at the meeting and argued that the second assessments were more reliable (Annex 6, paragraphs 7.40, 7.43, 7.45, 7.48, 7.50, 7.55, 7.60, 7.68, 7.73, 7.77). There was no unanimity on which assessment was more reliable.

Management Advice

4.46 The Working Group presented two views on possible TACs for *C. gunnari* which were in the range of 8 400 to 61 900 tonnes. Dr Gasiukov suggested that the highest value could form the basis for a TAC. Other Members felt that a conservative level was appropriate given uncertainties on population size, year class strength, future recruitment, and the potential by-catch of *N. gibberifrons*.

4.47 The Scientific Committee discussion of the assessments and management advice followed a similar pattern to that of the Working Group. In essence, there were two views. The first that the status of the stock is poor and that a conservative management approach is desirable. The second that the status of the stock is good and that a reasonable TAC could be set. No Member shared the view that a TAC of 61 900 tonnes could be recommended.

4.48 Prof. Beddington suggested that one option the Commission might consider was to close the fishery in 1991/92 pending the results of a further survey planned by the UK for January 1992. The basis for this suggestion was the concerns expressed in the Working Group that there appeared to have been a large decline in the stock in the absence of fishing and that there were indications that reproductive performance had been adversely effected, possibly by the shortage of krill.

4.49 The Scientific Committee drew attention to the problem of by-catch of *N. gibberifrons* if a TAC were to be set. Lic. E. Barrera-Oro (Argentina) recalled the analysis performed at last year's Scientific Committee (SC-CAMLR-IX, paragraph 3.42) which indicated that a by-catch of 500 tonnes would be reached with a catch of *C. gunnari* of 14 000 tonnes.

4.50 Dr Shust proposed that some reasonable TAC could be set in the range of 8 400 to 61 900 tonnes. He commented that if the stock size was sufficiently low so that no commercial concentrations were found, no commercial catch would be taken for economic reasons.

4.51 A number of Members responded that a low stock size did not guarantee that negligible catches would be taken because fishable concentrations might still be found.

4.52 The Scientific Committee endorsed the recommendation of the Working Group concerning other conservation measures.

(i) Conservation Measure 19/IX dealing with 90 mm mesh size should be continued.

(ii) Conservation Measure 20/IX, the ban on bottom trawls in the directed fishery for *C. gunnari* should be continued.

(iii) Conservation Measure 21/IX, the closed season between 1 April and the end of the next Commission meeting should be continued.

Dissostichus eleginoides (Subarea 48.3)
(Annex 6, paragraphs 7.86 to 7.128)

4.53 Three conservation measures were in force. Conservation Measure 24/IX set the TAC for the period 2 November 1990 to 2 November 1991 as 2 500 tonnes. Conservation Measures 25/IX and 26/IX related to the reporting of catch, effort and biological data.

4.54 Reported catches in 1990/91 consisted of 1 440 tonnes caught before the Commission meeting last year and 2 394 tonnes caught since. All catches were caught by longlining.

4.55 Conservation Measure 25/IX was adhered to and catch and effort data from five-day reporting periods were submitted.

4.56 Conservation Measure 26/IX had not been adhered to, no haul-by-haul data had been presented and only limited length frequency data (for a few months) has been submitted.

4.57 Mr V. Brukhis (USSR) stated that there were difficulties in radio communication with the fishing vessels. It was therefore difficult to ensure that haul-by-haul data and the relevant biological data were presented as required.

4.58 A number of Members pointed out that this situation had presumably been known at the time that Conservation Measure 26/IX was adopted.

4.59 In view of the obligation set out in Conservation Measure 26/IX to submit haul-by-haul data from the longline fishery on *D. eleginoides*, the Soviet representative agreed to extract these data from the longline vessels and submit them to CCAMLR, if possible.

4.60 Dr C. Moreno (Chile) stated that it was the intention of Chile to conduct longline operations in Subarea 48.3 as an extension of an ongoing project involving *D. eleginoides* as reported in WG-FSA-91/10. This operation would provide haul-by-haul and biological data.

4.61 Two papers, WG-FSA-91/20 and WG-FSA-91/24 contained assessments. The former, which was based on trawl surveys, gave markedly different estimates for two successive years. The latter, was a cohort analysis which used biological data from the fishery, but which had not been tuned to either survey or CPUE data. A third assessment was performed at the meeting using a modified deLury method which used CPUE data from one and two years. There are substantial differences in the estimates of stock size and catch of $\mathbf{F_{0.1}}$ obtained by the different methods (Annex 6, Table 8).

4.62 The Working Group was unable to reach agreement on which of the methods were most reliable.

Management Advice

4.63 The management advice presented by the Working Group reflected the uncertainties encountered in assessing the stock. The range of estimates of possible TACs was between 794 and 8 819 tonnes. Drs Shust and Gasiukov believed this range was too large and believed the appropriate range was from 3 800 to 8 819 tonnes. Other Members did not believe there was sufficient information for choosing any part of the range.

4.64 Discussion in the Scientific Committee reflected these differences, there were two views.

4.65 Prof. Beddington, supported by a number of Members, indicated that because no haul-by-haul data had been submitted and insufficient other data were available, no assessment was sufficiently reliable to use as a basis for setting a TAC.

4.66 Dr Shust stated that the TAC should be chosen from the range 3 800 to 8 819 tonnes.

4.67 Attention was drawn by a number of Members to the problems identified (paragraphs 8.4 to 8.11) with the incidental mortality of seabirds in the fishing for *D. eleginoides*. The Scientific Committee therefore draws the Commission's attention to the fact that this incidental mortality will be related to the level of any TAC set.

Notothenia gibberifrons (Subarea 48.3)
(Annex 6, paragraphs 7.177 to 7.179)

4.68 The Scientific Committee endorsed the recommendations of the Working Group.

Management Advice

4.69 The analyses undertaken by the Working Group indicated a TAC of 1 500 or 3 000 tonnes would be appropriate.

4.70 It was agreed, however, that the TAC could only be obtained by bottom trawling which would result in by-catch of other species in Subarea 48.3 (Annex 6, paragraph 7.196). It was also agreed that the potential effects on other species should preclude direct fishery by any fishing method for *N. gibberifrons* in 1991/92. Some Members felt the by-catch in the pelagic fishery for *C. gunnari* should be limited to 500 tonnes of *N. gibberifrons* (see Conservation Measure 20/IX).

4.71 Dr Shust suggested that a TAC of 1 500 tonnes as a by-catch in pelagic fisheries could be recommended.

General Considerations on the Re-Opening of a Directed Fishery
and the Application of TACs to 'By-Catch' Species in Subarea 48.3
(Annex 6, paragraphs 7.189 to 7.197)

4.72 The recommendations of the Working Group were endorsed by the Scientific Committee.

Management Advice

4.73 In any mixed bottom trawl fishery where catches are at $\mathbf{F_{0.1}}$ (the agreed policy of the Commission) or $\mathbf{F_{max}}$, the TAC of *N. gibberifrons* will be reached first if catches of the various species remain in similar proportions to those calculated from Polish catches (i.e., the TAC of *N. gibberifrons* is limiting). The sustainable yield of the target species *C. gunnari* from a bottom trawl fishery therefore cannot be higher than six times the TAC for *N. gibberifrons* (8 800 tonnes at $\mathbf{F_{max}}$). If that fishery is targetting *C. gunnari*, the MSY from the fishery including all species would be about 13 000 tonnes under the most favourable circumstances, and would likely be much less given the uncertainties surrounding these estimates and the adverse effects of bottom trawling on benthos which may affect fish communities in the medium or long-term, e.g. by habitat destruction (see WG-FSA-90/24).

4.74 Given the low current yield ($\mathbf{F_{0.1}}$) and potential yield (MSY) of a bottom trawl fishery in Subarea 48.3, the uncertainties surrounding the ratios of the species in catches of mixed fishery and in stock size estimates and the potentially adverse effects of habitat destruction, the Working Group recommended that the prohibition of bottom trawling should remain in force.

Electrona carlsbergi (Subarea 48.3)
(Annex 6, paragraphs 7.129 to 7.150)

4.75 The Scientific Committee endorsed the recommendations of WG-FSA and made several additional observations which are reported below.

4.76 No information was available to either WG-FSA or the Scientific Committee on the design of midwater trawls used in the *E. carlsbergi* fishery although indications from CCAMLR-X/13 implied that the nets used were very large. Soviet scientists were asked to provide a description of trawls used in time for the next meeting of WG-FSA.

4.77 The assessments provided in Annex 6 were based largely on standing stock estimates from two surveys. Dr Shust noted that three such surveys had been undertaken and agreed to arrange for the detailed data to be supplied to the next meeting of WG-FSA.

4.78 It was noted that there are particular problems with assessing this species because part of the population is thought to occur north of the Polar Frontal Zone (PFZ) and hence outside the CCAMLR Convention Area. The degree to which there is mixing between areas on either side of the PFZ is unknown, as is the degree of aggregation and distribution of fishable concentrations within Subarea 48.3. To reduce the uncertainty over the estimates WG-FSA had based its analysis on two-year old fish because that is the age-class on which the fishery is based and its distribution was inferred from the surveys in Subarea 48.3.

4.79 In spite of an extremely limited database, WG-FSA had provided an assessement for *E. carlsbergi*. This was in response to a request from the Commission that the Scientific Committee estimate the potential yield of this species as a matter of urgency (CCAMLR-IX, paragraph 4.27).

Management Advice

4.80 It was noted that an $\mathbf{F_{0.1}}$ policy is not appropriate for this species since it would imply very low ratios of exploited to unexploited spawning stock biomass. The Working Group decided to use an **F**-value that would allow a ratio of 50% exploited to unexploited spawning stock biomass to determine TAC levels.

4.81 The Scientific Committee recommends to the Commission that a conservation measure in the form of a TAC should be set because of the very rapid expansion in the fishery.

4.82 Two options on which a TAC might be based were considered. The first was to set a TAC for the whole of Subarea 48.3 and the second for the Shag Rocks shelf area and its immediate vicinity.

4.83 The extreme uncertainty over the estimates that WG-FSA was able to provide caused some problems in deciding on a suitable TAC. The options are listed in Annex 6, Table 12. Bearing in mind the uncertainty in the estimates the Scientific Committee suggested that a TAC could be set in the range 245 000 to 398 000 tonnes for the whole of Subarea 48.3 and in the range 32 700 to 53 000 tonnes for the Shag Rocks shelf region.

4.84 Soviet experts feel that these values are only preliminary, since they do not fully take into account those factors mentioned in paragraph 4.71.

South Orkney Subarea (48.2)
(Annex 6, paragraphs 7.198 to 7.224)

4.85 Commercial fishing for finfish in this subarea has been prohibited under Conservation Measure 27/IX.

4.86 A standing stock survey undertaken by scientists from Spain indicated that there had been a slight increase in most species since the last survey. However, most species appear still to be well below their initial stock size.

4.87 No standing stock surveys are currently planned for this subarea during the forthcoming season.

Management Advice

4.88 WG-FSA had considered the implications of re-opening the fishery to bottom trawling, different scenarios were considered, none of which would result in a potential yield exceeding one to three thousand tonnes. Most Members recommended that the Conservation Measure 27/IX should be retained.

4.89 Dr Shust suggested that a limited fishery, in accordance with the calculated MSY should be allowed as it would provide valuable data on which to base future assessments.

4.90 Dr Everson noted that the provision of data from the commercial fishery had, in the past, been extremely poor and felt that it would be inappropriate to allow even a limited fishery in the circumstances. This view was supported by other Members.

Antarctic Peninsula Subarea (48.1)
(Annex 6, paragraphs 7.225 to 7.227)

4.91 The recommendations of the Working Group were endorsed by the Scientific Committee.

Management Advice

4.92 In view of the very limited new information available to re-assess the state of the stocks in the Peninsula region, the Scientific Committee recommended that the conservation measures in force for the 1990/91 season should be extended (Conservation Measure 27/IX).

Statistical Area 58

4.93 In 1990/91 fishing took place in Divisions 58.4.1 and 58.5.1. In addition, an exploratory longline fishing cruise took place in Division 58.5.1 in the deep sea zone (>500 m) off the Kerguelen Islands shelf. There was also a joint French/Soviet scientific cruise in the same area to investigate the *Notothenia rossii* stock.

Division 58.5.1 (Kerguelen)
(Annex 6, paragraphs 7.232 to 7.237 and 7.245 to 7.251)

4.94 The Working Group's advice with respect to *N. rossii*, *D. eleginoides* and *N. squamifrons* was endorsed by the Scientific Committee without comment.

Management Advice

4.95 The existing regulations in force which prohibit directed fishing on *N. rossii* should continue in order to protect the adult stock. Trends in the abundance of juvenile *N. rossii* need to continue to be monitored and research on prespawner and spawner biomass should be continued during the 1991/92 spawning season.

4.96 Previous biomass estimates and VPA analyses of the *N. squamifrons* stock reported to WG-FSA from 1988 to 1990 indicate that the stock size is very low. In the light of this, even a low level of catches could prevent recovery of the stocks of this species.

4.97 In view of the steadily declining CPUE of *D. eleginoides* in the western sector, the management advice in paragraph 166 of the Report of the 1989 Meeting of WG-FSA (SC-CAMLR-VIII, Annex 6) that the catch should not exceed 1 100 tonnes should be continued. This will need to be revised if the new fishing grounds identified this season are further exploited. Bearing in mind that this species is likely to become of increased importance in the Kerguelen fishery, further information on age, growth and other parameters is needed for stock assessment in the future.

Champsocephalus gunnari (Division 58.5.1)
(Annex 5, paragraphs 7.238 to 7.244)

4.98 The advice of the Working Group was endorsed by the Scientific Committee.

Management Advice

4.99 Given the steady decline in index of abundance at similar ages in successive cohorts, the catch in the 1991/92 season of 3 year old fish should be less than that on previous cohorts at the same age (i.e., less than 17 000 tonnes). The cohort analysis does not indicate a significant decrease in year class strength between cohorts. This analysis, however, makes assumptions about parameters such as **F** and **M**, and so is possibly a less reliable index than CPUE, which is a direct observation from a large body of data.

4.100 The cause of disappearance of age 3 fish still needs to be resolved during the 1991/92 season.

Division 58.5.2 (Heard Island)
(Annex 6, paragraph 7.253)

4.101 The Working Group noted that no fishery occurred in this area, no new data were available and therefore no advice could be given. This was endorsed by the Scientific Committee.

Management Advice

4.102 No fishery occurred in this area, and no other new data are available. No advice can be provided.

Subarea 58.4 (Annex 6, paragraphs 7.254 to 7.258)

4.103 The Scientific Committee endorsed the analyses of the Working Group.

Data Requirements (Annex 6, paragraphs 8.1 to 8.15)

4.104 The Scientific Committee endorsed the list of data requirements specified by the Working Group with the following additional comments. These are set out in Annex 6, Appendix E.

4.105 Dr D. Robertson (New Zealand) drew the Scientific Committee's attention to item 22 in Annex 6, Appendix E (information on levels of discarding and conversion rates from fish product to nominal weight) pointing out that errors in conversion factors could cause enormous errors in estimating the impact of fishing. Most Members agreed that information on discards and conversion rates should be obtained from the Observer Scheme currently under discussion (paragraphs 10.1 to 10.8).

4.106 Dr Shust indicated that the list of activities proposed under the Observation Scheme was continually growing and that information on discards and conversion rates would be yet another item in an already heavy workload. Dr Everson responded by suggesting that the proposed level of sampling was only a small addition to a list that had been agreed by all Members in recent years.

4.107 Dr Holt noted that the requirements for data agreed by the Scientific Committee had undergone little change in recent years and yet, generally speaking, there had been a very poor response to these requirements. He felt that the lack of data should be a factor that is taken into account by the Commission in determining management plans.

Workshop on Survey Design

4.108 Difficulties associated with survey design and the application of the 'swept area' method to survey data on demersal species that are patchily distributed have been a considerable problem to WG-FSA in the past. The problem was again in evidence in this year's assessments, for example, those of *C. gunnari* in Subarea 48.3 (Annex 6, paragraph 7.24) and Subarea 48.2 (Annex 6, paragraph 7.204). The Working Group at its meeting in 1990 and again in 1991 drew attention to the need for investigation of this problem as a matter of priority (SC-CAMLR-IX, Annex 5, paragraph 91). Because of the specialised and detailed examination required, this work cannot be done during a regular meeting of the WG-FSA.

4.109 The Working Group therefore recommended that a workshop on survey design and analyses of research vessel surveys be held in the 1991/92 intersessional period. The following terms of reference were identified for the workshop:

Theoretical Aspects	Practical Aspects (influencing theoretical aspects)
• Survey design for sampling different types of fish distribution • Two-phase surveys • Properties of estimators of biomass and definition of acceptable levels of CV	• Sources of errors in comparisons between surveys: - gear comparison - method of choosing location of trawl stations

Synthesis
• Survey design and how to carry out the survey • Cost effective allocation of sampling resources

4.110 Dr Kock offered to host such a workshop in Hamburg, Germany, preferably in June 1992 for eight working days. This offer was gratefully accepted.

Working Group Convener

4.111 Mr Østvedt, Chairman of the Scientific Committee, thanked Dr Kock for presenting the report of the Working Group to the Scientific Committee and noted that in accordance with his intention, stated last year, Dr Kock had relinquished the Convenership of the Working Group. Members were unanimous in their praise for the amount of work, dedication and attention to detail that he had afforded the Working Group over the five years during which he had been its Convener. Mr Østvedt presented Dr Kock with a pair of magic spectacles essential for rational assessment of fish stocks.

4.112 In responding, Dr Kock thanked all his colleagues in the Working Group for their excellent collaboration, often in the face of enormous difficulties, over the years. He also thanked the Scientific Committee for its support of the work of the group and the Secretariat for their excellent support and guidance over the years. He wished his successor well in the future. Finishing on a sadder note he noted that a recent newspaper article was based on reports by an Estonian observer on board Soviet fishing vessels. The information contained in the report sought to discredit most of the data which is submitted to CCAMLR with obvious implications for the Working Group. This is a problem, he noted, that is present in fisheries world-wide and not confined to CCAMLR.

4.113 Dr Everson was then elected Convener of WG-FSA.

OTHER RESOURCES

Squid

5.1 The Commission had agreed to a Standard Form for reporting fine-scale catch data for a squid fishery at its 1990 meeting (CCAMLR-X, paragraph 4.31). No Members reported undertaking any squid fishing within the Convention Area during the past year.

5.2 Dr Croxall introduced a report on research and related activities relevant to CCAMLR in 1990/91 (SC-CAMLR-X/BG/16). No further data relevant to stock assessment of the ommastrephid squid *Martialia hyadesi* in Subarea 48.3 were available since the review by Dr Rodhouse last year (SC-CAMLR-IX/BG/13). The best estimate of predator consumption of this squid remains at 330 000 tonnes (SC-CAMLR-IX, paragraphs 4.8 to 4.9).

5.3 The United Kingdom and Germany conducted joint research in the vicinity of South Georgia Island and at the Antarctic Polar Frontal Zone to the west of South Georgia in January/February 1991. Data were collected on the vertical distribution of cephalopods and nekton in this area. Also, octopus samples were taken during a demersal finfish survey around South Georgia.

5.4 Several papers on Southern Ocean squid were presented at an International Symposium on 'The Recent Advances in Cephalopod Fishery Biology' held by the International Cephalopod Advisory Council in Shimizu City, Japan from 17 to 19 July, 1991. The titles of papers and posters presented at this conference are contained in SC-CAMLR-X/BG/16.

5.5 Dr K. Kerry (Australia) presented preliminary results of a study by Lu and Williams (SC-CAMLR-X/BG/9) on the biology of cephalopods obtained from a survey in Prydz Bay during the Australian marine science program in January to March 1991. A total of 341 cephalopod specimens were obtained, comprising 256 squids and 85 octopods. The range of three squids (*Brachioteuthis sp.*, *Kondakovia longimana*, and *Mastigoteuthis psychrophila*) have now been confirmed to extend into the high latitudes of the Indian Ocean. *Psychroteuthis glacialis* was the only species common on the shelf, and was locally quite abundant.

Crabs

5.6 Details of a permit for an experimental crab fishery using pots planned to be conducted by the USA in 1991/92 in Statistical Area 48 were presented in SC-CAMLR-X/BG/20. The major areas of interest are the submarine canyons in Subareas 48.3 and 48.4.

5.7 Dr Holt highlighted the features of this permit including:

- a catch limit of 400 tonnes;

- a catch restriction of 80 tonnes from any one submarine canyon;

- only mature males are allowed to be taken with a minimum size limit to be set during the fishing operations by the observers on board at 10% carapace width larger than the minimum observed size-at-maturity for each species;

- a bait fish catch, totalling 60 tonnes, is allowed to be taken in pots in Subareas 48.3 and 48.4, consistent with conservation and management measures adopted by the Commission. Prohibited finfish species found in baitfish traps are to be returned to the water;

- continuously frozen Pacific herring is allowed as bait. The possibility of introducing exotic species was considered to be negligible provided the bait had been frozen for greater than three hours and placed in the traps frozen;

- two USA National Marine Fisheries Service observers are to be present on board to collect relevant biological and fisheries data; and

- data requirements, log books and reporting systems are specified in the permit.

5.8 The details of the permit were developed in light of the consideration last year of new and developing fisheries by the Scientific Committee (SC-CAMLR-IX, paragraph 8.7) and Commission (CCAMLR-IX, paragraphs 9.1 to 9.10). A delay in the establishment of the operation has meant that the fishery will not occur in the 1991/92 season. Dr Holt envisaged that a permit will be re-issued for the 1992/93 season.

5.9 The Scientific Committee agreed that, as crab fisheries can be assessed with conventional techniques, assessment of the experimental crab fishery should be carried out by WG-FSA.

ECOSYSTEM MONITORING AND MANAGEMENT

6.1 Dr J. Bengtson (USA), Convener, presented the report of the Fifth Meeting of the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP), held at Santa Cruz de Tenerife, Spain, 5 to 13 August 1991 (Annex 7). He summarised the main current and planned initiatives of WG-CEMP, which were then reviewed by the Scientific Committee.

6.2 The text below reports the endorsement of specific initiatives and the discussion of these and other points during the Scientific Committee's review of the report. The remainder of the WG-CEMP report was endorsed generally by the Scientific Committee.

6.3 The Scientific Committee thanked the Working Group for its work during the intersessional period and at the meeting, for which particular thanks for the quality of the facilities and working environment were expressed to the hosts.

6.4 It was noted that, despite the very active work of WG-CEMP, the attendance only comprised 19 scientists from 10 Members. The absence of scientists from Argentina, Brazil and Chile, which have active programs monitoring CEMP parameters and from France, Germany, New Zealand and South Africa, each of which has major programs of research directly relevant to CEMP, was particularly regretted.

Predator Monitoring

6.5 No proposals for new monitoring sites had been received. Deletion of the minke whale from the list of indicator species, pending a specific proposal for reinstatement including a definition of appropriate parameters for monitoring (Annex 7, paragraph 7.16) was approved by the Scientific Committee.

6.6 The gentoo penguin had been added to the list of selected CEMP indicator species in 1990; full details of the resulting modifications to the Standard Methods had been prepared intersessionally and were adopted subject to minor modifications. These have now been submitted to the Secretariat.

6.7 The Scientific Committee agreed that the Secretariat should produce and circulate addenda to the Standard Methods as necessary between full revisions of the complete document. In particular, the Secretariat would circulate annually, to all Members and all CEMP field program investigators, additions to and comments and advice on existing sites, species, parameters and procedures.

6.8 The Scientific Committee endorsed the suggestion that henceforth proposals for the inclusion of new species, parameters, or sites in CEMP would only be considered if submitted in writing with full supporting evidence by 30 June.

6.9 In order to help develop standard methods on activity budgets of seabirds and seals at sea - a potentially very important index - WG-CEMP has been developing proposals for a workshop on methods to monitor the at-sea behaviour of penguins and pinnipeds (Annex 7, paragraphs 4.45 to 4.47). This would consider various aspects of the topic and prepare specific recommendations for CEMP.

6.10 The Scientific Committee agreed there was a need for such a workshop and approved the overall terms of reference of the workshop:

(i) to review the current state of the art regarding the design and deployment techniques;

(ii) to review the available information on the potential instrument effects on animals;

(iii) to review the existing data collection, processing, and analytical methods and the compatibility of these within and between various devices and species;

(iv) to identify appropriate procedures for analysing the data sets of at-sea behaviour produced by time/depth recorders and satellite-linked instruments; and

(v) to assess whether indices of at-sea activity, suitably standardised for use in routine monitoring operations (e.g. as part of CEMP), can be derived from the data currently being collected on behaviour of seals and seabirds;

and those pertaining to the special component of the workshop which will address the needs of the CEMP Program:

(i) to advise on the most suitable indices for monitoring the at-sea behaviour of pinnipeds and penguins; and

(ii) to propose draft standard methods for collecting, processing, analysing and submitting summaries of such data to CCAMLR.

It noted that the workshop was unlikely to be held before late 1993 and approved the intersessional tasks (Annex 7, paragraph 4.52) for developing detailed implementation proposals.

6.11 Data submissions received on the standard reporting forms had generally been easy to understand. The Scientific Committee reiterated the request that Members should ensure that their data are reported on the current versions of the data submission forms; the Secretariat was recirculating these to all Members active in CEMP and can make additional sets available on request.

6.12 The WG-CEMP initiative on the processing and analysis of data on monitored predator parameters - to ensure standard indices for comparative purposes - was approved. This requires that the Secretariat:

(i) use specified procedures in calculating the indices;

(ii) prepare a document describing in detail the methods used (together with worked examples); and

(iii) prepare annually a summary of calculated indices and trends in indices.

Prey Monitoring

6.13 The Scientific Committee noted that substantial progress had been made through the excellent work of WG-Krill's Subgroup on Survey Design. The current situation, therefore, was that agreed survey designs are now available for:

(i) determining availability of krill within the foraging ranges of penguins and fur seals in respect of the parameters monitored by Standard Methods A5, A6, A7, C1 and C2;

(ii) investigating meso-scale distribution and abundance of krill (i.e., at scales directly relevant to CEMP work in Integrated Study Regions (ISR)); and

(iii) investigating interactions between macro-scale distribution and abundance of krill and major environmental factors in a fashion appropriate to helping WG-CEMP interpret predator and environmental monitoring data.

6.14 Members were encouraged to implement such surveys as soon as possible.

6.15 Concerning monitoring of prey species other than krill, Dr Shust stated that fine-scale catch and biological data on *Pleuragramma antarcticum* have been received by the Secretariat.

6.16 Dr Kock expressed concern about the appropriateness of using surveys of *Pleuragramma* larvae as an index of availability of this species in the Anvers Island area to predators which only consume post-larval and juvenile fish (Annex 7, paragraph 4.71). Clarification of this point would have to await the provision of detailed information on the United States long-term ecological research program at Palmer Station.

Environmental Monitoring

6.17 WG-CEMP had developed detailed proposals for acquiring data on characteristics of sea-ice within ISRs. In addition to site-based records it was regarded as essential to acquire data at a regional scale, which can only feasibly be done using remote sensing techniques.

6.18 The Secretariat had prepared a detailed review of this topic (WG-CEMP-91/9) suggesting a methodology for the acquisition of data on sea-ice distribution, involving use of JIC weekly ice charts and AVHRR data on sea-ice distribution in fully processed image form (Annex 7, paragraphs 4.77 to 4.91).

6.19 In order to evaluate further this approach, WG-CEMP recommended an initial pilot study be conducted for two CEMP sites over a two-month period. The aim of the study would be:

(i) to establish the mechanism of extraction of data on sea-ice distribution from satellite imagery;

(ii) to compute relevant parameters from these data, such as distance from the CEMP site to the ice edge, ice cover, etc.; and

(iii) to compute indices from these data for use by CEMP.

The Secretariat had been asked to prepare a detailed estimate of the expected costs for consideration by the Scientific Committee. This was presented in SC-CAMLR-X/7.

6.20 The Scientific Committee reviewed this proposal in detail, seeking to confirm that:

(i) the work required was not duplicating existing initiatives elsewhere; and

(ii) the procedure for data acquisition was the most efficient and cost effective (especially in regard to acquiring data from cloud-free images).

6.21 The Data Manager was able to reassure the Scientific Committee on these points. Accordingly, the Scientific Committee endorsed the pilot study and noted the budgetary implications for consideration later. Members noted that this was the first formal proposal by WG-CEMP for acquiring data from satellite imagery, a topic on which the Working Group had commenced detailed evaluation (initially through invited experts) in 1987. The concept of a pilot evaluation study was also commended.

Ecosystem Assessment

6.22 The Scientific Committee noted that WG-CEMP had now largely completed arranging the structure and content of the system for acquiring and reporting relevant data on predators to the Secretariat. Therefore it was now entering a phase of evaluation of these data and of the provision of advice to the Scientific Committee.

6.23 Data from monitoring predator parameters held by the Secretariat are summarised in SC-CAMLR-X/BG/2. The instructions for analysis and presentation of these data have already been specified.

6.24 In order to formulate advice based on integrated evaluation of predator, prey and environmental data, WG-CEMP is requesting that all available data on:

(i) fine-scale distribution of krill catches; and

(ii) estimates of krill biomass and fluxes and movements of krill at relevant spatial scales;

be made available annually, together with summaries of sea-ice and relevant environmental data.

The Scientific Committee endorsed these requests.

6.25 Members noted that the formulation of advice based on interactions between predator, prey and environment was a complicated topic. Relationships between environmental conditions, krill abundance, krill availability to predators and predator responses in terms of measured parameters and calculated indices would inevitably require careful evaluation. Notwithstanding this, the attention of WG-Krill was drawn to the comments in Annex 7, paragraphs 5.9 to 5.11 which reported interpretations of predator-prey-environment interactions relevant to the FIBEX estimates of krill biomass.

6.26 Particular attention was given to the implications of the recent analysis of the fine-scale krill catch data (WG-CEMP-91/25 and SC-CAMLR-X/BG/7) for Subareas 48.1 and 48.2.

6.27 WG-CEMP had noted the extensive overlap between the krill harvest and the foraging ranges of penguins and fur seals during their breeding seasons and the significant potential for competition that this creates.

6.28 Within Subarea 48.1 over 50% of the krill harvest has been taken from within the breeding season foraging ranges of these predators in each of the three years for which data are available. In some years the catch was almost half the requirements of predators at this time.

6.29 The Scientific Committee noted that a situation, whereby a substantial krill fishery consistently operates within the foraging range of krill-dependent predators at a critical time of year (when the predators have dependent offspring), had long been identified as a most serious concern and one where close and urgent attention needs to be given to appropriate management action (see also paragraph 3.53).

6.30 The Scientific Committee endorsed the calls of WG-CEMP for:

(i) urgent research into krill biomass, productivity and fluxes in Subarea 48.1 generally and in the area of the operation of the fishery in particular;

(ii) obtaining accurate estimates of the requirements of land-based predators in these areas;

(iii) noting the increased significance of existing CEMP activities in the area and of the need for enhanced activity wherever and whenever possible; and

(iv) noting the urgency of examining precautionary management procedures such as restrictions on timing and location of the krill fishery (see also paragraph 3.60).

6.31 The Scientific Committee also noted the importance of comparative analyses of the predator monitoring data from sites both very close to the main area of krill fishing and from sites more distant from the main krill fishing areas.

6.32 Furthermore, the Scientific Committee noted that, although in Subarea 48.2 the fishery had overlapped with penguin and fur seal foraging ranges to an extent comparable to the situation in Subarea 48.1 only in two of the four years for which data are available, nevertheless the magnitude of the krill fishery in Subarea 48.2 (65% of the total historic catch in Statistical Area 48) was such that interactions between fishery and predators there were potentially equally, if not more, serious.

6.33 Accordingly, the Scientific Committee recommended that similar priority attention be given to undertaking the same initiatives in Subarea 48.2 as outlined for Subarea 48.1 in paragraph 6.30 above. At present CEMP monitoring activities in Subarea 48.2 are restricted to the network sites at Signy Island and Laurie Island and are considerably less extensive than similar activities in Subarea 48.1. Thus the CEMP Program in Subarea 48.2 is considerably less extensive than in Subarea 48.1 and enhanced activity is particularly needed.

6.34 A precautionary management procedure to provide protection for land-based predator populations at the critical time of year when they are breeding would be to prevent fishing within the foraging range of these predators (0 to 50 km for penguins; 0 to 80-100 km for fur seals) at the time when they are rearing offspring (December through February). The Scientific Committee agreed with WG-CEMP (Annex 7, paragraph 5.20) that it was important to investigate, with Members conducting fishing in these areas and in conjunction with WG-Krill, implications and consequences of such potential conservation measures.

6.35 To start this process an *ad hoc* group held discussions and made the following report to the Scientific Committee.

6.36 Questions of relevance to developing the exact formulation of future conservation measures might include:

(i) Within Subareas 48.1 and 48.2, does the consistent concentration of the krill fishery in particular parts of these subareas, reflect that:

 (a) these are the only parts of these subareas where economic krill fishing is consistently possible;

 and/or

 (b) these are consistently the best parts of the subareas for krill fishing?

(ii) What is known about krill concentrations in the parts of these subareas further from land than 100 km?

(iii) How critical is the December through February period to the efficient operation of the krill fisheries in parts of Subareas 48.1 and 48.2 to which they are currently restricted?

(iv) How does the abundance and distribution of krill in areas, currently the focus of the fishery, change throughout the fishing season? In particular, what are the abundance and distribution characteristics immediately before and after the breeding seasons of penguins and fur seals (i.e., prior to December and after February)?

6.37 It was recognised that complete answers to these, and other similar, questions were unlikely to be readily available. However, this situation should not preclude further dialogue and attempts to answer these questions with the best information presently available.

6.38 Furthermore, it was noted that it was impossible now and likely to be so for a considerable time in the future, to define the functional relationships between krill abundance, krill availability to the fishery and to predators, and reproductive performance and survival of predators.

6.39 It was, therefore, impossible now to determine accurately the escapement rates from these krill fisheries which would be adequate to meet the reasonable needs of predators during their breeding seasons.

6.40 Last year, concern over the rapid development of fisheries on myctophids led the Scientific Committee to request Members to submit data to WG-CEMP on the significance of myctophids, and especially *E. carlsbergi*, as prey for predators in the Convention Area (SC-CAMLR-IX, paragraph 5.20).

6.41 To assist in this process the Secretariat had prepared a review of the published literature (WG-CEMP-91/17 revised as SC-CAMLR-X/BG/6).

6.42 The Scientific Committee noted the conclusions arising from the WG-CEMP evaluation of this excellent and comprehensive review. These were that:

(i) myctophids are important prey for a wide range of vertebrate predators; and

(ii) *E. carlsbergi* and *Electrona antarctica* are of particular importance and thus there is a need for more and better data on their quantitative importance in predator diets.

6.43 The Scientific Committee further noted that the report of WG-FSA (Annex 6, paragraph 7.130) indicates that the catches of *E. carlsbergi* in the two years for which fine-scale data are available (1988 and 1990) were concentrated close to Shag Rocks and South Georgia, well within the foraging ranges of the main myctophid-eating seabird predators (e.g. king penguins and white-chinned petrels) at a time of year when they have dependent offspring.

6.44 Dr Croxall noted that a paper on the food consumption of predators in Statistical Area 48 (WG-CEMP-90/31) estimated that seabird and seal predators consume about 250 000 tonnes of myctophids annually. The main prey species are *E. carlsbergi* and *Krefftichthys anderssoni*, which are frequently found together in diet samples from predators.

6.45 The Scientific Committee recognised that in Subarea 48.3 a situation exists where there is a real likelihood of significant potential competition between the myctophid fishery and species significantly dependent on myctophids.

6.46 Furthermore, the tripling of the myctophid catch in this area in the last year raises additional concerns about the unregulated continuation of a fishery for which there are significant risks of competition between predators and fishery.

6.47 In response to questions concerning the identity of the myctophids caught by the fishery, Dr Shust stated that in the early years of experimental fishery on myctophids it was established that the catches were mainly *E. carlsbergi*, although *K. anderssoni* was present in small quantities.

6.48 Confusion existed as to whether fishing for myctophids had been undertaken in Subarea 48.2 (see paragraph 4.17). If this were the case it was pointed out that the target species was most likely to be *E. carlsbergi* and it would therefore represent the start of a new fishery. Dr Shust undertook to investigate further.

6.49 The Scientific Committee noted progress in evaluating the use of GIS and VS systems for use in CCAMLR data management and analysis initiatives. It was particularly encouraging to see the plans for collaborative pilot studies involving specific research tasks. Members stressed the importance of using these systems to analyse high quality data collected to address well-defined hypothesis.

6.50 Dr Croxall reported the existence of the Antarctica Digital Database project (SC-CAMLR-X/BG/17), a multi-national program coordinated by the SCAR Working Group on Geodesy and Geographic Information, developing a digital topographic database of Antarctica. To date the project has successfully validated and incorporated data on coastline, ice-fronts and inland rock and glacial features.

6.51 It was noted that the second phase, which might include the incorporation of bathymetric data, could be of particular interest to CCAMLR. Furthermore, the project as a whole had numerous aspects of potential relevance to CCAMLR.

6.52 The Scientific Committee agreed that the Data Manager should contact the manager of the Antarctica Digital Database Project to discuss existing and potential developments of mutual interest.

Prey Requirements for Krill Predators

6.53 The Scientific Committee noted the considerable progress towards estimating krill consumption by predators in Integrated Study Regions and the potential relevance of these towards assessing interactions in the main areas of operation of the krill fishery. They endorsed the proposed program of future work (Annex 7, paragraphs 6.8 to 6.24).

6.54 It was noted that there had been little progress towards assessing escapement levels adequate to predator needs and WG-CEMP was asked to provide at least preliminary advice at its next meeting.

6.55 WG-FSA had suggested that krill predation by fish might be incorporated into the WG-CEMP initiatives outlined in paragraph 6.53 (Annex 6, paragraph 5.12).

6.56 It was felt that before WG-FSA commenced work on this topic (e.g. Annex 6, paragraph 5.13) it would be helpful to discuss the whole matter with WG-CEMP in order to clarify the precise objectives of such work.

6.57 WG-FSA had also noted that CEMP data and advice might be valuable in interpreting changes in abundance and distribution of certain fish stocks, especially *C. gunnari*. WG-CEMP will consult with WG-FSA to ensure that the latter received appropriate documents and advice.

Other Matters

Collaboration and Awareness of CEMP

6.58 Publication by CCAMLR of the brochure describing the aims of CEMP was a welcome development in publicising the activities of the program.

6.59 The Scientific Committee endorsed the efforts to improve participation in the activities of CEMP (Annex 7, paragraph 7.12). Members noted that it was important to correct some apparently widespread misconceptions that the CEMP Program was restricted to krill-related matters in a few geographically restricted areas.

6.60 Collaborative work would also be enhanced by closer collaboration between the Working Groups of the Scientific Committee; in particular, broader participation of members of one Working Group in the work of others was required. This would be assisted by holding the meetings in close conjunction.

CCAMLR/IWC Workshop on the Feeding Ecology of Southern Baleen Whales

6.61 The Scientific Committee noted the current status of this initiative (Annex 7, paragraph 7.13 to 7.16). It agreed that because the original reasons for interest in this Workshop no longer apply, it would be inappropriate for CCAMLR to continue as a co-sponsor of current IWC initiatives for a Workshop on the Feeding Ecology of Southern Baleen Whales.

6.62 However, it reiterated CCAMLR's interest in this topic and welcomed further consultations when IWC had produced some detailed proposals.

6.63 The Executive Secretary was asked to inform the Secretary of IWC and Dr Reilly (the new IWC Convener of any future Workshop on Feeding Ecology of Southern Baleen Whales) of the CCAMLR position.

CCAMLR System of Observation

6.64 The Scientific Committee noted the comments of WG-CEMP pertaining to this topic, which had acknowledged the importance of such a system in ensuring that reliable biological data were collected from commercial operations (Annex 7, paragraphs 7.25 to 7.31).

New and Developing Fisheries

6.65 The Scientific Committee endorsed the points agreed by WG-CEMP in its discussion of new and developing fisheries (Annex 7, paragraphs 7.32 to 7.36). The Scientific Committee noted that WG-CEMP agreed that predictive management was the logical basis for the implementation of Article II. It was clarified that this applied to the establishment of new fisheries, and that as a fishery progressed, a transition to some form of feedback management would be the preferred approach.

Future Work of WG-CEMP

6.66 The Scientific Committee endorsed the program of future work (Annex 7, paragraph 9.1). It was felt that greater emphasis should be placed on management issues, including those which would arise out of the formulation of advice to the Scientific Committee (Annex 7, paragraph 9.1(viii) and (ix)). WG-CEMP was asked to give this attention during the intersessional period.

6.67 In reviewing the program of work as outlined, the Scientific Committee noted that there was no explicit reference to the need to give priority attention to the topic of coincidence of krill catches and predator consumption in restricted areas at critical times of year. Members were therefore requested to consider the implications of the situation as a matter of priority. WG-CEMP was asked to collaborate with WG-Krill in work on this topic.

6.68 It also noted that the prompt submission of due and outstanding data was essential for the success of the meeting and urged Members to make this a high priority.

Management Plans for CEMP Sites

6.69 At its last meeting, the Commission adopted Conservation Measure 18/IX to afford protection to CEMP sites, scientific investigations and Antarctic marine living resources therein (CCAMLR-IX, paragraph 6.5). This conservation measure requires the provision of a management plan for any CEMP site for which protection is desired and its consideration by WG-CEMP, Scientific Committee and Commission.

6.70 The United States had drafted and submitted to the Secretariat a draft management plan for protection of the CEMP site at Seal Islands (WG-CEMP-91/7) following the procedure outlined in Conservation Measure 18/IX. This document was distributed to Members the required three months in advance of the WG-CEMP meeting. The Working Group agreed that, with minor revisions, the proposal adequately provided the information required, and should be passed along to the Scientific Committee.

6.71 The Scientific Committee reviewed the revised management plan for the Seal Islands (SC-CAMLR-X/11), which incorporated the suggestions of WG-CEMP.

6.72 The Scientific Committee approved the revised draft management plan and recommended that the Commission should adopt this management plan and take appropriate action to implement its observance.

6.73 Dr Marín noted that Chile had forwarded a draft management plan for Cape Shirreff, Livingston Island, South Shetland Islands to the Secretariat but that this had arrived late for consideration by WG-CEMP. It would therefore be considered at the next meeting of this Working Group.

Advice to the Commission

6.74 The Commission is requested to encourage Members with active programs of research directly and indirectly contributing to CEMP, to participate in the meetings of WG-CEMP (paragraphs 6.4, 6.11 and 6.68).

6.75 Most Members recognised the potentially serious situation of substantial krill fisheries consistently located near seal and seabird colonies, (paragraphs 6.28 and 6.31), the current lack of data adequate for any precise assessment of the magnitude and consequences of these problems (paragraph 6.30(i) and (ii), paragraph 6.36) and the advice on precautionary management procedures available to mitigate these problems (paragraph 6.34). Most Members felt that it was highly desirable to implement now a conservation measure to provide adequate protection for predators in appropriate parts of Subareas 48.1 and 48.2 until such time that sufficient data are available to assess the situation more precisely.

6.76 Dr Naganobu felt that there is no scientific evidence that the fishery is having any marked effect on seal and penguin colonies.

6.77 In view of concerns last year over the development of the *E. carlsbergi* fishery, WG-CEMP had reviewed data on the significance of myctophids and especially *E. carlsbergi* as food of predators in the Convention Area. The Scientific Committee considered this review in the light of the current data on the *E. carlsbergi* fishery (paragraph 6.42 to 6.44) and concluded that there is likelihood of significant potential competition between the myctophid fishery and species significantly dependent on myctophids (paragraph 6.42). The Commission's attention is drawn to this advice, which may be relevant to the formulation of conservation measures.

6.78 The Scientific Committee draws the Commission's attention to progress made by WG-CEMP in preparing estimates of krill consumption by seabirds and seals in Integrated Study Regions (Annex 7, paragraphs 6.8 to 6.24). The Commission was advised that detailed proposals for future activities had been prepared and approved by the Scientific Committee (paragraph 6.53).

6.79 The Scientific Committee recommended that a meeting of WG-CEMP be held during 1992 (paragraph 6.66).

6.80 The Scientific Committee approved WG-CEMP's draft management plan for the CEMP site at Seal Islands, South Shetland Islands, and forwarded it for consideration by the Commission (paragraph 6.72).

MARINE MAMMAL AND BIRD POPULATIONS

Status and Trends of Populations

7.1 The SCAR Group of Specialists on Seals and the SCAR Bird Biology Subcommittee in 1988 provided CCAMLR with a review of the status and trends in Antarctic seabird and pinniped populations. It is intended that the results of an updated review will be presented to the Scientific Committee in 1992.

7.2 As requested by the Scientific Committee at its 1990 meeting, the Secretariat has provided the SCAR groups with copies of the previous summaries and instructions regarding the formats in which the updated population review should be presented to CCAMLR.

7.3 The Scientific Committee noted that the IWC Scientific Committee will be undertaking a comprehensive review of baleen whales in the Southern Hemisphere, to be completed in 1993.

Workshop on Southern Elephant Seals

7.4 A workshop on southern elephant seals was held in Monterey, California, from 22 to 23 May 1991. The workshop received financial support from CCAMLR and SCAR. Dr Bengtson summarised the workshop report (SC-CAMLR-X/BG/3).

7.5 A review of stock abundance and trends indicated that southern elephant seal populations are declining in the Indian and Pacific Ocean sectors of the Antarctic. Simulations based on recent demographic rates suggest that the South Georgia stock may also be declining, but there is no direct evidence of such a decline based on census data.

7.6 The workshop provided an opportunity to draw together the most recent and complete data on population trends, life history aspects, and demographic parameters. These were summarised in Tables 1 and 2 of the workshop report (SC-CAMLR-X/BG/3).

7.7 Regarding the potential causes of past and present population trends, various factors were identified as possibly being responsible for causing declining populations. Although it was agreed that several of these were not likely to be relevant, other factors deserve further investigation to determine to what extent they may be involved in population declines. The workshop concluded that at present, it is not possible to identify with confidence the factor or factors (e.g. predation, disease, ecological or climatic change, competition for prey with commercial fisheries) that have caused southern elephant seal populations to decrease so precipitously over the past 50 years.

7.8 Concerning possible fisheries interactions, the workshop concluded that there is as yet no evidence to suggest that finfish fisheries activities in the Convention Area have played any causal role in the population decrease of southern elephant seals.

7.9 The Scientific Committee agreed that the workshop had succeeded in fulfilling its terms of reference and producing a very useful report. Although no conclusive evidence was found pertaining to the causes of the population declines, the workshop identified several areas of priority research for future investigations. It is expected that the results from these studies will contribute significantly to the process of stock assessment and interpreting changes in stock size of southern elephant seals in the context of ecosystem processes.

Pack Ice Seal Censuses

7.10 Survey data from the early 1980s have raised questions about the possibility that crabeater seal population abundance may have declined dramatically during the 1970s. SCAR has identified the urgent need for additional surveys of pack ice seals in order to help answer these questions, and has called on national programs to undertake such surveys as a matter of priority.

7.11 Similarly, over the past several years the Scientific Committee has urged Members' national programs to conduct censuses of pack ice seals when opportunities arise to stage aerial surveys from icebreakers (SC-CAMLR-VII, paragraph 6.7; SC-CAMLR-IX, paragraph 6.4).

7.12 In response to these requests, several Members indicated that they are taking steps to initiate surveys of crabeater and other pack ice seals. South Africa has committed funding and ship time to conduct annual surveys in each of the next three to five years in the pack ice zone adjacent to Queen Maud Land; these surveys will complement focussed studies on Ross seals near the Filchner Ice Shelf. The United States Delegation reported that the US hopes to conduct aerial censuses of pack ice seals from an icebreaker during the 1992/93 austral summer. Japan indicated that they are seeking a possibility of initiating censuses of pack ice seals in the near future; these studies would be conducted together with studies utilizing satellite technology.

ASSESSMENT OF INCIDENTAL MORTALITY

Incidental Mortality in Longline Fisheries

8.1 The issue of seabird mortality associated with the longline fishery for *D. eleginoides* was discussed in detail at the Scientific Committee's 1990 meeting (SC-CAMLR-IX, paragraphs 7.3 to 7.14). These discussions led to the Commission adopting a conservation measure (Conservation Measure 26/IX) requiring the reporting of seabird entanglements and mortality in the longline fishery.

8.2 The Commission also adopted recommendations of the Scientific Committee on information needed from the fisheries which would help determine the best method of reducing the incidental mortality of seabirds and which required modifications of longline fishing techniques, based on those which, in other longline fisheries, have been successful in reducing incidental mortality (CCAMLR-IX, paragraph 5.4(iii)).

8.3 In 1990, it was proposed that these latter requirements and recommendations be put into effect through a conservation measure, but some Members felt that the technical detail of the methods needed further examination by national experts. The Commission agreed that the formal adoption of such a conservation measure would be considered at its 1992 meeting.

8.4 Dr G. Duhamel (France) has summarised a paper describing incidental mortality observed during an experimental longline fishery trip carried out in 1991 around the Kerguelen Islands, Division 58.5.1 (SC-CAMLR-X/BG/14). It was noted that three species of seabirds had been attracted by bait, caught on the hooks, and drowned (black-browed albatross, *Diomedea melanophris*; giant petrels, *Macronectes* spp.; and white-chinned petrel, *Procellaria aequinoctialis*).

8.5 Dr Duhamel stated his concern that this mortality was not limited to the Kerguelen Islands where a longline fishery has not been developed. It was noted that such mortality can be avoided very easily by modifying fishing gear and the method of its deployment. He emphasised that it was necessary to reduce or eliminate seabird mortality caused by longline fisheries in the Convention Area.

8.6 It was noted that the longline fishing vessels referred to in SC-CAMLR-X/BG/14, operating near Kerguelen, were also known to have worked in the South Georgia area.

8.7 The ASOC observer drew the Scientific Committee's attention to a report (CCAMLR-X/BG/18) which described three days of observations of the activities of two longlining vessels near Shag Rocks (in Subarea 48.3). Incidental mortality of one black-browed albatross, an unidentified albatross, and four smaller seabirds (perhaps white-chinned petrels) was observed during daylight operations of two longline vessels. This catch rate was similar to that reported in SC-CAMLR-X/BG/14. Tori poles and associated recommended precautions were not being used during these observations and it appears unlikely that they were in use at all.

8.8 A verbal report by Mr Brukhis on activities relating to incidental mortality associated with the Soviet longline fishery during the past year was presented. It was reported that incidental mortality does occur in the South Georgia longline fishery. A total of 12 seabirds was reported to have been caught during these operations.

8.9 However, this total did not include the observations reported in SC-CAMLR-X/BG/18, no information on the species involved was recorded (see CCAMLR-V, paragraph 42) nor were data on the incidence of mortality of birds entangled but not brought on board available.

8.10 The Soviet Delegation expressed its view that technical means to reduce incidental seabird mortality currently are not available. A variety of attempts (e.g. technical means as well as light and noise makers) had been made to reduce incidental mortality of seabirds but these methods had not been successful. There are plans to continue evaluations of other possible means of reducing incidental mortality.

8.11 The Soviet Delegation noted that the use of 'tori' poles was thought unlikely to be effective. Although tori poles work in temperate waters to frighten seabirds near longliners, thereby reducing incidental mortality, doubt was expressed that such devices would be effective within the Convention Area.

8.12 In response to a query concerning whether the invitation made last year (SC-CAMLR-IX, paragraph 7.11) to have observers work aboard the Soviet longline fishing vessels was still open, the Soviet Delegation confirmed that this invitation was still in effect.

8.13 The Scientific Committee welcomed the verbal report of the Soviet Delegation, and noted that it looks forward to receiving a written report on this topic prior to its 1992 meeting.

8.14 Dr Croxall expressed his delegation's deep concern over the incidental mortality of seabirds associated with the longline fishery in the Convention Area. He reviewed the information which now indicate that this mortality is a significant problem:

(i) bird bands, recovered from wandering albatrosses, *Diomedea exulans*, killed in the South Georgia longline fishery in both 1989/90 and 1990/91 and reported to the Russian bird banding office, demonstrate mortality is occurring. These data reveal previous statements, denying that incidental mortality was occurring (SC-CAMLR-IX, paragraph 7.7), to be incorrect;

(ii) the verbal comments of the Soviet Delegation (paragraph 8.8) at the present meeting confirm that seabird incidental mortality is a regular occurrence; and

(iii) independent direct observations of longline fishing activities and incidental seabird catch rates as described in CCAMLR-X/BG/18, indicate a substantial incidental mortality in Subarea 48.3. During the 1990/91 season, it is estimated that there were approximately 580 ship days of longline fishing. At the prevailing catch rate a total of 1 700 birds would have been killed (about 580 of which would be albatrosses; the remainder smaller petrels).

8.15 The Soviet Delegation expressed its doubts on the abovementioned calculations (paragraph 8.14), and attention was drawn to the lack of any reliable data for the conclusions contained in paragraphs 8.14(i) and (iii).

8.16 The United Kingdom Delegation noted that the data presented in paragraph 8.14(i) and CCAMLR-X/BG/18 are the only reliable quantitative data on this topic available for this fishery in Subarea 48.3.

8.17 Dr Croxall noted that such rates of mortality are comparable to those observed in the tuna longline fishery. This fishery had been the single most important known cause of mortality in wandering albatrosses (accounting for about half the annual adult mortality) and the major cause of the population decline of this species in the Convention Area in general and at South Georgia in particular (SC-CAMLR-X/BG/8).

8.18 That an additional cause of mortality, of potentially equal magnitude, is being allowed to occur immediately adjacent to the species' only breeding site in Subarea 48.3 (and thereby particularly affecting breeding birds with dependent offspring), is a matter of the gravest concern.

8.19 Furthermore, the existing decline of wandering albatross populations at South Georgia is currently irreversible in the next two to three decades if the causal factors continue operating. This places an obligation on the Commission, as indicated in Article II of the Convention, to take all measures possible to rectify this situation.

8.20 In response to assertions by the Soviet Union that the number of birds observed to be caught were few, Dr Kerry noted that although the catch rate of individual birds per number of hooks fished seems small, the total impact of the fishery is large because such a large number of hooks is deployed during the fishing season. The actual mortality that results for seabird populations is likely to be substantial.

8.21 Furthermore, typically in such fisheries, many birds are entangled and drowned without being brought aboard vessels. Reports of birds actually caught will therefore be substantial underestimates of actual mortality.

8.22 Dr Kerry expressed doubts about whether, and if so, how thoroughly, the use and effectiveness of tori poles in the Soviet longline fishery in Antarctic waters had been tested. He noted that the experience from similar areas outside but adjacent to the Convention Area strongly suggested that tori poles would be very effective in reducing seabird incidental mortality, since sea conditions and the avian species following the vessels would be the same.

8.23 The Scientific Committee noted that despite the Commission's request in 1990 that detailed information on longlining be provided, such data have not been provided. Furthermore, incidental mortality has been inaccurately reported in 1990/91 (a minimum underestimate of 33%) and no reports had been made in previous years in which mortality was known to have occurred. In addition, it was evident that at least three of the four agreed recommendations, specified by the Commission in 1990 to be followed until such time as the data required under (i) and (ii) of paragraph 5.4 (CCAMLR-IX) were made available, were not followed during the past year:

(i) longlines were deployed during daylight;
(ii) tori poles were apparently not used; and
(iii) baits were sinking very slowly.

Advice to the Commission

8.24 Most delegations recommended that last year's draft conservation measure (CCAMLR-IX, Annex 6) be implemented and that all other relevant recommendations should remain in force.

8.25 In addition, given the following circumstances, the Scientific Committee agreed that the Commission should take further steps to protect seabirds from incidental mortality from the longline fishery:

(i) there is significant seabird mortality occurring in association with the longline fishery in the Convention Area;

(ii) the degree to which it is possible to modify longlining gear or methods to reduce incidental mortality is uncertain;

(iii) the information specified by the Commission (CCAMLR-IX, paragraph 5.4(ii)) to assist in determining the best methods of reducing seabird incidental mortality has not been provided;

(iv) the modifications to longline fishing techniques recommended by the Commission (CCAMLR-IX, paragraph 5.4(iii)) were not followed; and

(v) reporting of incidental mortality has been misleading and inaccurate.

8.26 The Scientific Committee agreed that the only two realistic options (which are not mutually exclusive) for the Commission to consider in adopting additional measures to reduce seabird incidental mortality associated with longline fisheries in the Convention Area are:

(i) to require improved modifications of gear or fishing methods;
and/ or
(ii) to restrict the operation of the fishery through some combination of catch and/or effort limitation.

Incidental Mortality in Trawl Fisheries

8.27 During the Scientific Committee's 1990 meeting, the New Zealand Delegation called attention to instances of seabird mortality occurring in Soviet trawl fisheries in New Zealand waters. Members were reminded that a similar problem had been reported for the trawl fishery operating around the Kerguelen Islands, and were requested to investigate this matter further and to report to the 1991 meeting.

8.28 Dr Robertson summarised a paper describing the incidental catch of seabirds in the Soviet squid trawl fishery around the Auckland Island shelf (SC-CAMLR-X/BG/4). There is significant mortality with at least one species of seabird (white-capped albatross, *Diomedea cauta steadi*), and it is due to colliding with and becoming entangled in net monitor cables (electrical control cables).

8.29 Actual mortality is underestimated. This is because some birds, after becoming entangled with the cable, are then swept off between the sea surface and the net. These lost birds are obviously not counted by observers when the net is retrieved.

8.30 Although the observations described in the New Zealand paper were from outside of Antarctic waters, net monitor cables are used in the fishery on krill, *C. gunnari* and *E. carlsbergi* in the Convention Area. Therefore, it is reasonable to conclude that similar mortality is occurring.

8.31 Bird mortality associated with the use of the netsonde cable during the fishery for *C. gunnari* was also noted on the Kerguelen Shelf (SC-CAMLR-X/BG/14).

8.32 The rapid expansion of the *Electrona* fishery (tripled in the past year) highlights the importance of this issue. The fishery operating in the vicinity of Shag Rocks is very near the highest density of nesting albatrosses in the Convention Area.

8.33 WG-FSA addressed this problem (Annex 6, paragraphs 5.7 to 5.10) and agreed that wherever possible in commercial fisheries the use of netsonde cables should be phased out.

8.34 It is technically feasible to phase out netsonde monitor cables because new technology is available in which the netsounders operate by an acoustic link to the ship. French researchers reported that once the net monitor cables were removed from nets, mortality of seabirds ended (SC-CAMLR-X/BG/14).

Management Advice

8.35 The Scientific Committee recommends to the Commission that the use of net monitor cables be phased out as rapidly as possible. During this phase out period, interim measures should be encouraged to decrease seabird mortality (e.g. rig net monitor cables at the stern of the ship and out of the flight path of birds).

8.36 The Representative of the USSR noted that at present the USSR was not ready to suspend the use of net monitor cables. He stated that because various fish species are fished by different methods, different procedures should be used with different species to reduce incidental mortality.

8.37 The Scientific Committee emphasized that the recommendation to phase out net monitor cables does not apply to research vessels, as there have been no reports of incidental mortality associated with the use of these cables on research vessels.

8.38 Research on additional trawl gear modification to reduce incidental mortality should be undertaken during the phase-out period.

Impact of Bottom Trawling

8.39 The Australian Delegation presented a study concerning the effects of bottom trawling on benthic communities (SC-CAMLR-X/BG/19). A research trawl was used for 14, 30-minute hauls on a variety of different bottom habitats. The most common benthic catch except for fishes were sponges and ascidians. Catches of fish only exceeded 50 kg at two stations while the weight of sponges exceeded 50 kg at 50% of the stations.

8.40 Because the research trawls in this study were shorter in duration than commercial trawls and the action of the doors and ground gear was not examined, it is expected that commercial trawls would cause considerably more disturbance of benthic communities.

8.41 Given the potentially severe adverse impacts of repeated bottom trawling in certain areas, it was suggested that selected areas might be set aside or closed periodically to allow recovery of benthos in these areas.

8.42 Dr Shust commented that benthic communities at the 400 to 700 m depth range are usually stable, and affected by coastal currents. Furthermore, it is unknown whether commercially harvestable fish are found in such areas.

Marine Debris

8.43 Members' reports on the assessment and avoidance of incidental mortality in the Convention Area had been received from Australia (CCAMLR-X/BG/8), Brazil (CCAMLR-X/BG/13), Korea (CCAMLR-X/BG/19), the United Kingdom (CCAMLR-X/BG/5 and CCAMLR-X/BG/16), and the United States (CCAMLR-X/BG/7).

8.44 Dr Croxall drew the Scientific Committee's attention to CCAMLR-X/BG/5, which outlined the results of an annual survey of fur seal entanglement at Bird Island, South Georgia. He noted that the incidence of observed entanglement had declined by 30% over the previous year (with a 40% decline during the year before that). The observed rate of fur seal entanglement at Bird Island has dropped approximately 80% over the past two years, and this may reflect the Commission's efforts to stop dumping debris at sea.

8.45 The UK paper pertaining to beach litter surveys at Signy Island was introduced as a possible model for beach surveys conducted by other Members (SC-CAMLR-X/BG/16). Members were encouraged to consider whether the approach used in this paper would be appropriate for reporting the results of their surveys of marine debris.

8.46 Dr Kerry stated that Australian surveys of marine debris had resulted in finding floats, oil, and other debris (SC-CAMLR-X/BG/8). He noted that an over-wintering party at Heard Island intended to conduct surveys of entangled fur seals throughout the winter.

8.47 The Korean Delegation noted that Korean fishermen have been asked to report sightings and encounters with marine debris during the time that they are in the Convention Area. Annual surveys of marine debris will be continued in the future.

8.48 The US Delegation informed the Scientific Committee that the US and Chile were planning to undertake a cooperative census of pinnipeds and seabirds in the South Shetland Islands during the 1991/92 austral summer. During this survey, records will be kept of marine debris and entangled wildlife encountered. The results of this survey will be reported at the Scientific Committee's next meeting.

8.49 Dr Holt reviewed a paper describing the incidence of plastic in the diets of Antarctic birds (SC-CAMLR-X/BG/18). The occurrence of plastic in the diets of Antarctic seabirds is relatively low compared to other oceans. This suggests that there is relatively little plastic floating on the surface of ocean waters south of the Antarctic Convergence. Data were collected between 1976 and 1988, and included diet information for 1 200 seabirds of 23 species.

Driftnet Fisheries

8.50 It was recalled that at its 1990 meeting, the Commission adopted Resolution 7/IX, which declared there will be no expansion of large-scale pelagic driftnet fishing into the Convention Area (CCAMLR-IX, paragraph 5.15).

8.51 At the present meeting, Members reported that they were not aware of any information or plans regarding the future use of driftnets in the Convention Area.

General Matters

8.52 Recognising that issues pertaining to incidental mortality assessment and marine debris are considered under both the agenda of the Scientific Committee and the Commission, the Scientific Committee suggested that future discussions of these topics be structured as follows: the Scientific Committee should consider primarily evidence of impacts on biota, whereas the Commission should consider general issues concerning the incidence of debris, dumping, pollution, etc.

DEVELOPMENT OF APPROACHES TO CONSERVATION

New Fisheries

9.1 During the intersessional period, the Secretariat communicated with Members and prepared a discussion paper on appropriate definitions for 'new and developing' fisheries (CCAMLR-X/6) to aid the development of a conservation measure on new and developing fisheries being considered by the Commission (CCAMLR-IX, paragraph 9.9). This paper was distributed to the Working Groups of the Scientific Committee for comments. The sections of the respective reports pertaining to this discussion are paragraphs 7.5 to 7.9 for WG-Krill (Annex 5), 5.1 to 5.6 for WG-FSA (Annex 6), 7.32 to 7.36 for WG-CEMP (Annex 7).

9.2 The Scientific Committee endorsed the view of WG-Krill that the definition for a New Fishery provided by the Secretariat (CCAMLR-X/6, paragraph 15) needed to be expanded to reflect the types of information needed for assessment purposes indicated in last year's report of WG-FSA (SC-CAMLR-IX, Annex 5, paragraph 289) and reiterated by WG-FSA as being a valid summary of the information required for assessing initial catch levels in a new fishery (Annex 6, paragraphs 5.2 to 5.4).

9.3 Based on a revision of the definition developed by WG-FSA that takes these concerns into account (Annex 6, paragraph 5.6), the Scientific Committee agreed to a definition for a new fishery on any marine living resource in the Convention Area such that:

> A new fishery, for the purposes of this conservation measure, is a fishery on a species using a particular fishing method in a statistical subarea for which:
>
> (i) information on distribution, abundance, demography, potential yield and stock identity from comprehensive research/surveys or exploratory fishing have not been submitted to CCAMLR;
> or
> (ii) catch and effort data have never been submitted to CCAMLR;
> or
> (iii) catch and effort data from the two most recent seasons in which fishing occurred have not been submitted to CCAMLR.

9.4 It was emphasised that the last criterion in this definition should exclude from consideration, seasons in which fishing for the species concerned was prohibited by conservation measures established by the Commission.

9.5 In this context, the Scientific Committee agreed that the crab fishery being established by the USA would be considered a new fishery. Similarly, there was agreement that existing krill fisheries would not be viewed as new fisheries.

9.6 In further discussion on approaches to new fisheries, the Scientific Committee endorsed the recommendation of WG-CEMP (Annex 7, paragraph 7.35) that evidence or arguments that the proposed fishery will not adversely affect dependent and associated species should be presented for consideration by the Scientific Committee and its Working Groups.

General

9.7 The interaction between Working Groups to provide sound management advice to the Commission on approaches to conservation in all fisheries is considered to be a high priority for the Scientific Committee. Meetings between Conveners as well as overlapping or combined meetings of the Working Groups would facilitate this work. As a focus for this work, the Scientific Committee endorsed the discussion on this subject by WG-Krill as a basis for developing general approaches to conservation (Annex 7, paragraphs 6.4 to 6.30) and agreed that feedback management procedures should be the aim for all fisheries.

9.8 In terms of general management policy, the assessment of the myctophid fishery by WG-FSA (Annex 6, paragraphs 7.136 to 7.142 and 7.144) revealed that the application of the Commission's policy of using $\mathbf{F_{0.1}}$ to determine fishing mortality is not applicable in this type of fishery. The Scientific Committee endorsed the approach used by WG-FSA in assessing a TAC for the myctophid fishery which took into account escapement of the spawning stock biomass.

9.9 The Convener of WG-CEMP, Dr Bengtson, indicated that the addition of Ecosystem Assessment to the Working Group's agenda reflects movement into a new phase. Over the past several years excellent progress has been made in identifying CEMP priorities, developing methodological protocols, and specifying data submission formats. Now that the Secretariat is receiving and archiving Members' CEMP data, the emphasis of the Working Group is shifting away from solely program development toward data evaluation and the formulation of advice to the Scientific Committee. It was felt that this advice could provide significant assistance to the Commission in its deliberations on fisheries management.

CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION

10.1 At its Ninth Meeting, the Commission directed the CCAMLR Secretariat to produce a draft paper on scientific observation for circulation to Members for comment in the intersessional period and consideration at CCAMLR-X (CCAMLR-IX, paragraph 11.10). The draft paper (CCAMLR-X/7) was considered by the Scientific Committee. As part of its task the Secretariat also produced a proposal for the formats for observations by observers on commercial fishing vessels in the CCAMLR Convention Area. The two papers were considered by intersessional meetings of the Scientific Committee's Working Groups and changes suggested to the observation formats by the Working Groups were taken into account in the paper considered by the Scientific Committee (SC-CAMLR-X/8).

10.2 The Scientific Committee recommended that the Commission adopt the observation formats as agreed by the Working Groups, subject to amendment as necessary on the basis of further review, and that these be annexed to the document elaborating the scheme.

10.3 There was discussion of Attachment D to CCAMLR-X/7 which specified the provisions of the CCAMLR Scheme of International Scientific Observation and the tasks and functions of international scientific observers. Concern was expressed about the means by which observation of research vessels is provided for in the proposed scheme. The Scientific Committee clearly identified observation on commercial vessels as the priority. It was pointed out that the research activities of Members already involve some degree of international cooperation. A formal scheme specifying tasks for observers on research vessels could unnecessarily constrain their ability to participate effectively in the research program of the vessel, particularly in relation to other researchers. The Scientific Committee therefore agreed to recommend to the Commission that the tasks of observers on research vessels not be specified in the scheme.

10.4 In relation to observers on commercial vessels, the essential purpose of gathering and validation of scientific data was reiterated. To achieve this the scheme should be flexible enough to enable the changing research priorities identified by the Scientific Committee to be addressed. The priorities for collection of data would also vary according to the vessel and fishery involved. The Scientific Committee agreed therefore that the observers' actual tasks should not be specified in the document elaborating the scheme. The list of tasks in this document should, however, broadly outline the key areas of work which the observer will be required to undertake. It was agreed that this should include effort as well as catch data, the procedures by which catch weight is measured and measurement of product to green weight conversion factors. Accordingly, a revised draft of Attachment D, Section 2, was prepared for the Commission (Annex 8).

10.5 Dr Shust suggested that observers of the flag state of a commercial vessel would be best equipped to further the aim of collection and validation of data. Others argued that the presence of observers from an international pool would improve the comparability of data collected from different vessels, and increase the reliability of the data received by the Commission through validation by the observer of data collected. The importance of distinguishing between inspection and observation in this context was reiterated and it was agreed that these points should be taken into account by the Commission in its consideration of the issue.

10.6 The Scientific Committee noted the comments of the Working Groups on the proposed scheme (Annex 5, paragraphs 7.10 to 7.13; Annex 6, paragraphs 4.1 to 4.22; and Annex 7, paragraphs 7.25 to 7.31) and accepted with appreciation the offers by members of both WG-Krill and WG-FSA to assist in the preparation of a manual for observers in consultation with the Secretariat.

10.7 The Scientific Committee endorsed the priorities identified by WG-FSA for allocation of activities under the scheme to the following fisheries (in order of priority):

(i) Champsocephalus gunnari;
(ii) longline fishery for Dissostichus eleginoides;
(iii) by-catch of juvenile fish in the krill fishery; and
(iv) Electrona carlsbergi.

10.8 The Convener of WG-Krill pointed out that the Working Group had also identified (iii) above as a priority, noting that collection of data by observers is likely to be the only means of obtaining this information and referred to the high priority (paragraph 3.21) of having observers on krill vessels.

COOPERATION WITH OTHER ORGANIZATIONS

11.1 The Chairman invited the Observer from the Intergovernmental Oceanographic Commission (IOC) to address the Scientific Committee in regard to the IOC's activities in the Southern Ocean. The IOC sponsors two programs, GOOS and GLOBEC, for which collaboration with CCAMLR is desirable.

11.2 The Global Ocean Observing System (GOOS) is intended to support the coordinated monitoring of environmental and climate changes globally, regionally and nationally, by encouraging the coordinated management of data generated from regular observations of major physical, chemical and biological properties of the oceans, including coastal zones. In the Southern Ocean, GOOS will encourage collaboration with SCAR and CCAMLR, and programs such as WOCE (World Ocean Circulation Experiment) and Southern Ocean JGOFS (Joint Global Ocean Flux Study).

11.3 A document outlining the proposed structure and content of this program would be given to the Secretariat for circulation to Members.

11.4 Dr Croxall, the Observer from SCAR, presented a report on SCAR activities of relevance to CCAMLR over the last year (CCAMLR-X/BG/15). The Workshop on Southern Elephant Seals, sponsored jointly by SCAR and CCAMLR, was reported on in SC-CAMLR-X/BG/3 and in paragraphs 7.3 to 7.8.

11.5 SCAR is currently involved in potential co-sponsorship of two major international, multidisciplinary programs of biological research in the Antarctic sea-ice zone. The first, Southern Ocean JGOFS, is primarily concerned with biogeochemical cycles at lower trophic levels and has limited direct relevance to CCAMLR. The second, Southern Ocean GLOBEC (Global Ocean Ecosystem Dynamics Research and Monitoring Program), plans to focus on the role of physical and biological processes influencing the dynamics of marine animal populations within the context of global change. This initiative has considerable potential relevance to the objectives of CCAMLR. Current plans are for the main field programs to commence around 1996 and to focus on study areas in the Bellingshausen Sea (i.e., upstream of the CEMP Antarctic Peninsula Integrated Study Region) and Southern Indian Ocean (including the Prydz Bay Integrated Study Region). The research of the program is likely to be complementary to directed research already being performed in support of the resources management and monitoring work of CCAMLR. Close links between Southern Ocean GLOBEC and CCAMLR would be of considerable mutual benefit. Several scientists who regularly attend meetings of the Scientific Committee of CCAMLR are on the present planning committee of Southern Ocean GLOBEC.

11.6 The BIOMASS Colloquium, the final meeting of the multinational Southern Ocean marine research program which started in 1977, was held in Germany in September 1991. CCAMLR was well represented at the meeting and Members were invited to comment on the paper which dealt with BIOMASS-CCAMLR relations: past, present and future (CCAMLR-X/BG/14).

11.7 At the SCAR Conference on Antarctic Science - Global Concerns (also held in Germany in September 1991), the CCAMLR Secretariat, represented by the Science Officer, presented a poster on the work of the Commission and Scientific Committee which attracted considerable attention. The work of WG-FSA and WG-CEMP was also described in posters prepared by SCAR on finfish exploitation and on monitoring the Southern Ocean marine environment.

11.8 The end of the BIOMASS progam also sees the conclusion of the work of the BIOMASS Data Centre (BDC). SCAR, through the BIOMASS executive, had generously offered to provide CCAMLR, free of charge, with a copy of the data held in the BDC.

11.9 The Scientific Committee welcomed this offer, especially because the BDC contained data of considerable relevance and use to CCAMLR, notably those collected during FIBEX and SIBEX (paragraph 3.78).

11.10 However, the Scientific Committee recognised that it might be over one year before the BDC data were actually available for transmission to CCAMLR. Furthermore, CCAMLR did not at present have the facilities for analysis of the BDC data, which are organised within the Oracle relational database system.

11.11 Accordingly, the Data Manager was requested to consult with the manager of the BDC to determine the most efficient and cost-effective way of acquiring the BDC data.

11.12 The Observer at IWC, Dr W. de la Mare (Australia), described work in the IWC to develop and test revised management procedures which is almost complete (SC-CAMLR-X/BG/15). These tests have resulted in a number of possible procedures which seem to be satisfactory for future management of pelagic minke whale whaling in the Antarctic. The procedures are robust to problems of stock misidentification so long as whaling is evenly distributed over the whaling grounds. The discussions by the IWC on the Workshop on Feeding Ecology of Southern Baleen Whales are reported elsewhere (paragraph 6.61 to 6.63).

11.13 Lic E. Marschoff (Argentina) drew the attention of the Scientific Committee to the fact that Dr Kock had suggested that a 'control' area where fishing was minimal be set aside within the CEMP Program, and that Bransfield Straight (being an area containing CEMP sites but without any krill fishery to date) could be used for this purpose. Should a control area be set aside for the CEMP Program, as suggested by Dr Kock, it would be necessary to ensure that all CEMP parameters were monitored within the control area. Lic. Marschoff informed the Scientific Committee that he would be willing to coordinate the allocation of resources between monitoring sites to ensure this.

11.14 The Observer at ICES 79th Statutory Meeting, Mr Østvedt, reported that the meeting had considered more than 300 papers, in many different theme sessions, often running concurrently. At many of these sessions, such as those on the methodology of survey design and fish stock assessments, it would be of benefit if the Scientific Committee were represented by a member of the Secretariat in addition to the nominated observer. The Committee endorsed the suggestion that provision be made in the budget for the Data Manager to attend the 80th Statutory Meeting of ICES in Rostock, Germany, in 1992.

11.15 The following were nominated as observers for meetings taking place in 1992:

- 80th Statutory Meeting of ICES: Mr E. Balguerías

  Secretariat representation: Data Manager;

- 1992 Meeting of IWC Scientific Committee: Dr W. de la Mare;

- SCAR Meetings 1992 (Working Group on Antarctic Biology; Bird Biology Subcommittee; Subgroup on Antarctic Seals): Dr J. Croxall.

REVIEW AND PLANNING OF THE PROGRAM OF WORK OF THE SCIENTIFIC COMMITTEE

12.1 The Scientific Committee agreed that all three Working Groups should meet during the intersessional period.

12.2 An offer was received from Chile to host both WG-Krill and WG-CEMP in 1992. This offer was warmly received by the Scientific Committee.

- WG-Krill will meet from 3 to 10 August 1992 in Punta Arenas, Chile;
- WG-CEMP will meet from 12 to 21 August 1992 in Viña del Mar, Chile;
- WG-FSA will meet from 13 to 22 October 1992 in Hobart, Australia.

12.3 Additionally, a Workshop on Survey Design (June, Hamburg) (paragraphs 4.108 to 4.110) and a one-day meeting to consider the initial parameters for a workshop on the prey requirements of krill predators (paragraph 6.78) were recommended.

12.4 Following fruitful *ad hoc* discussions between the Conveners of WG-Krill, WG-CEMP and WG-FSA at the current Scientific Committee meeting, it was suggested that a meeting to coordinate the efforts of the Working Groups be held for one day immediately preceding the Scientific Committee in 1992 (i.e., on 25 October 1992). The meeting would be open to attendance by participants from all Working Groups and other interested parties.

The meeting's agenda would be established by the Working Group Conveners, taking into account the discussions at the most recent meetings of the Working Groups.

BUDGET FOR 1992 AND FORECAST BUDGET FOR 1993

13.1 The Draft Budget is given in Annex 9. It includes provision for three Working Group meetings and two special meetings, one on the planning and analysis of demersal trawl surveys and the other, a meeting to consider preliminary requirements for a review of krill requirements by krill predators.

13.2 In addition, the re-analysis of FIBEX data (paragraph 3.101) and the pilot study on satellite imagery (paragraphs 6.19 to 6.21) are included in the Draft Budget.

13.3 The Chairman reported that he had presented the draft Scientific Committee Budget to the Standing Committee on Administration and Finance and had been asked to prepare alternative budgets on the assumption of 10%, 20% and 30% reductions alternatively.

13.4 The Scientific Committee strongly expressed the view that the Draft Budget was relatively conservative considering the amount of work planned. It pointed out that this work was directed at providing responses to questions asked of it by the Commission.

13.5 Should a reduction be unavoidable then certain budget items were identified as being of lower priority and a budget reduced by nearly 10% could be presented to the Standing Committee on Administration and Finance. The presentation should be made with the advice that any reduction at all is opposed and reduction beyond 10% is unacceptable.

13.6 It was noted that a part of the effective increase in the Scientific Committee Budget from the previous year is due to the depletion of the Norwegian Contribution Special Fund which will be exhausted after 1993. It was also noted that the Scientific Committee would be likely to have the same opinion of the budget required for it to operate effectively at the 1992 Meeting.

ELECTION OF VICE-CHAIRMEN OF THE SCIENTIFIC COMMITTEE

14.1 The Chairman thanked Dr G. Duhamel (France) and Dr T. Lubimova (USSR) for their work as Vice-Chairmen of the Scientific Committee. Dr Lubimova had retired in 1991 and was not present at the Scientific Committee meeting, Dr Shust brought her best wishes to the Committee. The Chairman thanked her for her contributions to the work of the Committee over many years and on behalf of the Committee wished her well for the future.

14.2 Mr E. Balguerías (Spain) and Dr R. Holt (USA) were unanimously elected as Vice-Chairmen of the Scientific Committee for the period from the end of the Tenth Meeting until the end of the Scientific Committee meeting in 1993, in accordance with Rules 3 and 8 of the Rules of Procedure.

NEXT MEETING

15.1 The Scientific Committee agreed that its next meeting should be held in Hobart, Australia from 26 to 30 October 1992.

OTHER BUSINESS

16.1 There was no other business.

ADOPTION OF THE REPORT

17.1 The Report of the Tenth Meeting of the Scientific Committee was reviewed and adopted.

CLOSE OF THE MEETING

18.1 Mr Østvedt thanked participants, Working Group Conveners, rapporteurs and the Secretariat for their support and cooperation.

18.2 Mr Østvedt then closed the meeting.

ANNEX 1

LIST OF PARTICIPANTS

LIST OF PARTICIPANTS

CHAIRMAN	Mr Ole J. Østvedt Deputy Director Institute of Marine Research Bergen

ARGENTINA

Representative:	Dr Jorge Mastropietro Ministerio de Relaciones Exteriores y Culto Dirección de Malvinas, Atlántico Sur y Antártida Buenos Aires
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Representative:	Dr Knowles Kerry Antarctic Division
Alternate Representatives:	Mr Richard Williams Antarctic Division
	Dr Stephen Nicol Antarctic Division
	Mr Peter Heyward Antarctic Section Department of Foreign Affairs and Trade
	Dr William de la Mare Special Adviser
Advisers:	Mr R.H. Wyndham Assistant Secretary Environment and Antarctic Branch Department of Foreign Affairs and Trade

	Dr Patrick Quilty Antarctic Division
	Ms Robyn Graham Antarctic Division
	Ms Sharon Moore Antarctic Division
	Mr James Shevlin Antarctic Division
	Dr Andrew Constable Representative of Non-Governmental Organizations

BELGIUM

Representative:	His Excellency Dr J. Scavée Ambassador Royal Belgian Embassy Canberra

BRAZIL

Representative:	His Excellency Mr Marcos H.C. Côrtes Ambassador for Brazil Canberra
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Alternate Representative:	Dr Carlos Moreno Director Instituto de Ecología y Evolución Universidad Austral de Chile Valdivia

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	Mr Takenobu Takahashi Japan Deep Sea Trawlers Association Tokyo
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Alternate Representative:	Mrs Désirée Edmar Ministry of Foreign Affairs Stockholm
Adviser:	Dr Bengt Sjöstrand Institute for Marine Research Lysekil

USSR

Representative:	Dr K.V. Shust Head of Laboratory VNIRO Moscow
Advisers:	Mr V.I. Ikriannikov Ministry of Fisheries Representative Melbourne
	Mr A.N. Yakunin Director-General of ‘Yugryba’ Concern Sevastopol
	Mr V.M. Brukhis Chief of Section, Main Department of Fishing Resources Ministry of Fisheries of the USSR Moscow
	Mr L.G. Zhukov Deputy General Director ‘Atlantika’ Fishing Enterprise Sevastopol
	Mr S.N. Komogortsev Foreign Relations Department Ministry of Fisheries of the USSR Moscow
	Mr K.P. Tkachenko Chief of Foreign Section BAMR Enterprise Vladivostok

Mr V.V. Abramovitch
Chief of Commercial Fisheries Section
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Senior Inspector
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	Dr J. Bengtson National Marine Mammal Laboratory National Marine Fisheries Service Seattle, Washington
	Professor Marc Mangel Department of Zoology University of California Davis, California
	Ms Beth Marks Department of Biology Yale University New Haven, CT
	Dr George Watters Southwest Fisheries Science Center National Marine Fisheries Service La Jolla, California

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NETHERLANDS	Mr Alfred Evers Royal Netherlands Embassy Canberra
	Dr W.J. Wolff IBN Leersum Netherlands
URUGUAY	Mr J. Giambruno Chargé d'Affaires Embassy of Uruguay Canberra

OBSERVERS - INTERNATIONAL ORGANIZATIONS

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	Dr Tom Polacheck CSIRO Division of Fisheries Hobart
IWC	Dr R. Holt Southwest Fisheries Science Center National Marine Fisheries Service La Jolla, California
SCAR	Dr J. Croxall British Antarctic Survey Cambridge

OBSERVERS - NON-GOVERNMENTAL ORGANIZATIONS

ASOC	Ms J. Dalziell ASOC Sydney

ANNEX 2

LIST OF DOCUMENTS

LIST OF DOCUMENTS

SC-CAMLR-X/1	PROVISIONAL AGENDA FOR THE TENTH MEETING OF THE SCIENTIFIC COMMITTEE FOR THE CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES
SC-CAMLR-X/2	ANNOTATED PROVISIONAL AGENDA FOR THE TENTH MEETING OF THE SCIENTIFIC COMMITTEE FOR THE CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES
SC-CAMLR-X/3	PROPOSED AMENDMENT TO PART X OF THE SCIENTIFIC COMMITTEE RULES OF PROCEDURE Executive Secretary
SC-CAMLR-X/4	REPORT OF THE THIRD MEETING OF THE WORKING GROUP ON KRILL (Yalta, USSR, 22 to 30 July 1991)
SC-CAMLR-X/5	REPORT OF THE WORKING GROUP ON FISH STOCK ASSESSMENT (Hobart, Australia, 8 to 17 October 1991)
SC-CAMLR-X/6	REPORT OF THE WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM (Santa Cruz de Tenerife, Spain, 5 to 13 August 1991)
SC-CAMLR-X/7	PROPOSAL FOR THE DEVELOPMENT OF A SYSTEM FOR PRODUCING DATA ON SEA ICE DISTRIBUTION FROM SATELLITE IMAGERY AS PART OF THE ECOSYSTEM MONITORING PROGRAM Secretariat
SC-CAMLR-X/8	A PROPOSAL FOR THE FORMATS FOR OBSERVATIONS BY OBSERVERS ON COMMERCIAL FISHING VESSELS IN THE CCAMLR AREA Secretariat
SC-CAMLR-X/9	PROPOSALS ON KRILL AGGREGATION MODEL PROJECT (KRAM PROJECT) Delegation of USSR
SC-CAMLR-X/10	PRECAUTIONARY CATCH LIMITS FOR KRILL Delegation of United Kingdom

SC-CAMLR-X/11	DRAFT MANAGEMENT PLAN FOR THE PROTECTION OF SEAL ISLANDS, SOUTH SHETLAND ISLANDS, AS A SITE INCLUDED IN THE CCAMLR ECOSYSTEM MONITORING PROGRAM (Submitted by the Working Group for the CCAMLR Ecosystem Monitoring Program)

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SC-CAMLR-X/BG/1	SUMMARY OF FISHERY STATISTICS FOR 1991 Secretariat
SC-CAMLR-X/BG/2	CCAMLR DATABASES AND DATA AVAILABILITY Secretariat
SC-CAMLR-X/BG/3	ELEPHANT SEAL WORKSHOP Secretariat
SC-CAMLR-X/BG/4	INCIDENTAL CATCH OF SEABIRDS IN TRAWL FISHERIES Delegation of New Zealand
SC-CAMLR-X/BG/5	VACANT
SC-CAMLR-X/BG/6	MYCTOPHIDS IN THE DIET OF ANTARCTIC PREDATORS Secretariat
SC-CAMLR-X/BG/7	KRILL CATCHES AND CONSUMPTION BY LAND-BASED PREDATORS IN RELATION TO DISTANCE FROM COLONIES OF PENGUINS AND SEALS IN THE SOUTH SHETLANDS AND SOUTH ORKNEYS Secretariat
SC-CAMLR-X/BG/8	REPRODUCTIVE PERFORMANCE, RECRUITMENT AND SURVIVAL OF WANDERING ALBATROSSES *DIOMEDEA EXULANS* AT BIRD ISLAND, SOUTH GEORGIA Delegation of UK
SC-CAMLR-X/BG/9	CONTRIBUTIONS TO THE BIOLOGY OF CEPHALOPODS IN PRYDZ BAY, ANTARCTICA - A PRELIMINARY REPORT Delegation of Australia
SC-CAMLR-X/BG/10	CPUES AND BODY LENGTH OF ANTARCTIC KRILL DURING 1989/90 SEASON IN THE FISHING GROUND NORTH OF LIVINGSTON ISLAND AND NORTHWEST OF ELEPHANT ISLAND Delegation of Japan

SC-CAMLR-X/BG/11 DATA ON KRILL, *EUPHAUSIA SUPERBA* DANA, CONSUMPTION BY COASTAL FISHES IN DIVISION 58.4.2 (KOSMONAVTOV AND SODRUZHESTVA SEAS)
Delegation of USSR

SC-CAMLR-X/BG/12 REPRODUCTION IN ANTARCTIC NOTOTHENIOID FISH - A REVIEW
Delegation of Germany

SC-CAMLR-X/BG/13 THE STATE OF EXPLOITED FISH STOCKS IN THE SOUTHERN OCEAN - A REVIEW
Delegation of Germany

SC-CAMLR-X/BG/14 INCIDENTAL MORTALITY ARISING FROM FISHERIES ACTIVITIES AROUND KERGUELEN ISLAND (DIVISION 58.5.1)
Delegation of France

SC-CAMLR-X/BG/15 OBSERVERS REPORT FROM THE 1991 MEETING OF THE SCIENTIFIC COMMITTEE OF THE INTERNATIONAL WHALING COMMISSION
Observer (W.K. de la Mare, Australia)

SC-CAMLR-X/BG/16 REPORT ON CEPHALOPOD FISHING AND RESEARCH ACTIVITIES IN THE CCAMLR AREA 1990/91
Delegation of United Kingdom

SC-CAMLR-X/BG/17 ANTARCTICA DIGITAL DATABASE PROJECT
Delegation of United Kingdom

SC-CAMLR-X/BG/18 THE INCIDENCE OF PLASTIC IN THE DIETS OF ANTARCTIC SEABIRDS
Delegation of USA

SC-CAMLR-X/BG/19 POTENTIAL IMPACTS OF BOTTOM TRAWLING ON BENTHIC COMMUNITIES IN PRYDZ BAY, ANTARCTICA
Delegation of Australia

SC-CAMLR-X/BG/20 NEW AND DEVELOPING FISHERIES: A REVIEW OF US ACTIVITIES IN PERMITTING AN EXPLORATORY CRAB FISHERY IN STATISTICAL AREA 48
Delegation of USA

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CCAMLR-X/1 PROVISIONAL AGENDA FOR THE TENTH MEETING OF THE COMMISSION FOR THE CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES

CCAMLR-X/2	ANNOTATED PROVISIONAL AGENDA FOR THE TENTH MEETING OF THE COMMISSION FOR THE CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES
CCAMLR-X/3	EXAMINATION OF THE AUDITED FINANCIAL STATEMENTS FOR 1990 Executive Secretary
CCAMLR-X/4	REVIEW OF THE 1991 BUDGET, DRAFT 1992 BUDGET AND FORECAST 1993 BUDGET Executive Secretary
CCAMLR-X/5	LATE PAYMENT OF CONTRIBUTIONS Executive Secretary
CCAMLR-X/6	NEW AND DEVELOPING FISHERIES Executive Secretary
CCAMLR-X/7	CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION Executive Secretary
CCAMLR-X/8	COMMEMORATIVE SCULPTURE Secretariat
CCAMLR-X/9	IMPLEMENTATION OF CONSERVATION MEASURES IN 1990/91 Executive Secretary
CCAMLR-X/10	PROTOCOL ON ENVIRONMENTAL PROTECTION TO THE ANTARCTIC TREATY Executive Secretary
CCAMLR-X/11	VACANT
CCAMLR-X/12	REPORT OF THE ACTIVITIES CARRIED OUT FROM THE ICEBREAKER *ALMIRANTE IRIZAR* IN ACCORDANCE WITH THE SYSTEM OF INSPECTION Delegation of Argentina
CCAMLR-X/13	REPORT OF INSPECTION IN THE CCAMLR CONVENTION AREA, 1990/91 USSR
CCAMLR-X/14	PROPOSAL FOR THE ELIMINATION OF INCIDENTAL SEABIRD MORTALITY CAUSED BY NET MONITOR CABLES Delegation of New Zealand

CCAMLR-X/15	REPORT OF THE MEETING OF THE STANDING COMMITTEE ON OBSERVATION AND INSPECTION
CCAMLR-X/16	EXTRACTS FROM THE DOCUMENT CCAMLR-X/BG/23 'CCAMLR'S CONTRIBUTION TO THE WORLD CONFERENCE ON ENVIRONMENT AND DEVELOPMENT' Chairman of the Commission
CCAMLR-X/17	THE EXECUTIVE SECRETARY'S REPORT ON THE MEETING OF THE STANDING COMMITTEE ON ADMINISTRATION AND FINANCE (SCAF)

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CCAMLR-X/BG/1 REV.1	LIST OF DOCUMENTS
CCAMLR-X/BG/2 REV.1	LIST OF PARTICIPANTS
CCAMLR-X/BG/3	STATEMENT BY THE CCAMLR OBSERVER AT THE XVITH ANTARCTIC TREATY CONSULTATIVE MEETING Chairman of the Commission
CCAMLR-X/BG/4	EXTRACTS FROM A PACIFIC FISHERY AGREEMENT - OBSERVER PROGRAM Delegation of New Zealand
CCAMLR-X/BG/5	ENTANGLEMENT IN MAN-MADE DEBRIS OF ANTARCTIC FUR SEALS AT BIRD ISLAND, SOUTH GEORGIA Delegation of UK
CCAMLR-X/BG/6	OUTLINE OF THE ORDINANCE ON SCIENTIFIC OBSERVERS IN THE KERGUELEN ISLAND FISHERY Delegation of France
CCAMLR-X/BG/7	REPORT ON ASSESSMENT AND AVOIDANCE OF INCIDENTAL MORTALITY IN THE CONVENTION AREA 1990/91 United States of America
CCAMLR-X/BG/8	REPORT ON ASSESSMENT AND AVOIDANCE OF INCIDENTAL MORTALITY IN THE CONVENTION AREA 1990/91 Australia
CCAMLR-X/BG/9	CHOICE OF A PROCEDURE FOR DECIDING CLOSURE OF CCAMLR FISHERIES: A SIMULATION MODEL Secretariat

CCAMLR-X/BG/10	CONSERVATION MEASURES - CURRENT STATUS Secretariat
CCAMLR-X/BG/11	INVITATION TO CCAMLR TO SEND AN OBSERVER TO THE 1992 MEETING OF THE INTERNATIONAL COALITION OF FISHERIES ASSOCIATIONS (ICFA) Secretariat
CCAMLR-X/BG/12	UNCED - EVALUATION OF THE EFFECTIVENESS OF EXISTING INTERNATIONAL AGREEMENTS Secretariat
CCAMLR-X/BG/13	REPORT ON THE ASSESSMENT AND AVOIDANCE OF INCIDENTAL MORTALITY Delegation of Brazil
CCAMLR-X/BG/14	BIOMASS - CCAMLR RELATIONS: PAST, PRESENT AND FUTURE Delegation of United Kingdom
CCAMLR-X/BG/15	REPORT OF THE SCAR OBSERVER TO CCAMLR Observer (J.P. Croxall, United Kingdom)
CCAMLR-X/BG/16	BEACH LITTER SURVEY SIGNY ISLAND, SOUTH ORKNEY ISLANDS, 1990/91 Delegation of United Kingdom
CCAMLR-X/BG/17	REPORT OF THE 79TH STATUTORY MEETING OF ICES CCAMLR Observer (O.J. Østvedt, Chairman, Scientific Committee)
CCAMLR-X/BG/18	INFORMATION OF INTEREST TO CCAMLR COLLECTED BY M.V. *GONDWANA* ON GREENPEACE'S 1990/91 EXPEDITION ASOC Observer
CCAMLR-X/BG/19	REPORT ON ASSESSMENT AND AVOIDANCE OF INCIDENTAL MORTALITY IN THE CONVENTION AREA IN 1990/91 Korea
CCAMLR-X/BG/20	CONSERVATION MEASURE 19/IX - CONCERNS OF THE FRENCH DELEGATION Executive Secretary
CCAMLR-X/BG/21	REPORT OF THE 43RD ANNUAL MEETING OF THE IWC CCAMLR Observer (usa)

CCAMLR-X/BG/22	REPORT OF THE CCAMLR OBSERVER AT THE XI SPECIAL CONSULTATIVE MEETING AND THE XVI ANTARCTIC TREATY CONSULTATIVE MEETING Chairman of the Commission
CCAMLR-X/BG/23	CCAMLR'S CONTRIBUTION TO THE WORLD CONFERENCE ON ENVIRONMENT AND DEVELOPMENT Chairman of the Commission
CCAMLR-X/BG/24	REPORT ON ASSESSMENT AND AVOIDANCE OF INCIDENTAL MORTALITY IN THE CONVENTION AREA 1990/91 Japan
CCAMLR-X/BG/25	CONSERVATION AND MANAGEMENT OF LIVING RESOURCES OF THE HIGH SEAS Delegations of Argentina, Chile and New Zealand
CCAMLR-X/BG/26	STATEMENT ON CONSERVATION MEASURE 32/X HEAD OF DELEGATION OF THE REPUBLIC OF KOREA
CCAMLR-X/BG/27	STATEMENT ON THE COMMEMORATION OF THE TENTH MEETING OF CCAMLR Head of Delegation of the Republic of Korea

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CCAMLR-X/MA/1	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1990/91 South Africa
CCAMLR-X/MA/2	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1990/91 United Kingdom
CCAMLR-X/MA/3	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1990/91 Australia
CCAMLR-X/MA/4	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1990/91 Sweden
CCAMLR-X/MA/5	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1990/91 Poland
CCAMLR-X/MA/6	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA 1990/91 Spain

CCAMLR-X/MA/7	REPORT OF MEMBER’S ACTIVITIES IN THE CONVENTION AREA 1990/91 USA
CCAMLR-X/MA/8	REPORT OF MEMBER’S ACTIVITIES IN THE CONVENTION AREA 1990/91 USSR
CCAMLR-X/MA/9	REPORT OF MEMBER’S ACTIVITIES IN THE CONVENTION AREA 1990/91 Norway
CCAMLR-X/MA/10	REPORT OF MEMBER’S ACTIVITIES IN THE CONVENTION AREA 1990/91 France
CCAMLR-X/MA/11	REPORT OF MEMBER’S ACTIVITIES IN THE CONVENTION AREA 1990/91 Italy
CCAMLR-X/MA/12	REPORT OF MEMBER’S ACTIVITIES IN THE CONVENTION AREA 1990/91 Germany
CCAMLR-X/MA/13	REPORT OF MEMBER’S ACTIVITIES IN THE CONVENTION AREA 1990/91 New Zealand
CCAMLR-X/MA/14	REPORT OF MEMBER’S ACTIVITIES IN THE CONVENTION AREA 1990/91 Brazil
CCAMLR-X/MA/15	REPORT OF MEMBER’S ACTIVITIES IN THE CONVENTION AREA 1990/91 Japan
CCAMLR-X/MA/16	REPORT OF MEMBER’S ACTIVITIES IN THE CONVENTION AREA 1990/91 Republic of Korea
CCAMLR-X/MA/17	REPORT OF MEMBER’S ACTIVITIES IN THE CONVENTION AREA 1990/91 Argentina

ANNEX 3

AGENDA FOR THE TENTH MEETING
OF THE SCIENTIFIC COMMITTEE

AGENDA FOR THE TENTH MEETING
OF THE SCIENTIFIC COMMITTEE

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

2. Rules of Procedure for the Participation of Observers

3. 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

4. Fish Resources
   (i) Fisheries Status and Trends
   (ii) Report of the Working Group on Fish Stock Assessment (WG-FSA)
   (iii) Data Requirements
   (iv) Advice to the Commission

5. Other Resources
   (i) Review of Activities Related to Squid
   (ii) Review of Activities Related to Crab Species
   (iii) Other Resources
   (iv) Advice to the Commission

6. Ecosystem Monitoring and Management
   (i) Report of the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP)
   (ii) Management Plans for CEMP Sites
   (iii) Advice to the Commission

7. Marine Mammal and Bird Populations

8. Assessment of Incidental Mortality
   (i) Incidental Mortality in Longline Fisheries
   (ii) Incidental Mortality in Trawl Fisheries
   (iii) Marine Debris

9. Development of Approaches to Conservation of Antarctic Marine Living Resources

10. CCAMLR Scheme of International Scientific Observation

11. Cooperation with Other Organisations
   (i) Reports of SC-CAMLR Representatives at Meetings of Other International Organisations
   (ii) Nomination of SC-CAMLR Observers to Meetings of Other International Organisations
   (iii) Application for Observer Status by ASOC

12. Review and Planning of the Program of Work of the Scientific Committee
   (i) Activities in the Intersessional Period
   (ii) Coordination of Field Activities for 1991/92 and 1992/93

13. Budget for 1992 and Forecast Budget for 1993

14. Election of Vice-Chairmen of the Scientific Committee

15. Next Meeting

16. Other Business

17. Adoption of the Report of the Tenth Meeting of the Scientific Committee

18. Close of the Meeting.

ANNEX 4

**PROPOSED AMENDMENTS AND ADDITIONS TO PART X
OF THE SCIENTIFIC COMMITTEE RULES OF PROCEDURE**

PROPOSED AMENDMENTS AND ADDITIONS TO PART X OF THE SCIENTIFIC COMMITTEE RULES OF PROCEDURE

PART X OBSERVERS

The following replaces existing Rules 19 and 20 and adds new Rules 21, 22 and 23.

RULE 19

Subject to Article XII of the Convention on the Conservation of Antarctic Marine Living Resources, the Scientific Committee may:

(a) extend an invitation to any State party to the Convention which is not entitled to be a member of the Commission under Article VII of the Convention to attend, in accordance with Rules 21, 22 and 23 below, as observers in meetings of the Scientific Committee;

(b) invite, as appropriate, any other state to attend, in accordance with Rules 21, 22 and 23 below, as observers in the meetings of the Scientific Committee unless a Member of the Scientific Committee objects;

(c) invite, as appropriate, organisations named in Article XXIII (2) and (3) of the Convention to attend, in accordance with Rules 21, 22 and 23 below, as observers in the meetings of the Scientific Committee;

(d) invite, as appropriate, other inter-governmental and non-governmental organisations, to which Article XXIII (3) of the Convention may apply, to attend in accordance with Rules 21, 22 and 23 below, as observers in the meetings of the Scientific Committee unless a Member of the Scientific Committee objects.

(e) The Scientific Committee may also invite observers, in accordance with Rules 19 (a) to (d), to the meetings of any subsidiary body of the Committee.

Observers invited under this rule shall have appropriate scientific qualifications.

RULE 20

(a) The Chairman may, when preparing with the Executive Secretary the preliminary agenda for a meeting of the Scientific Committee, draw to the attention of Members of the Scientific Committee his view that the work of the Scientific Committee would be facilitated by the attendance at its next meeting of an observer referred to in Rule 19, an invitation to which was not considered at the previous meeting. The Executive Secretary shall so inform Members of the Scientific Committee when transmitting to them the Preliminary Agenda under Rule 7;

(b) Unless a Member of the Committee objects to the participation of an observer no later than 65 days before the beginning of the next meeting, the Executive Secretary shall issue to that observer an invitation to the next meeting of the Scientific Committee. An objection by a Member of the Committee in accordance with this Rule shall be considered at an early point during the next meeting of the Committee.

RULE 21

If a Member of the Committee so requests, sessions of the Committee at which a particular agenda item is under consideration shall be restricted to Member of the Committee.

RULE 22

(a) The Chairman may invite observers to address the Committee unless a Member of the Committee objects;

(b) Observers are not entitled to participate in the taking of decisions.

RULE 23

(a) Observers may submit documents to the Secretariat for distribution to Members of the Committee as information documents. Such documents shall be relevant to matters under consideration in the Committee;

(b) Unless a Member or Members of the Committee request otherwise such documents shall be available only in the language or languages and in the quantities in which they were submitted;

(c) Such documents shall only be considered as Committee documents if so decided by the Committee.

ANNEX 5

REPORT OF THE WORKING GROUP ON KRILL

(Yalta, USSR, 22 to 30 July 1991)

REPORT OF THE THIRD MEETING OF THE WORKING GROUP ON KRILL

(Yalta, USSR, 22 to 30 July 1991)

INTRODUCTION

1.1 The Third Meeting of the Working Group on Krill (WG-Krill) was held at the Oreanda Hotel, Yalta, USSR, from 22 to 30 July 1991. The meeting was chaired by the Convener, Mr D.G.M. Miller (South Africa).

1.2 The Working Group was welcomed to Yalta by the Deputy Mayor of Yalta and Director of the Yalta Fish Factory, Mr A.A. Vorobyov.

REVIEW OF THE MEETING OBJECTIVES AND ADOPTION OF THE AGENDA

2.1 The Convener opened the meeting and described the meeting objectives. These were set out in paragraphs 2.59 to 2.61 of the Scientific Committee's report of 1990 (SC-CAMLR-IX) and were primarily the review of fishing activities, refinement of estimates of potential yield and biomass. In addition, the Scientific Committee and WG-Krill have been specifically requested to provide best estimates for precautionary catch limits on krill in various statistical subareas and to identify various options on which such limits could be based (CCAMLR-IX, paragraphs 8.1 to 8.14). The Working Group noted that the USSR, Japan and Korea had considered that there was no need for such precautionary measures as the fishery has remained at approximately the same level since 1986 (CCAMLR-IX, paragraph 8.9) and fishing countries have indicated that they have no intention of dramatically increasing their effort.

2.2 In light of the tasks identified above, the Working Group agreed that all topics should be considered in the the context of improving management advice on krill and continued development of approaches to krill management (SC-CAMLR-IX, paragraph 2.60).

2.3 A Preliminary Agenda had been circulated prior to the meeting. Two additions were suggested, under Item 3 and Item 6. With these additions the Agenda was adopted.

2.4 The Agenda is given in Appendix A, the List of Participants in Appendix B, and the List of Documents submitted to the meeting in Appendix C.

2.5 The report was prepared, in agenda item order, by Drs D.J. Agnew (Secretariat), I. Everson (UK), R. Hewitt (USA), M. Basson (UK), E. Murphy (UK), V. Siegel (Germany/EEC), S. Nicol (Australia) and D. Butterworth (South Africa).

REVIEW OF FISHERIES ACTIVITIES

3.1 Document WG-Krill-91/9 described in detail the fine-scale distribution of catches in the years 1988 to 1990. These data showed a highly consistent pattern of fishing in Subarea 48.1, concentrated around Elephant and Livingston Islands. The distribution of fishing in Subarea 48.2 was much more variable and could not be predicted from year to year.

3.2 The two papers WG-Krill-91/36 and 39, together with comments from Members, established the following preliminary catch figures for krill in the 1990/91 season.

Nationality	Months	Subarea/Catch (tonnes)		
		48.1	48.2	48.3
USSR	June - September			80 000
	May			30 000
	June			?
	October - December	4 000	21 000	
	January - May		120 000	
Poland	July - May			3 336.2
	December - April		5 998	
	December - January	315.3		
Chile	February - March	3 679		
	Totals	7 994	146 998	113 336

3.3 In addition to these catches there were reports that the Soviet Union had fished in the South Georgia region in July 1991, and in the Pacific Ocean sector (Statistical Area 88) from January to April 1991; Japan had fished in Statistical Area 48 at about the same level as in previous years and Korea had carried out fishing in the Scotia Sea taking 431 tonnes.

3.4 It was reported that at the moment the USSR and Poland have no plans for increasing the level of fishing for krill in the near future, the level of Japanese and Korean fishing may well fall, depending on market forces and Chile is likely to increase fishing effort slightly.

3.5 Dr Nicol reported that an application by an Australian company to harvest 80 000 tonnes of krill annually is currently under consideration. Australia is developing an interim management plan pending the development of a krill management procedure by CCAMLR in line with its precautionary approach to management. Mr O. Østvedt (Norway) reported that there was some interest in harvesting krill by Norwegian companies but that this may not develop in the near future.

3.6 Dr Everson noted that the indications of future fishing activity contained in Reports of Members' Activities, while being very helpful, did not contain all the information necessary for the Working Group to determine the likely level of fishing effort. He suggested that the number of fishing vessels expected to be operational during the season should be provided along with their catching capacity. This suggestion was endorsed by the Working Group.

3.7 Paper WG-Krill-91/39 described haul-by-haul data from the Chilean fishery north of the South Shetland Islands. These data enabled a detailed analysis of the distribution of catches and the behaviour of the fishery to be made. Analysis of catch-per-unit-effort (CPUE) where effort is measured in hours fished, showed a drop in CPUE in the years 1989 and 1990 and a return to high levels in 1991. A second paper, WG-Krill-91/37, also analysed CPUE values from haul-by-haul data, and it was emphasised that these sorts of calculations are preferable to analyses of catch rates alone because the processing capacity of fishing vessels usually sets a limit on daily catch rates.

3.8 The Working Group considered this an extremely useful analysis and recalled and endorsed paragraph 2.63 of SC-CAMLR-IX which encouraged the reporting of haul-by-haul data on the krill fishery within 10 km of land-based predator colonies. It was emphasised that depth of fishing and bottom depth should be included in these reports since the relation of krill catch depth to the sea floor will be important (e.g. in assessing by-catches of fish) for CEMP and in analysing the distribution of the fishery in relation to hydrological features.

3.9 Document WG-Krill-91/12 provided information collected by a scientific observer based on board a Soviet commercial fishing vessel. It was emphasised that biological and other data from the fishery were extremely important to the work of the Working Group, and therefore further reports of this type should be encouraged.

3.10 The Scientific Committee in 1990 called for an investigation of the by-catch of young and larval fish in the krill fishery in order to assess the potential impact of such by-catch on fish stocks (SC-CAMLR-IX, paragraph 3.16). A list of nine by-catch species of fish caught by one commercial Chilean vessel was presented in WG-Krill-91/39. An analysis of research vessel data from South Georgia presented in WG-Krill-91/25 showed that adult *Champsocephalus gunnari* was the fish most commonly caught, that it was more likely to be caught when krill catches were low, and that there was by-catch only when fishing was conducted over the shelf. The high risk area for this species was off Clerke Rocks, South East South Georgia. No data are yet available on the larval fish by-catch in the krill fishery.

3.11 The Working Group noted the concern that there may be a substantial mortality of krill not retained in the nets. Paper WG-Krill-91/6 suggested that only 5 to 10% of krill encountering a net are caught in the codend, and that 37 to 74% of those not caught may die as a result of the contact with the net. The Working Group regretted that the data contributing to this paper were not available. Dr V. Sushin (USSR) expressed doubts on the reliability of figures presented in WG-Krill-91/6 and indicated that neither the method nor the data for these estimates were ever published. Moreover, in order to determine the extent of such mortality, these 1975 studies were carried out by means of vertical tows of nets of a different type to those used today. Papers WG-Krill-91/18 and 22 presented a theoretical approach to the estimation of krill damage by midwater trawls.

3.12 The Working Group encouraged work of this nature to determine mortality of krill not retained in krill trawls as this information is extremely important for determining the impact of the krill fishery. If such mortality is high, fishing gear that minimises this mortality should be developed. For example, wings could be removed from nets or replaced by screens of compressed air that serve to herd krill into the net (the latter is included in an Italian Patent reported in *Fishing News International*).

3.13 In considering whether the 1990/91 season had been a poor fishing year for krill in all areas, the Working Group noted the information contained in papers WG-Krill-91/22, 39 and WG-CEMP-91/11 that krill were scarce to the north of the South Shetland Islands until early February 1991; this represented a delay in the arrival of krill of at least two weeks.

3.14 Dr Everson reported results from a fish stock assessment survey around South Georgia (to be presented to the next meeting of the Working Group on Fish Stock Assessment, WG-FSA) which found that only 20% of *C. gunnari* stomachs contained krill, in comparison to an average of 60% from earlier years. This implied a scarcity of krill in the South Georgia region in January 1991. The timing and duration of these periods of krill scarcity have important implications for the fishery and for predators.

INFORMATION NECESSARY FOR MANAGEMENT

Survey Methods and Biomass Estimation

Review of Subgroup on Survey Design's Work

4.1 The Convener of the Subgroup on Survey Design, Dr I Everson (UK), presented the report of the meeting which had been held in Yalta at the Hotel Oreanda from 18 to 20 July 1991.

4.2 The report of the Subgroup is attached in Appendix D.

4.3 In reviewing the report, the Working Group thanked the Convener and participants for all their hard work. A large number of papers tabled for WG-Krill had been considered by the Subgroup. A list of these documents is given in Attachment 3 of Appendix D.

4.4 The Working Group endorsed the report of the Subgroup and in receiving the report, used its findings as a basis for discussion under this agenda item.

4.5 To avoid unnecessary duplication, the Subgroup report is summarised here by section, designated by paragraph number. Where sections of the Subgroup report were accepted with only minor or no comment, this report refers to the relevant paragraphs in the Subgroup report. This section should therefore be read in conjunction with that report.

4.6 Analyses undertaken prior to the meeting and the discussion of the papers are described in Appendix D, paragraphs 7 to 23. Discussion arising from the working papers provided information on specific analytical techniques: standing stock estimation, variance of the standing stock estimate, distribution of patches, geostatistical techniques and aggregation shape (Appendix D, paragraphs 24 to 47).

4.7 The value of simulation studies was emphasised by the Working Group and it was noted that they would have particular application in the development of designs involving analysis by geostatistical techniques. Simulation would also provide indication of the robustness of the various estimators. Further work in these fields was encouraged.

4.8 The analytical techniques discussed by the Subgroup (Appendix D, paragraphs 48 and 56) were then applied to specific cases; monitoring prey to relate to data from CEMP predator monitoring and at three scales, meso (10s to 100s of km), micro (a few to 10s km) and macro (100s to 1 000s km) as used in WG-Krill-91/10.

Prey Surveys for CEMP

4.9 In considering prey surveys for CEMP, the Subgroup discussed, as an example, a design to provide prey information to relate to Predator Parameter A5 (Penguin Foraging Trip Duration) in the Antarctic Peninsula Integrated Study Region of CEMP. This example survey is set out in Survey Design 1 (Appendix D, Attachment 4).

4.10 The design proposed by the Subgroup involves a series of randomly spaced parallel transects. This layout of transects is different to the guidelines adopted last year (SC-CAMLR-IX, Annex 4, paragraph 100). The Working Group agreed that the design provided by the Subgroup offered significant advantages in terms of estimation of standing stock and determining the distribution of krill within a given area.

4.11 Random spacing of transects ensures unbiased estimates of variance, but it was felt that this requirement offered little advantage over a design involving the same number of regularly spaced transects. Regularly spaced transects have the advantage that they are more effective in providing information on krill distribution within the survey area. For this reason the Working Group favoured the use of regularly spaced transects for the survey design.

4.12 It was agreed that this example survey design should be submitted to WG-CEMP in this revised form.

4.13 The design described in Survey Design 1 is aimed at providing a time series of standing stock estimates throughout the CEMP integration period for parameter A5. The Working Group noted that much additional information on the distribution of patches and their composition is available from acoustic datasets and that this might be of value to WG-CEMP.

4.14 The Working Group therefore asks WG-CEMP to indicate the types of information on krill distribution and aggregation that are likely to be most useful in understanding predator/prey interactions. The following types of information might be derived from acoustic datasets collected according to an appropriate design:

standing stock
areal coverage of krill
estimated number of patches
distribution of patches
aggregation parameters:
- depth
- area
- density
- location
- spacing.

4.15 The Working Group, noting that the proposed design was quite specific in considering one predator parameter at one site, agreed that different designs will be required for the other parameters and at the other sites.

Surveys for Direct Abundance Estimation

4.16 The Subgroup had considered the proposals for studies in the south-west Atlantic sector in document WG-Krill-91/10 and had provided guidance on conducting surveys on micro-, meso- and macro-scales (Appendix D, Attachment 4, Survey Designs 2, 3 and 4).

4.17 The meso-scale survey (Survey Design 3) would form the central part of the investigation by providing a standing stock estimate of direct interest for krill studies and also for CEMP. Such a survey could be undertaken in two phases: a rapid mapping phase aimed at identifying gross environmental features and krill patches followed by more detailed local surveys in areas of particular interest.

4.18 In this form the meso-scale survey is broadly equivalent to, but on a slightly smaller scale than, that required for complete subareas. Survey Design 3 describes some of the general principles for the development of meso-scale survey design. These are of application in any situation where standing stock and distribution are of interest.

4.19 The macro-scale survey (Survey Design 4) would be aimed at determining broad-scale krill distribution and the location of specific features such as oceanic fronts. These might be further investigated by the use of drifting buoys.

4.20 The micro-scale surveys (Survey Design 2) would be at sites identified during the meso-scale survey as containing krill aggregations. The Working Group noted that the replication of these micro-scale surveys would need to be made within a short period: days rather than weeks.

Future Work

4.21 It was felt that further work should be directed at describing the general principles and specific details to be used in designing surveys. The following is a list of topics that the Working Group considered required further investigation:

Specific Topics

- Develop survey designs for specific CEMP predator parameters.

- Develop survey designs for determining krill distribution and standing stock at the meso-scale level within CEMP Integrated Study Regions.

General Topics

- Determine the likely variance for meso- and macro-scale surveys of krill standing stock as a function of survey intensity.

- Undertake simulation studies in order to determine the robustness of the parameter estimates under different designs and assumptions about krill distribution.

- Investigate the application of geostatistics to the analysis of acoustic survey data.

Submissions on these topics were encouraged for discussion at the next WG-Krill meeting.

4.22 The Soviet Delegation proposed the construction of a model for the conduct of simulation studies using real acoustic survey data for the development of survey designs and analysis procedures. The Working Group agreed that this was a useful proposal and urged the Soviet Delegation to submit full details to the Scientific Committee's next meeting.

4.23 Dr V. Tesler (USSR) reminded the Working Group that acoustic surveys were only one of several field observation techniques aimed at a better understanding of the distribution of krill. Much could be gained by the use of multi-purpose surveys. He noted that planning for such surveys would need coordination through a small international steering group for each region. He offered to provide the Working Group with a plan for the implementation of such a design for consideration at its next meeting. This offer was gratefully accepted.

Biomass Estimation

Acoustic Target Strength

4.24 A task group, convened by Dr R. Hewitt (USA) met to discuss working papers and informal communications regarding krill target strength. This value is critical to the estimation of krill biomass using calibrated echo sounders.

4.25 Three methods of defining krill target strength were recognised. These are:

(i) single animal measurements, either under controlled conditions or *in situ*;

(ii) aggregation measurements of a known quantity of animals, either caged or *in situ* and subsequently captured by trawl or photographed; and

(iii) theoretical modelling considering animal size, shape, orientation, and physical properties.

4.26 The task group discussed the measurements presented to them with the following comments:

(i) Dr Hewitt presented a distribution of *in situ* measurements of individual krill target strengths (WG-Krill-91/13). The distribution was broader than that expected considering the size frequency of the krill sampled at the same time using an Isaacs-Kidd Midwater Trawl (IKMT) net. The spread is likely to be due to two causes: firstly, variations in animal orientation and shape; and secondly, multiple targets being erroneously identified as single animals;

(ii) Dr S. Kasatkina (USSR) presented a paper describing measurements of encaged aggregations and direct trawl observations (WG-Krill-91/29). The dependence of target strength on biological condition and maturity state of krill was also described. The encaged experiments were undertaken at operating frequencies of 136 and 20 kHz. For aggregations of individuals with a mean length of 45 to 50 mm, target strength values in the range -68 to -69 dB were obtained. At 20 kHz, a series of experiments using krill from 43 to 47 mm total length gave target strength values ranging from -71 to -77 dB;

(iii) the trawl observations presented by Dr Kasatkina in WG-Krill-91/29, involved observation of krill aggregations using a transducer mounted either in front of the net, or on the headline or in the body of the net. The operating frequency of the system was 20 kHz. Catchability of the trawl was described in WG-Krill-91/32. There was a slight increase in the estimated mean target strength as krill entered the net; this was attributed to an artefact induced by aggregation. For krill of mean length 47 to 50 mm, target strength varied from -71 to -77 dB, while for krill in the range 41 to 47 mm the target strength varied from -76 to -81 dB;

(iv) Dr J. Watkins (UK) presented estimates of krill target strength based on underwater photographs on ensonified volumes of krill (WG-Krill-91/40). The results are preliminary and analyses of additional photographs will be presented in a later report. The study will also investigate target strength with respect to the variation of animal orientation;

(v) Dr Everson informally presented a series of target strength measurements made by J. Penrose and T. Pauly in Australia. These measurements were made on free-swimming individual krill in a 3 m deep tank using a 120 kHz system. A formal report is anticipated for the next meeting of the Working Group;

(vi) results from SC-CAMLR-VII/BG/30 and SC-CAMLR-VIII/BG/30 were also available to the meeting;

(vii) a paper by Greene *et al*. (1991) (*Nature 349*: 110), which had been tabled in draft form the previous year as WG-Krill-90/29 was discussed. This paper described measurements of target strength of a variety of zooplankton at 420 kHz and predictions of the likely values at other operating frequencies;

(viii) no working papers on theoretical models of target strength were presented, although the task group was aware of recent models described by Stanton (1988)

(*J. Acoust. Soc. Am. 86*: 1499-1510), and verified by Weibe *et al*. (1990) (*J. Acoust Soc. Am. 88*: 2346-2360), which include parameters for animal size, shape, orientation and physical properties; and

(ix) the task group also considered a communication from Dr K. Foote (Norway) (WG-Krill-91/41) regarding methods for the measurement of krill target strength and recommendations for future work. The task group endorsed the recommendations in the paper. Dr Foote also indicated in his paper that he would present a more formal review of the status of work on the definition of krill target strength at the 1991 Meeting of the Scientific Committee in Hobart.

4.27 The task group decided that it would be instructive to plot the various measurements at 120 and 136 kHz discussed in paragraphs 4.26(i) to 4.26(v) on a graph of krill target strength against animal length (Figure 1). Also included in Figure 1 is the description of target strength as a function of length at 120 kHz given in *BIOMASS Report No. 40* (1986) and the prediction published by Greene *et al*. (1991).

4.28 Using the same data and applying the frequency- and size-dependent functions described by Greene *et al*. (1991), Dr Tesler estimated target strength at 120 kHz values for 40 mm krill. These estimated values are compared with the BIOMASS value for a krill of the same size in the table below.

Target Strength for 40 mm Krill at 120 kHz	Data Source
-71.6 dB	Greene *et al*.
-71.6	WG-Krill-91/13
-71.4	WG-Krill-91/29
-72.7	WG-Krill-91/40
-72.9	SC-CAMLR-VII-BG/30
-71.5	SC-CAMLR-VIII-BG/30
-63.8	*Biomass Report No. 40*

4.29 The task group concluded that a growing body of evidence suggests that the BIOMASS definition of krill target strength as a function of length at 120 kHz consistently overestimates target strength. Furthermore, measurements over a range of animal lengths implies a stronger dependence of target strength on length than that predicted by the BIOMASS definition. These observations agree with theoretical models of scattering from elongated cylinders which predict that target strength is a function of animal volume rather than cross-sectional area.

4.30 The task group recommended that:

(i) the BIOMASS definition of krill target strength at 120 kHz should not be used when converting measurements of volume backscattering strength to biomass. Pending a more formal review of krill target strength, the task group recommends that the following definition, derived from Greene *et al*., be used:

$$TS\ (dB) = -127.45 + 34.85 \times \log_{10}(\text{length in mm});$$

(ii) additional measurements of krill target strength be made, in accordance with suggestions by Dr Foote (WG-Krill-91/41), and reported to WG-Krill and published in referred journals. These suggestions include:

(a) cage and *in situ* measurements of krill aggregations should be made over a range of acoustical frequencies and animal lengths and physiological condition. Because of difficulties in estimating trawl avoidance, a minimum of two frequencies should be used with *in situ* experiments so that the dependence of target strength on frequency can be measured without the need for quantitative estimates of the number of krill. Alternately, the numerical density of krill may be calculated with a second high resolution echosounder or from underwater photographs;

(b) *in situ* measurements of individual krill target strength should be made using dual- or split-beam echosounders. Because the target strength of an individual krill often approaches the detection threshold of the instruments used, particular attention should be paid to potential bias toward high measurements;

(c) the shape, orientation, and physical properties (including biological condition and maturity state) of krill should be measured whenever possible to determine the range of variation in these parameters under conditions when the animals would be surveyed; and

(d) the above measurements should be put into theoretical models so as to predict the distribution of individual target strengths that would be expected from a natural aggregation of animals.

Other Methods of Biomass Estimation

4.31 Working paper WG-Krill-91/32 was discussed. The catchability of commercial fishing trawls and small scientific trawls is strongly influenced by krill distribution characteristics. The precision of biomass assessment made with fishing trawls is considerably higher than that of an IKMT. The size distribution of krill obtained with an IKMT is also biased when compared to that obtained with a fishing trawl. Fishing trawls are thus considered to be more reliable than small scientific trawls for quantitative estimates of krill biomass.

Estimation of Yield and Production

4.32 At the 1990 Meeting of WG-Krill, it was requested that calculations of the numerical factor (λ) relating yield to initial, unexploited, biomass and natural mortality, be performed to take into account the seasonal growth of krill (SC-CAMLR-IX, Annex 4, paragraph 68). Results of these calculations are given in document WG-Krill-91/24.

4.33 The results indicate that the main factors affecting the parameter λ are the values of natural mortality and recruitment variability. Results are less sensitive to the values of age-at-first-capture, age-at-maturity and the degree of uncertainty in the survey estimate of biomass.

4.34 Results also seem to suggest that the effect of seasonality is not very strong.

4.35 The paper drew attention to two major caveats. Firstly, the calculations ignored any correlation between estimates of growth rate and natural mortality; these two factors ought to be considered together.

4.36 Secondly, the calculations assume that an estimate of the entire unexploited stock is known. It is, however, known that krill moves through some areas and that surveys may only provide estimates of some proportion of the stock.

4.37 Members agreed that the estimation of total unexploited biomass from estimates of part of the stock was very important and could be incorporated into the model.

4.38 It was pointed out that the model makes the implicit assumption that the krill population would respond to fishing in a compensatory fashion.

4.39 It was also noted that the model assumes that the fishing mortality was imposed homogeneously on the population and that localised effects (and their implications for krill predators, for example) are not considered.

4.40 This matter is difficult to deal with in the framework of the current model but attention was drawn to paragraph 69 of the 1990 Report of WG-Krill (SC-CAMLR-IX, Annex 4) where it was recognised that the resultant value for λ would need to be reduced by some amount to take account of the requirements of krill predators.

4.41 It was also pointed out that the model assumes three months fishing coinciding with the growth period whereas the USSR fishing fleet sometimes fishes in Statistical Area 48 throughout the year. It was explained that the choice of the current analysis was made, primarily, for simplicity and because it reflected an extreme situation. A large proportion of the catch was usually taken during the summer months in Subareas 48.1 and 48.2. Dr Butterworth indicated that alternative scenarios can be considered but it was felt that the duration and timing of fishing should not seriously affect results.

4.42 It was felt that further work was necessary to investigate the sensitivity of λ to the criterion used for the calculations. The results presented in paper WG-Krill-91/24 were obtained using that in the original paper by Beddington and Cooke (1983), as requested by the meeting. This criterion ensures that the probability of the krill spawning biomass falling below 20% of its average pre-exploitation level over a 20-year period of harvesting does not exceed 10%.

4.43 Members felt that because of the nature of the fishery, age-at-first-capture was not something that could be regulated or changed but information from commercial length frequencies should be used to refine the estimate of this parameter.

4.44 The Secretariat indicated that although a data collection scheme had been initiated at the WG-Krill meeting in La Jolla (1989), no biological data or length frequency data from commercial catches of krill had been submitted. The urgent need for such data was re-emphasised.

4.45 Dr Agnew drew attention to a report of a biologist-observer on a commercial trawler (WG-Krill-91/12). This report contains some graphs of length frequencies from the catches and could be used to give some preliminary guidance. Similar data on length distribution were provided from the Polish commercial fishery in WG-Krill-91/37. These data have yet to be submitted to the CCAMLR Secretariat.

4.46 It was felt that the current approach to the estimation of potential yield of krill was in general very useful and that it was now possible to focus on the input parameters, particularly natural mortality (**M**) and recruitment variability, to try to narrow the range of likely values.

4.47 The Working Group agreed that there were still many problems associated with calculation of $\mathbf{B_o}$, the initial biomass. The main problem was felt to be that of estimating immigration and emigration rates of krill between subareas.

4.48 The Working Group agreed that further calculations would be done for the next meeting of WG-Krill. These calculations would attempt to take most of the comments and suggestions into account. Details of these further calculations are given in Appendix E.

4.49 Paper WG-Krill-91/15 presents results from net sampling surveys in the Antarctic Peninsula region in December 1989 and January 1990. Comparisons are made between results from an identical survey done in 1987/88.

4.50 Results indicate that the seasonal variability in abundance is much higher than the interannual variability. The greatest effect on interannual variability was the near absence of juveniles of age group 1^+.

4.51 Production was estimated and ratios of production to biomass of 0.94 (1987/88) and 0.83 (1989/90) were found for the two surveys. These results are similar to those from other studies.

Distribution

4.52 Paper WG-Krill-91/11 presents results for 20 years of study in Subarea 48.2 in the region of the South Orkney Islands. Length frequency data are used to study the spatial distributions of size classes. Distributions varied from year to year and the distributions in the Antarctic Circumpolar Current waters were less complex that those in the Weddell Sea waters.

4.53 The long-term studies at the South Orkney Islands (WG-Krill-91/11), as well as the work on the Antarctic Peninsula (WG-Krill-91/15), note spatial separation of adolescent and adult krill. These observations suggest that the adolescent krill may have been spawned outside the respective survey areas.

4.54 It was felt that the differences in size compositions at different localities together with information on currents could be used to consider stock separation for management purposes.

4.55 Results from a general zooplankton survey in the Bransfield Strait during 1989/90 are presented in paper WG-Krill-91/14. During the survey period (December 1989 to January 1990), the proportion of krill in samples was only 1.3% in number.

4.56 Dr S. Kim (Korea) pointed out that the percentage of salps was very high and that these species tend to clog the type of nets used in the survey. This may have affected the sampling process.

4.57 Net avoidance is another possible factor that could have affected the percentage of krill in samples. Members indicated that krill avoidance, particularly in the case of Bongo nets, is well known.

4.58 Survey results of krill distribution north of the South Shetland Islands in the 1990/91 austral summer are presented in paper WG-Krill-91/22. The main aims of this study were to estimate the biomass of krill acoustically and to investigate mechanisms for the formation of krill concentrations.

4.59 Two different surveys were conducted and a 3.4-fold increase in krill abundance was observed over a 40-day period.

4.60 It was pointed out that the surveys covered very different areas and were therefore not directly comparable. It was also felt that information on strata used to estimate biomass, as well as confidence limits of biomass estimates, should be presented.

Movement

4.61 It was emphasised that the 1990 Meeting of WG-Krill had indicated that movement of krill between subareas may effect the estimation of yield (SC-CAMLR-IX, Annex 4, paragraph 34). This topic was considered to be sufficiently important to highlight the need for further information. A number of papers were presented to the Working Group and these were used as a basis for discussion.

4.62 The Working Group reiterated that localised estimates of instantaneous standing stock will not give an estimate of the effective total stock where krill fluxes (i.e., movement of krill) are significant. This has important implications for the calculation of potential yield from fisheries data. To obtain an estimate of effective total stock, large-scale instantaneous surveys may be required. An alternative is to investigate fluxes directly. This requires knowledge of input, export and residence times for krill in a particular area or region.

4.63 Dr Siegel reported (WG-Krill-91/15) on drifter buoy (FGGE[1]) releases in the Antarctic Peninsula region which produced an estimate of average current velocity of 0.2 m s^{-1} for the near-surface layer. On this basis, the calculated residence time of a specific body of water in the region was approximately three months. During a complete summer season the resident krill stock would therefore be changed approximately twice. Adding the local production, this would result in four to five times the biomass passing through the region during one season.

4.64 Dr V. Marín (Chile) told the Working Group that drift rates calculated using haul-by-haul data from the Chilean fishery (WG-Krill-91/39) were consistent with the results reported by Dr Siegel. Assuming that the fishing fleet located the same krill patch twice over a 17-day period on the northern shelf of King George Is., the estimated drift speed for the patch was 0.05 m s^{-1}.

4.65 Dr Marín also mentioned data obtained from an Argos drifter buoy released in this area as part of the RACER[2] program (USA). These produced an estimate of maximum current speed of 0.19 m s^{-1}.

4.66 Dr P. Fedulov (USSR) described an experiment carried out on the cruise of the RV *Atlantida* in June 1991 in the South Georgia area. This cruise was aimed at estimating the krill biomass transported to South Georgia and at comparing two methods of acoustic biomass estimation: one based on echo-integration and the other on information from each encountered swarm. An area of 8x6 miles, close to the area of operation of the commercial fishery was covered eight times. Preliminary results indicated that this approach can be used for the estimation of krill flux into an area as well as its influence on the resident standing stock.

4.67 The Working Group noted that this particular approach was likely to be extremely useful in studying krill flux through a region and WG-Krill looked forward to formal presentation of the results of this particular survey.

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1 First GARP (Global Atmospheric Research Program) Global Experiment
2 Rates and Processes in Antarctic Coastal Ecosystem Research

4.68 Preliminary results of estimates of krill drift over the shelf around South Georgia undertaken by Dr V. Popkov (VNIRO, USSR) were presented by Dr Shust. A mean value of 10 cm s^{-1} drift was obtained under conditions when there were no well-defined gyres over the shelf resulting in an estimated input of $2x10^5$ tonnes of krill to the shelf area in a 35- to 37-day period.

4.69 Dr M. Naganobu (Japan) informed the Working Group of Japanese Argos drifter buoy studies carried out during the 1990/91 season (WG-Krill-91/22). Four buoys were released on the northern side of the South Shetland Islands and were tracked. One buoy travelled north-east reaching South Georgia five and a half months after deployment. Other buoys showed complex tracks and a tendency to become entrained in topographical eddies generated in shelf waters.

4.70 Additional discussion focused on the extent to which krill could be considered as passive tracers of specific water masses. The Working Group acknowledged that there was little information on the capacity of krill to move against the prevailing current.

4.71 The Working Group was informed by Dr Murphy of the development of a project by IOS (UK) in which krill-like tracers are tracked in the Fine Resolution Antarctic Model (FRAM). This will provide further information on the potential large-scale movement of krill in the Southern Ocean.

4.72 Dr Marín indicated that the Chilean Antarctic Program in collaboration with the US RACER Program will undertake further studies with drifter buoys in the Gerlache Strait during the 1991/92 season.

4.73 The importance of horizontal fluxes of krill between particular regions was considered. Members agreed that such fluxes were likely to be significant within the Scotia Sea region.

4.74 In considering krill fluxes in the Scotia Sea (i.e., Subareas 48.1, 48.2 and 48.3) it was suggested that the Working Group should focus on three hypotheses, namely that:

(i) each subarea is a self-contained krill stock;

(ii) the whole of Statistical Area 48 contains a single stock consisting of interlinked populations; and

(iii) the major region of production is in the Antarctic Peninsula area, all other regions are then supplied by upstream fluxes of krill from this area.

The Working Group acknowledged that a fourth option existed involving much more complex processes.

4.75 A diagram was produced showing a schematic representation of the potential fluxes between subareas in the Scotia Sea (Figure 2). Regions of major fishing impact and containing predator colonies were used to restrict the areas of interest within each subarea. A simplified functional diagram of the flux system was also presented (Figure 3) and this identified the potential fluxes of krill within and between regions. The diagram was also used to illustrate the three hypotheses outlined in paragraph 4.74.

4.76 Members agreed that this series of diagrams provided a useful framework for developing further analyses of the operational dynamics of this complex system.

4.77 The quantitative and qualitative information available to the Working Group concerning water movement in the three subareas was summarised and is shown in Table 1. This table indicates the existence and the potential magnitude of some key fluxes. It is clear that very little of the required information was available to the Working Group. Members considered such information crucial to the further assessment of potential krill yield in the subareas concerned.

4.78 It was also acknowledged that considerably more information may be available in the wider scientific community and members saw that the synthesis of this type of information into a form useful to the Working Group is an important task.

4.79 The Working Group recommended that submissions on this topic be made to the next meeting of the WG-Krill. These should concentrate on estimating the fluxes in the form laid out in Table 1.

4.80 The Working Group formulated two questions for consideration in this regard:

(i) what existing quantitative information can members provide on water movements in the Convention Area for the depth range 0 to 200 m, in terms of velocity fields or integrated mass flows across statistical subarea boundaries?

(ii) what plans are in progress or under consideration for further research on water movements with respect to krill?

The Convener will convey these questions to SCOR and IOC for their consideration.

4.81 Members noted that submissions involving current measurements should also include information on the methodology involved to collect such data, the relevant water depths and details of the analyses undertaken.

4.82 The Working Group acknowledged that methods for considering the relationships between krill fluxes and oceanographic fluxes were required. It was noted that as well as large-scale work of the form described in paragraph 4.71, more localised work would be required. In particular, attention should be given to relating the flux of krill and the retention time in an area. This involves interaction between oceanographic and biological processes.

Demographic Parameters

4.83 Paper WG-Krill-91/15 presents estimates of total mortality (**Z**) from catch curves based on survey data from the Antarctic Peninsula region. Estimates are 0.88 (1989/90) and 0.96 (1987/88).

4.84 Some reservations were expressed regarding the appropriateness of pooling length frequencies where there is a possibility that individuals could be from different populations, where there is spatial succession or where haul-by-haul data are not homogeneous with respect to the population structure.

4.85 It was pointed out that four clusters of stations were identified on the basis of the length frequency distributions. The individual length frequency distributions were appropriately weighted by density strata before pooling within clusters and combining the four clusters.

4.86 Dr Agnew drew attention to results in paper WG-CEMP-91/25 which compares krill catches to estimates of predator consumption. These results suggest that, in certain regions, the fishing mortality could be quite a large proportion of total mortality.

4.87 Some members felt that a value of **Z** close to 1 may be too high if it is assumed that fishing mortality is relatively low and that the life span of krill is about seven years.

4.88 Dr Siegel agreed that longevity is closely related to natural mortality and, using the theoretical approach of Alagaraja (1984) (*Indian J. Fish 31*: 177-208), the expected values of **M** would range from 0.66 to 0.92 for a 7- and 5-year life span respectively (WG-Krill-91/15).

4.89 Three other factors that could lead to biased estimates of total mortality were noted:

(i) net avoidance (particularly of larger animals);

(ii) immigration and/or emigration; and

(iii) consumption by predators.

It was pointed out that it is well known that there are problems of net avoidance in krill, particularly in the case of smaller nets, but that it is very difficult to quantify this effect.

4.90 The surveys presented in WG-Krill-91/15 covered the whole distribution range of all age classes of krill along the Peninsula and the continuous drift of the stock through the area takes considerably longer than the survey. This occurs for all age groups so that immigration/emigration of single age groups which might affect the slope of the catch curve data is of minor importance to the estimate of **M** in Subarea 48.1, presented in this paper.

4.91 Dr L. Maklygin (USSR) reported preliminary results of mortality estimates from RV *Discovery* samples (1926 and 1928) and more recent samples (up to 1985). Estimates of **M** range between 0.75 and 1.13 and values from the *Discovery* and recent samples are very close.

4.92 Three tables of published demographic parameters were prepared. The tables contain growth parameters of the von Bertalanffy equation (Table 2), daily growth rates (Table 3) and estimates of total mortality (Table 4).

4.93 It was noted that the Working Group did not have the time to examine the estimates given in the tables or the methods used to obtain them and that this would need to be done in future. It was also noted that the evaluation of estimates have been done, to some extent, in paper WG-Krill-91/15 and Miller and Hampton (1989) *(BIOMASS Scientific Series No. 9*).

4.94 Members who have further information on demographic parameters were urged to submit these to the next meeting of WG-Krill.

ADVICE TO WG-CEMP

5.1 The Working Group considered several issues of direct relevance to WG-CEMP, in particular: (i) development of survey designs for prey monitoring, and (ii) estimation of the amount of krill consumed by predators. Papers considered relevant under this agenda item were: Report of the Subgroup on Survey Design (Appendix D), WG-CEMP-91/4 and 25.

Survey Design for Prey Monitoring

5.2 The specific results of the Subgroup on Survey Design's deliberations were discussed in detail under Agenda Item 4 (see paragraphs 4.1 to 4.20). Some of these results were further considered in light of their applicability to the work of WG-CEMP.

5.3 The Convener of WG-CEMP, Dr J. Bengtson (USA), said that he found the report of the Subgroup on Survey Design to be useful and that the Subgroup had made good progress in specifying survey guidelines for prey monitoring. In initiating its work, the Subgroup chose one Standard Method as an example (A5 - Penguin Foraging Trip Duration) and developed survey guidelines for prey monitoring specifically related to this parameter. He noted that it would be helpful if the Working Group could build on this successful start by developing survey guidelines for prey monitoring associated with the other Standard Methods as well.

5.4 The question was raised concerning whether WG-CEMP would be most interested in survey designs which assessed krill standing stock within particular predator foraging areas or the local distribution of krill aggregations. It was emphasised that obtaining these two types of data may require different survey designs. Because of the current uncertainties concerning the degree to which each of these two factors (abundance versus aggregation patterns) affect relative krill availability to predators, resolving this issue is expected to be a topic of directed research and discussion within WG-CEMP for a number of years. Until this matter is clarified, Dr Bengtson requested that WG-Krill further specify survey designs to be used in each of these cases as well as guidelines for surveys to provide both sorts of information simultaneously.

5.5 In reply, the Convener of WG-Krill drew the Working Group's attention to earlier discussions under Agenda Item 4 (paragraphs 4.9 to 4.15). Nevertheless, there was general agreement that the development of improved survey designs, specifically to address the problem of accurately assessing both aggregation patterns and overall biomass within an area of interest, will undoubtedly be facilitated by additional simulation studies aimed at considering the problems involved.

5.6 Furthermore, it was recognised that it may not be possible to provide a single generalised design for prey monitoring surveys for all areas since the criteria for stratification in one area may not necessarily apply to other areas.

5.7 It was emphasised that krill surveys do not necessarily need to be designed for each predator parameter individually since certain types of surveys would provide reliable information for several predator parameters simultaneously. Still, it would be helpful for various survey designs to be developed so that they may be implemented in conjunction with directed research on specific predator parameters. Such an approach would facilitate the study of specific aspects of interactions between prey availability and predator parameters monitored by Standard Methods.

5.8 It was noted that the general principles for the design of meso-scale standing stock surveys described in Survey Design 3 (Appendix D, Attachment 4) would be used in the development of survey designs for standing stock estimation in the vicinity of CEMP sites.

5.9 The Working Group agreed that more work was needed on the development designs for meso- and macro-scale surveys. Furthermore, the logistic constraints under which such surveys must operate will require additional evaluation. To assist WG-Krill in its work (see paragraph 4.21) during the forthcoming year, WG-CEMP is requested to consider the following questions at its 1991 Meeting:

(i) Is the approach outlined in the Subgroup's report (i.e., the survey design for prey monitoring related to Standard Method A5) appropriate from WG-CEMP's perspective?

(ii) Would it be helpful for WG-Krill to develop survey designs for additional Standard Methods (if so, specify which Methods are priorities for developing associated survey designs, which Methods can be grouped for this purpose and which temporal and spatial scales are appropriate to this task)?

(iii) Is it possible to state at this time whether surveys should be designed to emphasise preferentially either krill abundance or the distribution of aggregations, or both?

(iv) To what extent are the survey designs outlined in Subgroup Survey Designs 2, 3 and 4 relevant to prey monitoring for CEMP?

(v) Which methods of presenting acoustic data (as outlined in SC-CAMLR-IX, Annex 4, paragraph 102) would be most relevant for CEMP prey monitoring?

Krill Consumption by Predators

5.10 The Working Group expressed its continued interest in obtaining estimates from WG-CEMP on the amount of krill eaten by predators in various geographic areas. Such data are important both for estimating the potential yield of krill stocks and for calculating required krill escapement from the fishery. It was noted that in response to a request from the Commission (CCAMLR-IX, paragraph 4.36), WG-CEMP is currently addressing this matter and is considering holding a workshop to formulate the requested estimates. The Working Group endorsed WG-CEMP's efforts and encouraged it to proceed with the development of these estimates as soon as possible.

5.11 It was noted that relevant information required to formulate such estimates is presently more available for land-breeding predators such as fur seals and penguins than for other species. However, because of the importance of pelagic predators such as whales and ice-breeding seals, the Working Group recommends that WG-CEMP include these species in their deliberations on predator requirements (see paragraphs 8.4 and 8.5).

5.12 Dr Marín pointed out that there may be problems of scale when considering catches only at the subarea level and drew attention to the instruction from the Scientific Committee that krill harvesting should not disproportionally affect land-based predators when compared to pelagic predators (SC-CAMLR-IX, paragraph 2.19).

5.13 As the fine-scale data have shown (WG-Krill-91/7), the fisheries catch may be highly localised in areas where predators are foraging at times when krill availability is critical (e.g. predators' breeding season). Although the krill catch on a subarea basis may not appear great, it may be highly significant in terms of the impact that it has on local predator populations.

5.14 Dr Agnew had prepared a paper evaluating the fine-scale catch data in conjunction with important land-based colonies of penguins and fur seals (WG-CEMP-91/25). This paper indicated that a very high percentage of the commercial krill catch occurred close to some colonies during the breeding season, which highlighted the need for closer evaluation of the potential impact of highly localised commercial catches on land-breeding predators.

5.15 The interannual variation in krill consumption by predators may affect the extent to which the fisheries catch may potentially impact on predators. It was noted that there was certainly an upper limit to consumption by a predator population of a given size, although, in years when prey were relatively scarce, krill consumption by predators would probably fall below this upper limit. At present, the variability in the ratio between krill consumption by predators and the commercial catch level is unknown, but this ratio should be taken into account when assessing the interactions between fisheries and other krill consumers.

DEVELOPMENT OHF APPROACHES TO MANAGING THE FISHERY

Operational Definitions of Article II

6.1 At its previous meeting, the Working Group had suggested four concepts on which to base operational definitions of Article II (SC-CAMLR-IX, Annex 4, paragraph 61):

‘(i) aim to keep the krill biomass at a level higher than might be the case if only single-species harvesting considerations were of concern;

(ii) given that krill dynamics have a stochastic component, focus on the lowest biomass that might occur over a future period, rather than the mean biomass at the end of that period as might be the case in a single-species context;

(iii) ensure that any reduction of food to predators which may arise because of krill harvesting is not such that land-breeding predators with restricted foraging ranges are disproportionately affected in comparison with predators present in pelagic habitats; and

(iv) examine what level of krill escapement would be sufficient to meet the reasonable requirements of krill predators. It was agreed that WG-CEMP be asked to consider this aspect.’

6.2 The Scientific Committee and Commission (SC-CAMLR-IX, paragraph 2.19 and CCAMLR-IX, paragraph 4.17) had endorsed these suggestions as a useful basis on which to develop a management policy for krill, and the Working Group's request that members provide operational definitions to its next meeting. However, no such suggested definitions had been forthcoming.

6.3 The Working Group agreed that this matter required further attention. However, it noted that the matter needed to be considered in the context of a particular management procedure(s) and its associated mechanisms for monitoring the krill resource.

Possible Approaches to Managing the Fishery and their Development

6.4 The Working Group decided to base its discussions on the categories listed in paper WG-Krill-90/14, namely:

- reactive management;
- predictive management (modelling);
- open and closed areas;
- indicator species;
- pulse fishing; and
- feedback management.

Reactive Management

6.5 Reactive management is the practice of implementing conservation measures only <u>after</u> the need for them has become apparent.

6.6 The Working Group identified three questions pertinent to consideration of reactive management:

(i) What criteria would be used to decide when some form of regulation would be necessary?

(ii) What information about the status of the stocks would be needed to apply the criteria?

(iii) What confidence could there be that the regulations would be introduced in time and be sufficient to prevent failure or to achieve the conservation objectives of the Convention?

6.7 The Working Group was unable to provide any suggestions for (i) and (ii) above. With respect to (iii), the Working Group noted that reactive management has been the default approach in many fisheries, and that it entailed a very high risk of failure often resulting in the collapse of the fisheries. Accordingly, the Working Group agreed that reactive management was not a viable long-term strategy for the management of the krill fishery.

6.8 The Working Group agreed that a case could be made for a modified reactive strategy in which regulations had no effect on the conduct of the fishery until the fishery itself had attained certain characteristics; e.g. it had reached a certain annual catch. This is the type of approach that the Commission discussed at its Ninth Meeting (CCAMLR-IX, paragraph 8.6) in terms of a precautionary catch limit and a controlled rate of expansion of the fishery after it had reached that level.

6.9 Such precautionary limits would obviously have to be much less than the point estimate of the level of fishing which would maximise production from the stock. Calculations of a range of values for such precautionary limits are given below in paragraphs 6.31 to 6.59.

6.10 Once the precautionary limit has been reached, the Commission should be prepared to implement the next phase of its management strategy, which would be based on some combination of the approaches discussed below.

Predictive Management

6.11 Predictive management involves predicting the level of catch that the resource can sustain from available information, and is usually based on some form of model of the system. The formula $Y = \lambda M B_o$ discussed in paragraphs 6.42 to 6.55 below is an example of such a predictive model.

6.12 Predictive management should not be based on the 'best' estimates of parameters only. Plausible ranges for these parameters have to be considered to make allowance for uncertainty.

6.13 Positive aspects of predictive management are that it provides information on appropriate criteria for determining when conservation measures may need to be enacted and what data will be required to evaluate such criteria.

6.14 Negative aspects are that predictive management alone cannot be adequate in the long-term because of the need to correct, over time, for inexact estimates and imperfect models.

6.15 Simple compensatory single-species models (such as the model which leads to the $Y = \lambda MB_o$ equation) are usually used for predictive purposes. Concerns expressed in this regard were:

(i) the need for some additional adjustment factor to take account of multi-species aspects;

(ii) the justification for the assumption of compensatory behaviour; and

(iii) whether the additional mortality imposed by fishing would indeed be equally felt by all members of the population as is usually assumed by such models.

Open and Closed Areas

6.16 Closing certain areas, whose size would typically be much smaller than statistical areas or subareas, for part or all of the season could provide a mechanism to:

(i) reduce the by-catch of juvenile fish;
(ii) reduce any impact on the food resources of land-based predators; and
(iii) guarantee a certain escapement of krill from the fishery.

6.17 Positive aspects of such measures are that they may be implemented both cheaply and in the near future.

6.18 The negative aspect is the difficulty in defining the areas appropriately. Further, care would have to be taken that areas remaining open would still guarantee a ready availability of krill to the fishery.

6.19 Given present knowledge, closed area specifications could not be determined with sufficient confidence to guarantee adequate escapement of krill for conservation of the resource, so that such an approach would be inadequate in isolation, but might be used in conjunction with other approaches.

Indicator Species (and Other Indirect Methods)

6.20 The concept underlying this approach is to detect deleterious effects of krill fishing by monitoring condition factors of a small range of predators.

6.21 A positive aspect of this approach is its direct appeal to Article II, in terms of which predators must be monitored in any case. Further, it captures the effects of the location of fishing, which may adversely affect land-breeding predators while not compromising conservation of the krill resource itself.

6.22 Difficulties are calibration of non-linearities in the predator index versus krill abundance relationship, and the possibilities of time-lags in this relationship which could mean that it fails to provide timely warning of a threat to the krill resource. Further, distinguishing the effects of natural events from those of the fishery can be problematic.

6.23 As with closed areas, this approach would not be adequate on its own, but might form part of a suite of management tools.

6.24 Monitoring certain factors, such as environmental variables, might provide an indication of where krill is likely to be found, but this approach provides information on the krill habitat only, and not on resource status which is essential from a management perspective.

Pulse Fishing

6.25 Pulse fishing is intense fishing in a number of areas in sequence, so that the stock in a given area has recovered by the time that fishing recommences there.

6.26 No advantages were seen in such a system. Stock size and productivity would still have to be estimated (as for predictive management), continuous movement of the area of operation would probably be unattractive for the fishing operations, and heavy exploitation in a localised area would be likely to conflict with concerns for land-breeding predators.

Feedback Management

6.27 Feedback management involves successive adjustments to control measures (such as catch limits) as more information about the resource becomes available, so that management objectives are better achieved. Any management approach eventually requires adjustment in this feedback manner. An example of a possible feedback management approach for krill is given in SC-CAMLR-VIII/BG/17.

6.28 Feedback management procedures are developed by simulation testing and can be designed to be relatively robust to a number of the uncertainties about a stock's dynamics. Such trials also provide information on the relative value of different kinds of information about the stock; this information may be under consideration for collection.

6.29 Feedback management may require costly monitoring, and so may not be justified in the initial phase of a developing fishery. However, the development period should be used to test and select from a number of candidate feedback procedures, as well as to collect base-line information, so that such a procedure can be put into operation immediately the fishery reaches the appropriate size.

6.30 The Working Group agreed that developing a feedback management procedure for krill should be a long-term aim. In the meantime, the other approaches discussed would have to provide the basis for formulating the advice on precautionary measures for the krill fishery that had been requested by the Commission.

Precautionary Limits on Krill Catches

6.31 The preceding meeting of the Commission had asked for an indication of the best estimate of a precautionary limit for krill in the various statistical areas and an identification of the various options for the basis on which such a precautionary limit could be established (CCAMLR-IX, paragraph 8.5).

6.32 At that meeting 'The USSR, Japan and Korea stated their view that they were not in principle opposed to the idea of a precautionary limit on krill fishing, but that the quantitative basis for such a precautionary limit on fishing should have scientific justification based on assessments performed by the Scientific Committee' (CCAMLR-IX, paragraph 8.7).

6.33 The Working Group decided to concentrate its efforts on providing estimates for precautionary limits in the form of annual catches. However, it recognised that such limits could be formulated in different terms to achieve similar aims. For example, a limit might be set in terms of fishing effort, expressed, for instance, in vessel-months. Nevertheless, the level of effort selected would probably have to be derived from a prior calculation of an appropriate catch limit.

6.34 The Working Group noted that the rationale underlying the consideration of precautionary measures is the prevention of unregulated expansion of the fishery at a time when the information available for predicting potential yield is very limited. It stressed that such measures were short-term and would need regular review. Further, they were of an interim nature and should be superseded as soon as the information for an improved basis for management becomes available.

6.35 The Working Group recognised that it is possible to devise precautionary measures based on whole statistical areas or on individual subareas, and that each approach has different consequences.

6.36 The whole-area approach has the advantage that it is less sensitive to spatial and temporal variability, and allows a higher degree of flexibility to the fishery. The disadvantages of this approach are that the krill and predator populations may not enjoy the same degree of protection as they would under a scheme utilising the subarea approach.

6.37 Two alternative bases for specifying precautionary catch limits were considered for Statistical Area 48. The first sets these limits in relation to historical catches in the area. The second utilises the $Y = \lambda MB_o$ formula (see paragraphs 6.42 to 6.55 below) to specify a level of catch below which no management action would be necessary.

Historical Catch Basis

6.38 Table 5 provides precautionary limits based on historical catches in Statistical Area 48. The approach is to set the limit equal to the maximum annual catch that has been taken.

6.39 Two options are shown. The first is a whole-area approach which sets the limit for Statistical Area 48 to the sum of the maximum catch taken from each of the subareas over the history of the fishery, which is 619 500 tonnes.

6.40 The second option limits the catch in each subarea to the maximum ever taken in that subarea, but also 'caps' the catch in the whole area by the maximum catch ever taken in the whole area in one year, which is 425 900 tonnes. The reason for such a 'cap' is that there may be only one stock in the area, with variations in distribution from year to year, so that the calculation of the first option would overestimate an appropriate limit.

6.41 There are a number of objections to this general approach as the basis for setting precautionary limits:

(i) there is little scientific basis or relation to assessment of the stock;

(ii) the limits could be unnecessarily restrictive if the stock is capable of yielding much greater amounts than have been taken historically; and

(iii) it takes no account of changes in fishing effort due to economic and other factors.

' $Y = \lambda MB_o$ '

6.42 The formula $Y = \lambda MB_o$ provides an estimate of the potential yield from a resource. The resultant figure would be higher than would be appropriate for a precautionary limit for krill catches because:

(i) a precautionary limit should be <u>below</u> the possible ultimate level for the fishery, since the later stages of the growth of the fishery to such a level should take place under an improved management procedure (e.g. feedback control); and

(ii) allowance needs to be made for uncertainty in the estimates of the parameters used for the $Y = \lambda MB_o$ calculation.

6.43 A 'discount' factor **d** is introduced into the formula for these reasons. This factor has to be selected somewhat arbitrarily at this time, but common sense suggests that it should be neither too close to 1 nor too small. A value of 0.5 or 0.67 might therefore be appropriate; the calculations in Table 6 have used **d** = 0.67.

6.44 Values of λ were only available for the combination of choices for recruitment variability ($\sigma_{\mathbf{R}}$) and natural mortality (**M**) reported in Table 2 of WG-Krill-91/24. A selection had therefore to be made from amongst these combinations.

6.45 It was decided to base calculations on the choice $\sigma_{\mathbf{R}}$ = 0.4. The parameter $\sigma_{\mathbf{R}}$ measures the standard deviation in the natural logarithm of krill year-class strength. No information is as yet available from which to estimate σ_R for krill in Statistical Area 48, but 0.4 is a typical value for stocks of other pelagic prey species.

6.46 For $\sigma_{\mathbf{R}}$ = 0.4, the product λ **M** is relatively insensitive to whether **M** = 0.3 or 0.6 yr^{-1}. Further, there is no indication of a value of **M** as low as 0.3 in Table 4. Thus it was decided not to consider results for **M** = 0.3 further.

6.47 The preponderance of values for **M** in Table 4 is nearer to **M** = 1.0 than **M** = 0.6. However, the values in this table all assume **Z** = **M**, i.e. that fishing mortality is zero, so that they will be positively biased to some extent. Further, estimates of **M** are correlated with the growth rate used for krill; since a slowish growth rate was assumed for the calculations of WG-Krill-91/24, it would be inappropriate to use the results of that paper for a very large estimate for **M**.

6.48 Taking these facts into account, and appreciating that considerable uncertainty about an appropriate choice for **M** still remained, the Working Group decided that results should be reported both for **M** = 0.6 and **M** = 1.0.

6.49 The two values of **d**λ**M** are 0.093 and 0.14. The calculations based on these values are presented in Table 6.

6.50 The biomass estimates selected under Option 1 in Table 6 for the various subareas of Statistical Area 48, correspond to the most recent and extensive surveys in these regions. There are further recent estimates available (e.g. that given in WG-Krill-91/22 for Subarea 48.1), but substitution of such estimates would not substantially alter the results given.

6.51 Nevertheless, these estimates are for localised surveys within each subarea, and therefore provide negatively biased estimates of krill biomass in these regions, and fail to allow for immigration and emigration of krill transported by currents.

6.52 Accordingly, the biomass estimates shown should be multiplied upwards by a 'flux' factor (**f**), before being taken to correspond to the $\mathbf{B_o}$ value required for the formula. The precautionary limits shown corresponding to Option 1 (which assume **f** = 1) are therefore considerably smaller than is realistic.

6.53 Values for **f** in the range 2 to 4 may be appropriate. Option 2 in Table 6 gives results for a specific estimate of **f** in Subarea 48.1. However, there are possible problems in applying an **f** factor to every subarea because, unless these subareas contain effectively isolated stocks of krill, some multiple-counting may arise.

6.54 The Working Group's preferred basis for calculation is therefore Option 3 of Table 6. This uses the FIBEX estimate of biomass which is calculated from the results of simultaneous sampling of krill by a number of vessels at various localities throughout Statistical Area 48, and thus provides a direct estimate of $\mathbf{B_o}$ with little need for adjustment by some **f** factor.

6.55 The resultant estimate for a precautionary limit for the krill catch in Statistical Area 48 on this basis therefore lies in the range 1.4 to 2.1 million tonnes. These values are compatible with those for Options 1 and 2 in Table 6, if allowance is made for flux factors.

Other Information

6.56 The Working Group agreed that it was desirable to have more than one approach to calculating a precautionary limit, as more confidence could be placed in the result if different approaches provided similar answers.

6.57 Table 7 shows the results of an approach by Yamanaka (1983) based on a model of krill, natural krill predators and the fishery, which suggests that an appropriate level of fishing mortality would be 10%. This leads to a precautionary limit of 1.5 million tonnes for Statistical Area 48 (also using the biomass estimate from the FIBEX survey).

6.58 SC-CAMLR-VIII/BG/17 investigated a feedback control management procedure for krill in Statistical Area 48. Its calculations suggested that a precautionary catch limit (below which no restrictions would be placed on the rate of expansion of the fishery) should lie in the range 1 to 2 million tonnes.

6.59 The values suggested by these two different approaches in paragraphs 6.57 and 6.58 are therefore similar to those obtained from the $Y = \lambda MB_o$ approach and listed in paragraph 6.55 above.

Conclusions

6.60 The Working Group agreed that its best estimate of a precautionary catch limit for krill in Statistical Area 48 is 1.5 million tonnes. Shortage of time prevented consideration of similar calculations for other areas and the Working Group recommended that these calculations be performed as soon as practicable.

6.61 The Working Group also agreed that this estimate for Statistical Area 48 should be divided on a subarea basis, to allow for the possibility that these subareas contain separate stocks. However, the calculations required to do this could not be performed, because the basic FIBEX data divided by subareas were not available at the meeting. The Working Group recommended that these calculations be carried out as a priority.

6.62 It was further noted that these calculations should ideally include immigration and emigration rates between subareas as discussed in paragraphs 4.61 to 4.82 and 6.52 to 6.55.

6.63 Dr Shust stated that the Soviet Delegation wished to re-emphasise the concerns they had raised earlier in the report about the various methods suggested for calculating a precautionary catch limit. These particular concerns are reflected in paragraphs 6.41 and 6.50 to 6.54. In the light of their concerns they considered that the best estimate arrived at in paragraph 6.60 was not necessarily an adequate basis for a recommendation for a precautionary limit.

6.64 In response, other members wished it noted that they too shared the concerns indicated above and had raised questions reflected in paragraphs 6.50 to 6.54. These concerns did not detract from the situation that the present calculations were the best that could be made at this time.

6.65 Dr Naganobu stated that Japan has been concerned that placing precautionary limits on the krill fishery would be premature. This is because:

(i) krill catches remain small compared, for example, to the krill consumed by baleen whales before their removal from the Antarctic ecosystem (the so-called 'krill surplus');

(ii) the available scientific information on which to base any precautionary limits is still subject to considerable uncertainty; and

(iii) there should not be unnecessary limitations on countries making rational use of renewable marine resources.

6.66 Dr Naganobu added that this should not be understood to imply that Japan was not concerned about the need for appropriate regulation of krill catches, and stated that he felt the approach advocated by the Working Group to formulate a precautionary limit might have potential. However, he needed more time to consider the details of this approach in consultation with his scientific colleagues in Japan, and accordingly wished to reserve Japan's position in respect of the Working Group's conclusions in paragraphs 6.60 and 6.61.

ADVICE TO THE SCIENTIFIC COMMITTEE ON THE STATUS OF STOCKS

The Status of Krill Stocks

7.1 The Working Group had sufficient time to review only the krill resource in Statistical Area 48. It considered the estimate of 15.1 million tonnes from FIBEX (now adjusted for a revised acoustic target strength relationship, see paragraph 4.30) to be the best available for the biomass of krill in the area (see paragraphs 6.60 to 6.61).

7.2 Calculations based on the formula $Y = \lambda MB_o$ suggest that current catches in Statistical Area 48 are well within the likely limits of productivity of the resource, if the harvest is viewed as a single-species fishery (compare Tables 5 and 6; see also paragraphs 6.42 to 6.55).

7.3 Nevertheless, much of the catch is taken in close proximity to colonies of land-breeding predators. Available evidence does not allow a determination of whether the fishery is having a marked effect on these colonies.

7.4 The Working Group agreed that its best estimate of a precautionary catch limit for krill in Statistical Area 48 is 1.5 million tonnes. This should be divided on a subarea basis as indicated in paragraph 6.61.

New and Developing Fisheries

7.5 At the 1990 Meeting of the Commission, the Executive Secretary had been asked to prepare a working document relating to appropriate definitions of 'new and developing fisheries'. Underlying this request was the concern that fishery development should not proceed faster than development of the data base necessary to assess the effects of harvesting on target, dependent and associated species.

7.6 Dr D. Powell (Secretariat) introduced document CCAMLR-X/6 which he had prepared towards this end, and sought comments from the perspective of WG-Krill on the ideas it contained, particularly in regard to the suggested definition of a 'New Fishery':

> 'A NEW FISHERY is a fishery on a species using a particular fishing method in a statistical subarea, for which catch and effort data never have been submitted to CCAMLR; or, a fishery on a species using a particular fishing method in a statistical subarea, for which catch and effort data have not been submitted to CCAMLR for at least the past two years.'

7.7 Comments made included:

(i) the definition did not adequately capture the sense of the information requirement, particularly as survey biomass estimates rather than effort data might be of more pertinence to krill;

(ii) there should be room for flexibility on common sense grounds;

(iii) the matter of differences between data submitted and data requested needed to be addressed; and

(iv) comments already made by WG-FSA were relevant from the krill fishery viewpoint as well.

7.8 Some views were expressed that 'definitions' *per se* might be problematic to develop, and that listing criteria might be more useful.

7.9 In summary, it was seen as important that the definition suggested be expanded to reflect the types of information needed for assessment purposes.

CCAMLR Scheme of International Scientific Observation

7.10 The Working Group noted that the Commission at its 1991 Meeting, will discuss the details of an international scientific observation scheme. A paper (CCAMLR-X/7) has been prepared by the Secretariat to assist in the discussions. Each of the Working Groups of the Scientific Committee have been asked to provide an input to the discussions in the form of tasks to be undertaken and methods to be used by scientific observers on board fishing vessels.

7.11 At its 1990 Meeting the Working Group had discussed a form used by Soviet observers to report biological information from commercial krill catches. This form was modified and expanded as a result of these discussions and distributed by the Secretariat in January, 1991 as SC-CIRC 91/1.

7.12 After some further modification it was agreed that these forms should be submitted to the Scientific Committee for inclusion in its advice to the Commission on the CCAMLR Scientific Observer Scheme.

7.13 The Working Group also noted that to use the above forms effectively, it will be necessary to provide some form of detailed handbook to ensure that Standard Methods are used. Consequently the Working Group welcomed an offer from the Soviet Delegation to provide the handbook accompanying their report of observation form and a colour identification chart of krill to the Secretariat. The Secretariat was requested to circulate a translated version of the handbook to Members during the intersessional period.

Future Work of WG-Krill

7.14 Table 8 provides a list of data and research requirements previously identified by the Working Group. The list is annotated to indicate progress to date, and also to indicate the Working Group’s comments on further action necessary.

7.15 Although a number of the topics identified by WG-Krill at its last meeting remained on the Working Group’s agenda, there was strong agreement that its work had progressed well. In particular, refinement of estimates of potential yield including the investigation of krill fluxes between areas in Statistical Area 48, the estimation of precautionary limits and discussions on the development of various approaches to management were seen as important.

7.16 The Working Group agreed that of the topics identified elsewhere in the report (see for example Table 8) which require further work during the forthcoming year, the following should be given the highest priority:

- investigations of flux in Statistical Area 48 and other areas;

- estimation of total effective biomass in Statistical Area 48 and other areas; and

- refinement of calculations of potential yield including further evaluation of the pertinent population models and demographic parameters used in such calculations.

7.17 Subject to these priorities, the Working Group recognised that its ongoing work should also continue to address problems associated with survey design, development of management approaches and the continued liaison with WG-CEMP on matters of common concern.

7.18 In regard to the continued collection of data from the commercial fishery the Working Group emphasised that:

(i) length frequency data from the fine-scale reporting areas should be submitted to the Secretariat. The Working Group acknowledged that the collection of this data would, to a large extent, only be possible by specially trained personnel; and

(ii) haul-by-haul data should be collected and submitted to the Secretariat. The Working Group recognised that the collection and submission of such data may on occasion be problematical.

7.19 The Working Group further agreed that the priority tasks referred to in paragraph 7.16 above should form the basis of the agenda for the Working Group's next meeting. It was noted that the Scientific Committee at its 1991 Meeting, will almost certainly raise matters for inclusion on this agenda. It was agreed that the favoured timing for the meeting of WG-Krill in 1992 would be July/August.

OTHER BUSINESS

8.1 The Convener advised that he had made formal contact with SCOR as he had been previously requested to do (SC-CAMLR-IX, Annex 4, paragraph 129), and had been forwarded several documents related to water circulation studies. Copies of these would be available through the Secretariat, and SCOR would be thanked for their response.

8.2 The Convener also made reference to a letter received last year from the Soviet Academy of Sciences concerning the potential impact of the krill fishery. A number of the papers submitted to the current meeting expressed views of members of the Academy (WG-Krill-91/4, 5 and 6) and these had been taken into account by the Working Group in its deliberations. It was agreed that this matter had now received appropriate consideration.

8.3 Dr Butterworth had written to the Convener pointing out that perceptions that there was the potential for a very large sustainable catch from the krill resource were based primarily on calculations of the so-called ‘krill surplus’ (the annual consumption of krill by major predators which have been subsequently removed from the Antarctic ecosystem). However, such calculations were now more than 10 years old, and many of the data and perceptions on which they were based had subsequently been revised. Dr Marín drew attention to further comments made on this matter in WG-Krill-91/4.

8.4 Dr Butterworth suggested that the time was appropriate for a review of the ‘krill surplus’ concept and a re-estimation of its magnitude, and that these might be effected by an expansion of the terms of reference of the planned joint IWC/CCAMLR Workshop on the Feeding Ecology of Southern Baleen Whales.

8.5 The Working Group agreed that a review of this matter was timely, and would provide information useful to WG-Krill. It noted that effective evaluation of the surplus would require consideration of predators other than baleen whales alone, and that WG-CEMP had plans for work along related lines (see paragraph 5.11). The Working Group believed that the Scientific Committee would be best placed to consider the most effective way to pursue the matter further.

ADOPTION OF THE REPORT

9.1 The report of the Third Meeting of the Working Group on Krill was adopted.

CLOSE OF THE MEETING

10.1 In closing the meeting, the Convener thanked the Convener of the Subgroup on Survey Design and the various task group conveners, the Secretariat and all the rapporteurs for their support and assistance in ensuring the meeting's smooth running. He also thanked the participants for the input and indicated that in his opinion the good spirit prevailing during the meeting was to a large measure the reason for the wide ranging discussions held and the comprehensive report that was a result. Finally, he thanked the meeting hosts, Southern Basin Joint Fishery Enterprise 'Yugryba' and the Oreanda Hotel for their hospitality and organisational support.

Table 1: Estimates of flow between areas in Figure 2.

Flux	Speed/Transport Time	Method	Proportion of Krill Standing Stock Exported	Reference and Comment
1. Inputs				
PA	Flux exists			
	Mean 0.20 m s^{-1}	Drift buoys		Capella, Ross, Quetin and Hoffmann (in press)
	~ 0.10 m s^{-1}	Geostrophic and current meters below 200 m		Referenced in WG-Krill-91/15
	Replacement of water mass off Peninsula ~ twice within 150 days ~ 3 months residence time	Production and fishing data		WG-Krill-91/15 and WG-Krill-91/36
			~ 100% imported from south-west 100% exported to east and north-east. Minor flow back to south-west with coastal current.	Siegel (1988)
	0.26 - 0.64 ms^{-1}		General flux of patches with the current within the Antarctic Peninsula region.	Everson and Murphy (1985)
2. Upstream Fluxes These fluxes exist and are probably significant but variable from year to year.				
AB	0.05 - 0.10 m s^{-1} 0.19 m s^{-1}			Flux from Peninsula goes to South Georgia and South Orkneys WG-Krill-91/39 Nieler, P. (Racer unpublished, MS)
BC	Probably exists			
AC	5.5 months 0.3 - 0.4 m s^{-1}			WG-Krill-91/22 Foster (1984) General for ACC

Table 1 (continued)

Flux	Speed/Transport Time	Method	Proportion of Krill Standing Stock Exported	Reference and Comment
3. Exports Losses probably exist but are uncertain and variable.				
AL	Rates similar to PA		100% export to east and north-east. Minor part back to south-west with coastal current.	
BL CL	Rates similar to AB, BC, AC classes		Loss is 100% to the east	General flow through areas Siegel (1986) Biomass - FIBEX Results of first Biomass Workshop *Biomass Rep. Ser. (22)*
4. Reverse Flows				
BA	Unknown/impossible			Unrealistic
CA	Possible	Months/years	Low	
CB	Possible		Possible via Weddell gyre but takes more than a year - probably longer	Maslennikov (1980) *Oceanology 2*: 192-195
			Number very low	Siegel (1986)

Key to flux codes:

PA Pacific to Antarctic Peninsula
AB Antarctic Peninsula to South Orkneys
BC South Orkneys to South Georgia
AC Antarctic Peninsula to South Georgia (direct)

AL Antarctic Peninsula loss
BL South Orkney loss
CL South Georgia loss

BA South Orkneys to Antarctic Peninsula return
CA South Georgia to Antarctic Peninsula return
CB South Georgia to South Orkneys return

Table 2: Von Bertalanffy growth function (VBGF) for krill.

Yearly growth Parameter **K**	$\mathbf{L}_\infty$	Method	Reference
0.445 / 0.429	62.4 / 62.5	Ford-Walford Plot	Siegel (1986)
0.445 / 0.4018	61.8 / 63.8	Non-linear regression VBGF	Siegel (1986)
0.4728	61.0	Modified VBGF (Pauly and Gaschütz, 1979)	Siegel (1986)
(0.27) 0.43 - 0.47	60.0	VBGF (seasonal growth)	Rosenberg *et al.* (1986)
0.478 / 0.354	63.3 / 61.3	Non-linear regression VBGF	Siegel (1987)
0.8		ELEFAN*	McClatchie (1988)

* Length-frequency analysis program

Table 3: Daily growth rates of Antarctic krill.

Daily Growth Rate (mm/day)	Comments	Reference
0.0354	Laboratory experiments	Murano *et al.* (1979)
0.07	Laboratory experiments (22 to 44 mm length)	Ikeda *et al.* (1985)
0.024 - 0.044	Laboratory experiments	Poleck and Denys (1982)
0.047	Laboratory experiments juvenile krill	Ikeda and Thomas (1987)
0.13	Theoretical approach, using a 90-day growth period for the year	Mauchline (1980b)
≡ 0.032	Mean annual growth rate	
0.141	In summer for 30 mm length class	Rosenberg *et al.* (1986)
0.083 - 0.156	Laboratory experiments for 32 mm length class	Buchholz (1988)
0.033	Mean annual growth rate for all age groups	Siegel (1986)
0.12	Juvenile age group 1+ in summer	
0.07	Sub-adult age group 2+ in summer	
0.13	0 age group in summer	McClatchie (1988)
0.025	Adult ≥ 3+ age group in summer	
0.01 - 0.048	In winter	

Table 4: Estimates of krill natural mortality.

M = **Z**	Method	Area	Reference
5.5	Edmondson's method		Kawakami and Doi (1979)
	Abundance data of length groups	Scotia sea	
2.31	Larval to sub-adults, 1-2 years old		Brinton and Townsend (1984)
0.51	2-3 years old		
0.78 - 1.17	Linearized catch curve data	Ant. Peninsula	Siegel (1986)
0.88 - 0.96	Linearized catch curve data		Siegel (1991)
0.94 - 0.99	Pauly (1980) formula on VBGF and **M** relationship		Siegel (1986)
0.8 - 1.35	**M** = 2 times **K** of VBGF	Scotia Sea	Priddle *et al.* (1988)
0.5	1-cumulative length frequency	RV *Discovery* data	Basson and Beddington (1989)
0.45 - 0.65	Length dependent predation curve		

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Table 5: Precautionary limits for Statistical Area 48 based on historical catch data.

Option	Subarea	Method of Calculation	Precautionary Limit 10^3 tonnes
1	Total of 48.1, 48.2 and 48.3	Sum of the maximum catches from each subarea over all years	619.5
2	48.1 48.2 48.3	Maximum catch over all years in subarea	105.6 257.7 256.2
	Total of 48.1, 48.2 and 48.3	Maximum of combined catch from three subareas over all years	425.9

Table 6: Precautionary levels based on the **dλMB₀** formula. Biomass estimates are from several sources. The calculations have assumed a discount factor **d** = 0.67, **M** = 0.6 and 1.0, and corresponding values of λ from Table 2 of WG-Krill-91/24 (the corresponding values of **dλM** were 0.093 and 0.14 respectively). The biomass estimates for Options 1 and 3 are unadjusted for flux (paragraphs 6.52 to 6.55); for Option 2 the biomass for Subarea 48.1 only is adjusted following the flux calculations presented in WG-Krill-91/15.

Option	Subarea	Data Source	Reasons for Choice	Year	Method	Area Covered (n. miles^2 x10^3)	Biomass (10^6 tonnes)	Precautionary Limit (10^3 tonnes) **dλM** = 0.093	Precautionary Limit (10^3 tonnes) **dλM** = 0.14
1	48.1	WG-Krill-91/15	Most extensive	Dec/Jan 1989/90	Net	92.8	1.16	107	162
	48.2	SC-CAMLR-VIII/BG/10	Only survey	Jan 1985	Acoustic	2.0	2.85[1]	264	399
	48.3	WG-Krill-91/30	Most extensive	Nov/Dec	Acoustic	45.5	1.83	169	256
	Total of 48.1, 48.2, 48.3						5.84	540	817
2	48.1	WG-Krill-91/15 estimates of production and flux over the summer months for Subarea 48.1 only.					4.3	398	602
	Total of 48.1, 48.2, 48.3	Total flux calculation for Subarea 48.1 only (from WG-Krill-91/15), plus Subareas 48.2 and 48.3 as above.					8.98	830	1 257
3	Total	Miller and Hampton (1989)	Combined FIBEX results	1981	Acoustic		15.1[1]	1 404	2 114

[1] This figure was calculated from the original FIBEX estimate multiplied by 5.7 to take into account the difference between the target strength values used during FIBEX and the most recent estimates of TS - see Figure 1 and Appendix F.

Table 7: Precautionary limit based on Yamanaka's calculations. A coefficient of 0.1 (Yamanaka, 1983) is applied to the estimate of biomass.

Subarea	Data Source	Reasons for Choice	Year	Method	Biomass 10^6 tonnes	Precautionary Limit 10^3 tonnes
Whole area	Miller and Hampton (1989)	Combined FIBEX results	1981	Acoustic	15.1[1]	1 500

[1] This figure was calculated from the original FIBEX estimate multiplied by 5.7 to take into account the difference between the target strength values used during FIBEX and the most recent estimates of TS - see Figure 1 and Appendix F.

Table 8: Data requirements.

Data Required	Reference	Data Submitted	Comments/Discussion at WG-Krill-III
Operational definitions of Article II	SC-CAMLR-IX, paragraph 2.19	No definitions submitted	These definitions probably need to be developed in conjunction with proposed management procedures (see paragraph 6.3).
Estimation of total effective biomass	SC-CAMLR-IX, paragraph 2.33	Papers WG-Krill-91/15, 22 and 30 provide estimates of recent surveys for Subareas 48.1 and 48.3	Further work should be done to estimate total biomass from all Subareas of Statistical Area 48, including re-working of FIBEX data. All estimates provided should be accompanied by a c.v. together with a description of the survey design and basis for strata selection (see also SC-CAMLR-IX, Annex 5, Appendix F).
Suggestions of methods to take account of predator needs	SC-CAMLR-IX, paragraph 2.40	WG-CEMP-91/25, estimates relative rates of catch and consumption	A ‘discount’ factor was used in calculation (Table 5); continued requirement, which the WG-CEMP will be addressing.
Estimates of potential yield should be obtained for areas other Subarea 48.3	SC-CAMLR-IX, paragraph 2.41	WG-Krill-91/24	Results shown in Table 5 for all subareas of Statistical Area 48. Statistical Areas 58 and 88 still to be addressed. Specification of further calculations required for the $Y = \lambda MB_0$ formula are given in Appendix E.
Review of demographic parameters	SC-CAMLR-IX, Annex 4, paragraphs 46 to 47	Siegel (in press): reproduced in Tables 2 to 4	Continued requirement (paragraph 4.94). The estimates in Tables 2 to 4 need to be reviewed by Working Group members.
Acoustic target strength	SC-CAMLR-IX, paragraph 2.31	WG-Krill-91/13, 29 and 40	Continued requirement (paragraph 4.30(i)).
Acoustic survey designs	SC-CAMLR-IX, paragraph 2.31	Appendix D and referenced papers	Continued requirement (paragraph 4.14, 4.16 to 4.20
Krill movement	SC-CAMLR-IX, paragraph 2.37	Table 1	Continued requirement (paragraph 4.80).
Analysis of fine-scale fisheries data	SC-CAMLR-IX, paragraph 2.65	WG-Krill-91/9, and 39 WG-CEMP-91/25	Continued requirement.
Observer reports from commercial fishery	SC-CAMLR-IX, Annex 4, paragraph 121	WG-Krill-91/12	Continued requirement (paragraph 3.9).
Investigation of sampling regimes for krill length-frequency data	SC-CAMLR-IX, paragraph 2.68	No investigations submitted	Continued requirement to assess optimum sample size and sampling regime.

Table 8 (continued)

Data Required	Reference	Data Submitted	Comments/Discussion at WG-Krill-III
Observer reports from commercial fishery	SC-CAMLR-IX, Annex 4, paragraph 121	WG-Krill-91/12	Continued requirement (paragraph 3.9).
Investigation of sampling regimes for krill length-frequency data	SC-CAMLR-IX, paragraph 2.68	No investigations submitted	Continued requirement to assess optimum sample size and sampling regime.
Length-frequency data	SC-CAMLR-IX, paragraph 2.68	WG-Krill-91/12 was only data submitted	Continued requirement (paragraph 7.18(i)). These data should be submitted to the Secretariat.
Haul-by-haul data	SC-CAMLR-IX, paragraph 2.63	WG-Krill-91/39	These data should be collected and submitted to the Secretariat (paragraph 7.18(ii)). (1) Collection should be irrespective of proximity to CEMP sites. (2) Collection by observers may be necessary although WG-Krill-91/39 shows that for some fleets collection by commercial personnel is possible. (3) If full fleet collection is not possible, collection by a subset of fleet is desirable. (4) All haul-by-haul data should be submitted to the Secretariat. Duplicate submissions of these data in fine-scale format should not be made as they will be compiled by the Secretariat
Biological data from the fishery	This report, paragraph 7.13		Observer forms and translations of USSR methodologies will be circulated, together with instructions on data submission to the Secretariat.
Analysis of acoustic and bridge log data from the commercial fishery	SC-CAMLR-IX, Annex 4, paragraph 120		Continued requirement.
Number and capacity of fishing vessels	This report, paragraph 3.6		Should be provided in Members' Activities Reports.

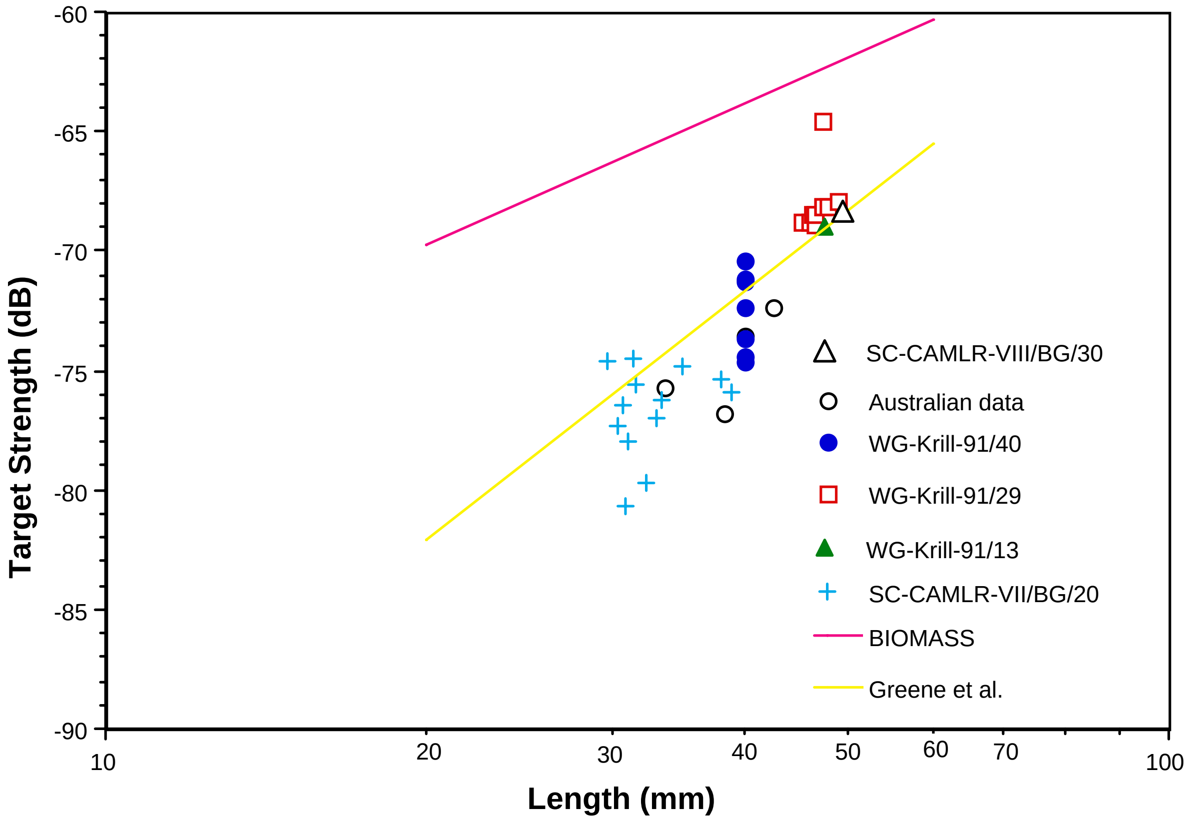

Figure 1: Target strength estimates from various sources.

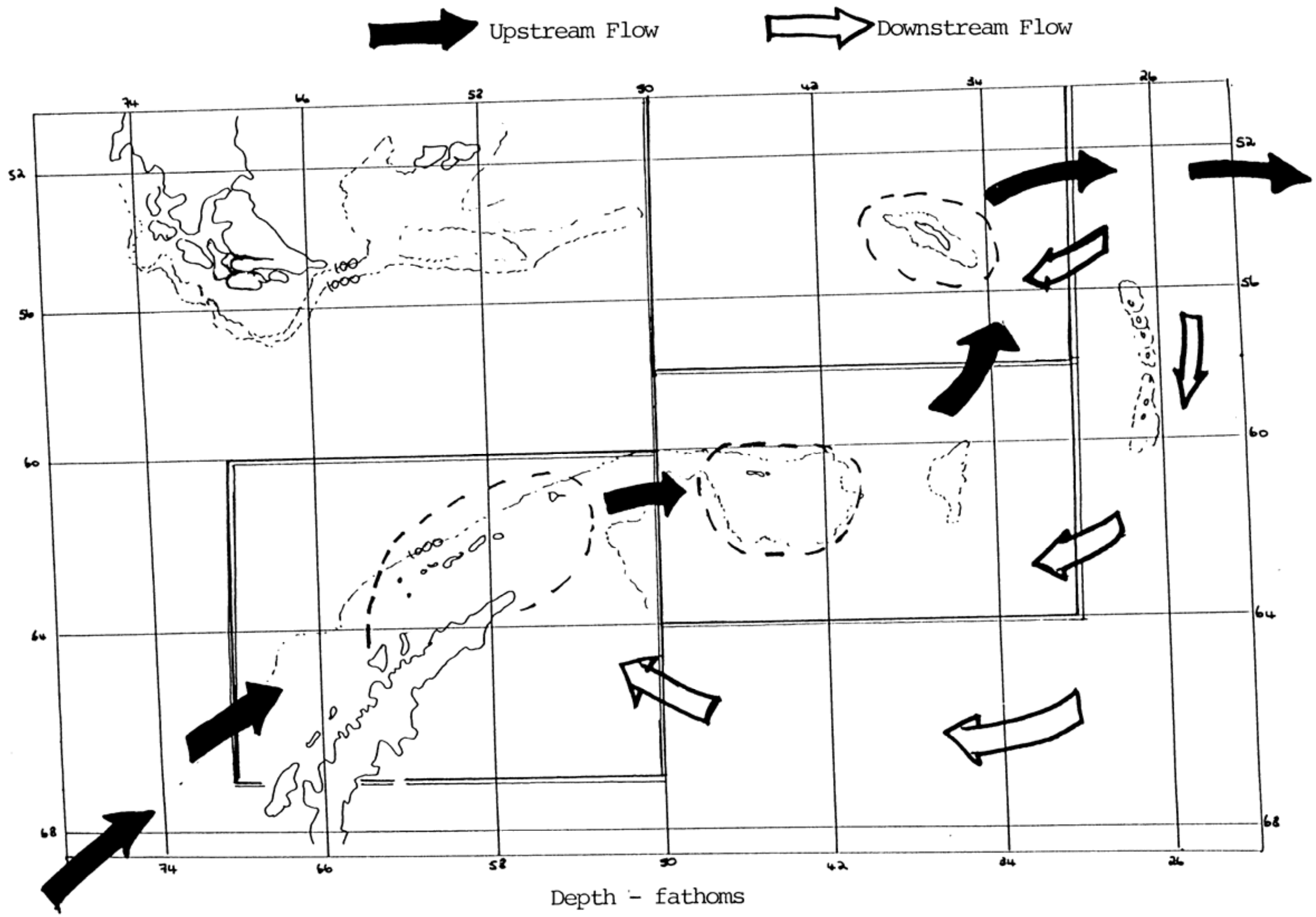

Figure 2: Schematic representation of movement of krill in the Scotia Sea. (Depth: fathoms)

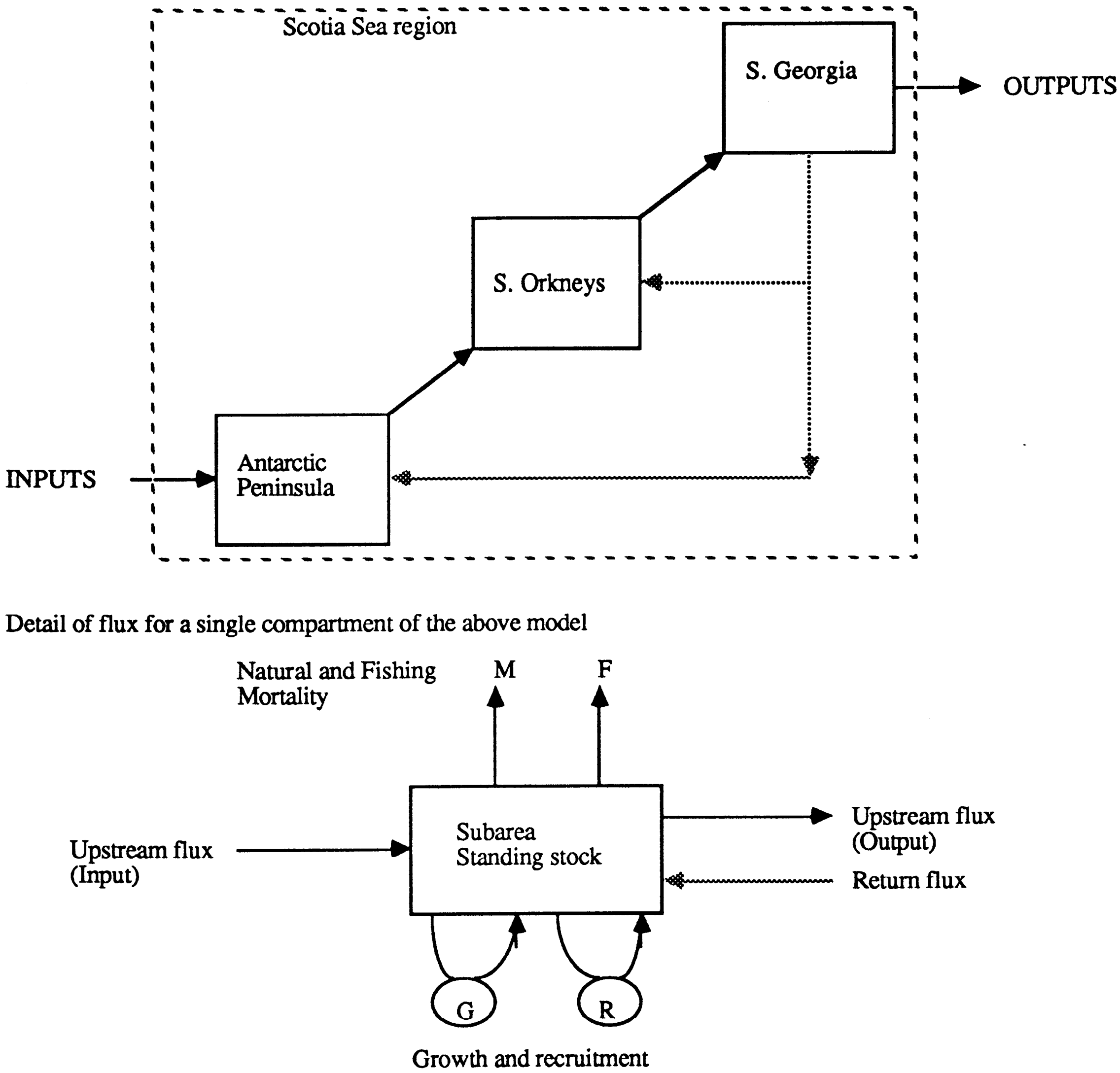

Figure 3: Functional subarea flows for one connected stock.

APPENDIX A

AGENDA FOR THE THIRD MEETING

Working Group on Krill
(Yalta, USSR, 22 to 30 July 1991)

1. Welcome

2. Introduction
   (i) Review of the Meeting Objectives
   (ii) Adoption of the Agenda

3. Review of Fisheries Activities and Other Information in 1990/91
   (i) Fisheries Information
      (a) Catch Levels
      (b) Location of Catches
      (c) Reports of Observers
   (ii) Other Information
      (a) Krill Distribution and Abundance
   (iii) Possible Future Trends

4. Information Necessary for Management
   (i) Survey Methods and Biomass Estimation
      (a) Review of the Subgroup on Survey Design's Work
      - Prey Monitoring Surveys
      - Surveys to Estimate Subarea Krill Biomass
      (b) Biomass Estimation
      - Acoustic Target Strength
      - Abundance Indicies
   (ii) Estimation of Yield and Production
      (a) Distribution
      - Stock Separation
      - Statistical Areas
      (b) Movement
      - Immigration/Emigration Rates
      - Residence Times

- Hydrographic Influences

(c) Demographic Parameters

- Natural Mortality (**M**)
- Other Essential Demographic Parameters (e.g. growth and longevity)

5. Advice to WG-CEMP
   (i) Review of Subgroup on Survey Design's Work
   (ii) Guidelines for Krill Monitoring Surveys
   (iii) Other Matters

6. Development of Approaches to Managing the Fishery
   (i) Operational Definitions of Article II
   (ii) Precautionary Limits on Krill Catches
      (a) Established and Current Fisheries
      (b) New and Developing Fisheries
   (iii) Other Possible Approaches and Their Development

7. Advice to the Scientific Committee on the Status of Stocks
   (i) The Status of Krill Stocks
   (ii) CCAMLR Scheme of International Scientific Observation
   (iii) Future Work of WG-Krill

8. Other Business

9. Adoption of the Report

10. Close of the Meeting.

APPENDIX B

LIST OF PARTICIPANTS

Working Group on Krill
(Yalta, USSR, 22 to 30 July 1991)

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APPENDIX C

LIST OF DOCUMENTS

Working Group on Krill
(Yalta, USSR, 22 to 30 July 1991)

Meeting Documents:

WG-KRILL-91/1	REVISED PROVISIONAL AGENDA
WG-KRILL-91/1 Rev.1	AGENDA
WG-KRILL-91/2	LIST OF PARTICIPANTS
WG-KRILL-91/3	LIST OF DOCUMENTS
WG-KRILL-91/4	ANTHROPOGENIC EVOLUTION OF ANTARCTICA'S PELAGIC COMMUNITIES N.M. Voronina (USSR)
WG-KRILL-91/5	ON THE CONSEQUENCES OF LARGE-SCALE HARVESTING OF MESOPELAGIC FISH AND ANTARCTIC KRILL N.I. Kashkin (USSR)
WG-KRILL-91/6	RESOLUTION OF THE ALL-UNION SYMPOSIUM "ECOSYSTEMS OF THE PELAGIC WATERS OF THE SOUTHERN OCEAN" (USSR)
WG-KRILL-91/7	CHARACTERISTICS OF KRILL SWARMS FROM PRYDZ BAY D.J. Agnew (Secretariat) and I.R. Higginbottom (Australia)
WG-KRILL-91/8	DEFINITION OF THE PROBLEM OF ESTIMATING FISH ABUNDANCE OVER AN AREA FROM ACOUSTIC LINE-TRANSECT MEASUREMENTS OF DENSITY Kenneth G. Foote and Gunnar Stefánsson (Norway)
WG-KRILL-91/9	FINE-SCALE CATCHES OF KRILL REPORTED TO CCAMLR 1988-1990 Secretariat

WG-KRILL-91/10	ON CONSTRUCTION OF MULTIDISCIPLINARY AND STOCK ASSESSMENT SURVEYS AS WELL AS ON COLLECTION OF MATERIAL ON *EUPHAUSIA SUPERBA* AND ENVIRONMENTAL CONDITIONS IN THE FISHING AREAS AND ADJACENT WATERS R.R. Makarov and V.V. Maslennikov (USSR)
WG-KRILL-91/11	PECULIARITIES OF *EUPHAUSIA SUPERBA* SIZE COMPOSITION IN STATISTICAL SUBAREA 48.2 (SOUTH ORKNEY ISLANDS) V.I. Latogursky and R.R. Makarov (USSR)
WG-KRILL-91/12	REPORT OF THE BIOLOGIST-OBSERVER FROM THE COMMERCIAL TRAWLER *GRIGORY KOVTUN*, SEASON 1989/90 A.V. Vagin (USSR)
WG-KRILL-91/13	TARGET STRENGTH OF ANTARCTIC KRILL Roger P. Hewitt and David A. Demer (USA)
WG-KRILL-91/14	OCEANIC CONDITION AND ZOOPLANKTON DISTRIBUTION/ ABUNDANCE IN BRANSFIELD STRAIT DURING AUSTRAL SUMMER 1989/1990 S. Kim and M.S. Suk (Korea)
WG-KRILL-91/15	ESTIMATION OF KRILL (*EUPHAUSIA SUPERBA*) MORTALITY AND PRODUCTION RATE IN THE ANTARCTIC PENINSULA REGION Delegation of Germany
WG-KRILL-91/16	ESTIMATION OF DISTRIBUTION CHARACTERISTICS OF THE FISHING OBJECTS FROM SHOAL LINEAR CROSS-SECTIONS (METHODICAL DIRECTIONS) Y.V. Kadilnikov (USSR)
WG-KRILL-91/17	AUTOMATED DATA COLLECTION AND PROCESSING SYSTEM RELEVANT TO FISHING OBJECT DISTRIBUTION Y.V. Kadilnikov, O.M. Khandros and Y.A. Starovoyt (USSR)
WG-KRILL-91/18	BRIEF PROGRAM AND METHODS OF INVESTIGATIONS ON KRILL DAMAGE BY MIDWATER TRAWL SECTIONS Y.V. Zimarev (USSR)
WG-KRILL-91/19	SMALL SCALE KRILL SURVEYS: SIMULATIONS BASED ON OBSERVED EUPHAUSIID DISTRIBUTIONS D.J. Agnew (Secretariat) and S. Nicol (Australia)
WG-KRILL-91/20	NOTE ON ESTIMATING ABUNDANCE FROM ACOUSTIC DATA ON INDIVIDUAL KRILL AGGREGATIONS I. Hampton and D.G.M. Miller (South Africa)

WG-KRILL-91/21	SOME COMMENTS ON THE PROCEDURE FOR TESTING ESTIMATORS OF KRILL ABUNDANCE WHICH UTILISE SURVEY DATA D.S. Butterworth, D.L. Borchers and D.G.M. Miller (South Africa)
WG-KRILL-91/22	KRILL (*EUPHAUSIA SUPERBA*) DISTRIBUTION IN RELATION TO WATER MOVEMENT AND PHYTOPLANKTON DISTRIBUTION OFF THE NORTHERN SOUTH SHETLAND ISLANDS Delegation of Japan
WG-KRILL-91/23	BRIEF REPORT OF THE SIXTH ANTARCTIC SURVEY CRUISE OF JFA R/V *KAIYO MARU* Mikio Naganobu, Taro Ichii and Haruto Ishii (Japan)
WG-KRILL-91/24	A SIMPLE APPROACH FOR CALCULATING THE POTENTIAL YIELD OF KRILL FROM BIOMASS SURVEY RESULTS D.S. Butterworth (South Africa) and M. Basson (UK)
WG-KRILL-91/25	BY-CATCH OF FISH IN THE KRILL FISHERY Inigo Everson (UK), Alexei Neyelov and Yuri Permitin (USSR)
WG-KRILL-91/26	WHEN WILL THE INFORMATION REQUIRED FOR RATIONAL MANAGEMENT OF THE KRILL FISHERY BECOME AVAILABLE AND WHAT SHOULD CCAMLR DO IN THE MEANTIME? Stephen Nicol and Andrew Constable (Australia)
WG-KRILL-91/27	KRILL AGGREGATION CHARACTERISTICS IN SOUTH ORKNEY ISLAND AREA IN APRIL 1990 P.P. Fedulov *et al.* (USSR)
WG-KRILL-91/28	POSSIBLE APPROACH TO KRILL MOVEMENT ESTIMATION BY HYDROACOUSTIC OBSERVATIONS P.P. Fedulov (USSR)
WG-KRILL-91/29	TARGET STRENGTHS OF KRILL AT 136 AND 20 KHZ S.M. Kasatkina (USSR)
WG-KRILL-91/30	ANALYSES OF ACOUSTIC LINE-TRANSECT DATA FROM THE WATERS AROUND SOUTH GEORGIA: ESTIMATION OF KRILL (*EUPHAUSIA SUPERBA* DANA) BIOMASS E. Murphy, I. Everson and A. Murray (UK)
WG-KRILL-91/31	KRILL AGGREGATION CHARACTERISTICS: SPATIAL DISTRIBUTION PATTERNS FROM HYDROACOUSTIC OBSERVATIONS D.G.M. Miller and I. Hampton (South Africa)

WG-KRILL-91/32	MIDWATER TRAWL CATCHABILITY REGARDING QUANTITATIVE ESTIMATION OF KRILL BIOMASS USING THE METHOD OF TRAWLING SURVEYS ON ABUNDANCE S.M. Kasatkina (USSR)
WG-KRILL-91/33	SOME STATISTICAL PROPERTIES OF KRILL ACOUSTICAL DATA FROM SIBEX AND ICE EDGE ZONE SURVEYS M. Godlewska (Poland)
WG-KRILL-91/34	KRILL DISTRIBUTIONS AND THEIR DIURNAL CHANGES M. Godlewska and Z. Klusek (Poland)
WG-KRILL-91/35	REPORT OF THE WORKING GROUP ON KRILL SUBGROUP ON SURVEY DESIGN (Yalta, USSR, 18 to 20 July 1991)
WG-KRILL-91/36	PRELIMINARY RESULTS OF THE POLISH COMMERCIAL KRILL FISHERY IN THE ANTARCTIC DURING 1990/91 SEASON I. Wójcik and R. Zaporowski (Poland)
WG-KRILL-91/37	CPUES AND BODY LENGTH OF ANTARCTIC KRILL WITHIN COMMERCIAL HAULS OF POLISH TRAWLER FV *LEPUS* IN THE FISHING GROUND OFF SOUTH ORKNEYS IN JANUARY AND FEBRUARY 1991 I. Wójcik and R. Zaporowski (Poland)
WG-KRILL-91/38	VOLUMETRIC ANALYSES OF ANTARCTIC MARINE ECOSYSTEM DATA Delegation of the USA
WG-KRILL-91/39	CHILEAN KRILL FISHERY: ANALYSIS OF THE 1991 SEASON Victor H. Marín *et. al.*
WG-KRILL-91/40	KRILL TARGET STRENGH ESTIMATED BY UNDERWATER PHOTOGRAPHY AND ACOUSTICS J.L. Watkins (UK)
WG-KRILL-91/41	REPORT ON DISCUSSIONS ON KRILL TARGET STRENGTH Kenneth G. Foote *et. al.*
WG-KRILL-91/42	A PROPOSAL FOR STOCK BIOMASS ESTIMATE OF *EUPHAUSIA SUPERBA* DANA BY THE ENVIRONMENTAL INDEX Q_{200} IN COMPARISON WITH HAMPTON'S METHOD (EXTENDED ABSTRACT) Mikio Naganobu (Japan)

WG-KRILL-91/43	HYDROMETEOROLOGICAL BASIS FOR FORECASTING BIOMASS AND SOME FISHERY INDICES OF ANTARCTIC KRILL IN THE SODRUZHESTVA SEA V.A. Bryantsev (USSR)

Other Documents:

CCAMLR-X/6	NEW AND DEVELOPING FISHERIES Executive Secretary
CCAMLR-X/7	CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION Executive Secretary
WG-CEMP-91/4	TEMPORAL AND SPATIAL SCALES FOR MONITORING CEMP PREDATOR PARAMETERS (WG-CEMP)
WG-CEMP-91/11	AMLR 1990/91 FIELD SEASON REPORT Delegation of the USA
WG-CEMP-91/25	KRILL CATCHES AND CONSUMPTION BY LAND-BASED PREDATORS IN RELATION TO DISTANCE FROM COLONIES OF PENGUINS AND SEALS IN THE SOUTH SHETLANDS AND SOUTH ORKNEYS, 1987-1990 D.J. Agnew (Secretariat)

APPENDIX D

REPORT OF THE WORKING GROUP ON KRILL SUBGROUP ON SURVEY DESIGN

(YALTA, USSR, 18 TO 20 JULY 1991)

INTRODUCTION

The First Meeting of the Subgroup on Survey Design of the Working Group on Krill met in Yalta, USSR, from 18 to 20 July 1991. The meeting was chaired by the Convener, Dr I. Everson (UK).

2. The Convener welcomed the Subgroup and introduced the Proposed Agenda. This was adopted with some minor changes. The Agenda is appended as Attachment 1, and a List of Participants as Attachment 2.

3. The report was prepared by Drs D.J. Agnew (Secretariat) and P.P. Fedulov (USSR).

BACKGROUND TO THE GROUP

4. The Convener outlined the Subgroup's terms of reference which were set out in paragraph 97 of the 1990 WG-Krill Report (SC-CAMLR-IX, Annex 4):

'Noting similar work being carried out within ICES, and on the basis of the *ad hoc* group's discussions, it is recommended that a small subgroup be charged to do the following:

(i) examine the problem of estimating krill biomass from acoustic measurements of density along line transects;

(ii) describe specific statistical techniques that can be used to derive estimates of biomass and associated variance;

(iii) describe how such estimates can be applied to various krill distributions, both assumed and observed;

(iv) meet for three days immediately prior to the next WG-Krill meeting in order to discuss and evaluate items (i) to (iii); and

(v) prepare a report to WG-Krill for consideration along with recommendation of specific standard techniques to be used by Members to describe krill distribution and estimate biomass from acoustic surveys.'

5. The Convener also noted that the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP) had endorsed the decision of WG-Krill to set the Subgroup up and that the members of WG-CEMP had been invited to participate in the Subgroup's work during the intersessional period, in addition to the members of WG-Krill (SC-CAMLR-IX, Annex 6, paragraphs 99 to 103).

6. A number of working papers submitted for the consideration of WG-Krill were considered by the Subgroup on Survey Design. These are shown in Attachment 3.

ANALYSES UNDERTAKEN

7. Three sets of data were available to the Subgroup on Survey Design:

- data derived from a transect in Prydz Bay in December 1990 completed by Australian RV *Aurora Australis*;

- South African data from a survey in the south west Indian Ocean during FIBEX collected by MV *S.A. Agulhas* in February/March 1981; and

- data from Germany collected during the FIBEX cruise on RV *Walter Herwig* during January to February 1981, from transects around 55°W.

These datasets were circulated to all members of the Subgroup and all members of WG-Krill and WG-CEMP were notified of their existence. Requests for the data were received from Dr V. Marín (Chile) and Dr V. Tesler (USSR).

8. Two documents presented to the Subgroup, WG-Krill-91/7 (Australia) and WG-Krill-91/31 (South Africa) described analyses based on the abovementioned datasets. The following distributional features and physical characteristics of *Euphausia superba* (WG-Krill-91/31) and *Euphausia crystallorophias* (WG-Krill-91/7) were calculated: length,

depth, thickness, between-swarm distance and biomass. An additional document (WG-Krill-91/21) used some of these data and is further described in paragraph 14. Dr E. Murphy (UK) informed the Subgroup that some swarm characteristics derived from these data had been used in some preliminary simulation studies.

9. Document WG-Krill-91/27 (USSR) presented krill aggregation characteristics derived from a survey in the South Orkney area by RV *AtlantNIRO* in April 1990. These data were not available to the Secretariat.

10. Summary statistics based on the available datasets and on information presented in tabled papers are compiled in Table 1. In general, the swarm characteristics calculated from various datasets and different subareas are in reasonable agreement.

11. The results presented in WG-Krill-91/27 emphasised that using different spatial resolution for the methods of swarm identification can lead to discrepancies in swarm dimension estimates, and that problems of this kind may be overcome by using methods with the highest resolution. Document WG-Krill-91/17 describes an automated acoustic data collection and processing system that may be employed as a standard method for collecting this type of information. The Subgroup felt that standardisation in this type of survey was important for making comparisons, but even in cases of the highest resolution possible there would probably be remaining problems, such as the operation of Doppler effects at these scales. It was also felt that because these data are often not normally distributed, provision of the raw data is important.

12. There was some discussion about the effects of target strength on survey estimates of biomass, and a number of papers concerned with target strength were tabled for consideration by WG-Krill. However, it was decided that whilst target strength has an important effect on absolute biomass estimates, the relative effect of this is the same irrespective of survey design, and target strength should more properly be addressed by WG-Krill than the Subgroup.

13. The Subgroup found WG-Krill-91/8 very useful as an introduction to the general problems and methodologies used for estimating biomass from acoustic transects. The general conclusion of this paper is that it is essential to be specific in the requirements of a survey in order to choose the methodology best suited to that survey.

14. WG-Krill-91/21 used South African data and introduced a two-level model of krill distribution which achieved overall spatial correlations similar to observed correlations,

derived by placing krill swarms at random within larger aggregations. Nevertheless, evidence of model mis-specification remains, and the ability of this kind of model and of more complex models to provide improved correlation with data needs to be investigated. This should be done before these kinds of model are used to provide simulated krill distributions to test alternative survey strategies and estimators of krill standing stock.

15. WG-Krill-91/19 examined the behaviour of two survey designs using known distributions and shapes of euphausiid swarms. It showed that parallel survey designs with transects travelling at right angles to the orientation of krill swarms have lower variances than either parallel designs with transects aligned with swarm orientation or radial designs. The relationship between the coefficient of variance and the number of transects can be used with power analysis to estimate the number of transects required to reliably detect changes in mean biomass.

16. The Subgroup recognised the importance of simulation studies to investigate various aspects of survey design in relation to krill standing stock estimates and distribution.

17. The Subgroup drew attention to the fact that there are two approaches to biomass estimation: one based on echo-integration and the other based on information from each encountered swarm. The theoretical principles and practical considerations of the last method were described in documents WG-Krill-91/16 and 17. In document WG-Krill-91/20 these approaches were compared; for the purposes of straightforward abundance estimation it was concluded that the echo-integration method has some advantages, since it is easier to apply and does not involve assumptions concerning aggregation distribution or form.

18. However, it was suggested that both methods were important in providing different information (on abundance, or on aggregation distribution) and that the appropriate design should be chosen for the task being considered.

19. The use of data from a large-scale acoustic survey around South Georgia in the estimation of total krill biomass was described by WG-Krill-91/30. Data were analysed using various definitions of strata. The Subgroup agreed that the use of strata for biomass estimation should improve biomass estimates. The paper briefly discusses other methods of survey analysis, and in particular cautions against the uncritical application of bilinear interpolation techniques.

20. A simulation model produced by Dr Murphy was discussed. The model is hierarchical and capable of introducing variation at different scales. It is of high resolution,

producing metre-by-metre transect data, and the effects of current and swarm movement are included. The model is being used to investigate survey design (for standing stock estimation) and the techniques for the analysis of swarm distribution.

21. A general approach to survey design proposed in WG-Krill-91/10 may provide the opportunity to obtain the information necessary for an abundance estimate as well as for a broad spectrum of additional problems (krill transport, distribution patterns, aggregation formation) in the larger area of the whole Scotia Sea. The approach is based on the combination of surveys of three different scales - micro, meso and macro. It was pointed out that this approach, whilst it would require the organisation of and cooperation between several vessels, would contribute significantly to the establishment of a baseline biomass estimate ($\mathbf{B_o}$) for the area in addition to contributing to the question of migration. Dr Murphy suggested that simulations, including the use of oceanic models of the form of the IOS* Fine Resolution Antarctic Model (FRAM), would contribute to investigation of the factors determining the large-scale distribution of krill.

22. Two papers described data from surveys completed in the current year (WG-Krill-91/7 and 22) and this was appreciated by the Subgroup. WG-Krill-91/22 described a survey off the South Shetlands by Japan which showed a relationship between krill distribution and water movements. Mr D. Miller (South Africa) informed the Subgroup that principal components analysis on some German data had shown that 60% of the variance in krill aggregation characteristics could be attributed to hydrographic variability and that this would have importance in the definition of strata for surveys.

23. WG-Krill-91/28 described a study on krill movement with respect to water current. This involved a repeated series of rectangular box surveys.

ANALYTICAL TECHNIQUES

24. The development of a survey design is dependent on scales of the processes being investigated. The various aspects in the development of acoustic survey designs for fish populations have been extensively studied. Particular reference was made to the ICES FAST (Fisheries Acoustic Science and Technology) Working Group. Key elements of any survey design are:

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* Institute of Oceanographic Sciences, UK

(i) definition of survey area;

(ii) stratification of the area;

(iii) track design, e.g.:
- predetermined;
- adaptive;

(iv) data analyses. Key techniques of relevance to krill:

(a) strata-based analyses: to produce area-weighted estimates of density;

(b) object-based analyses: swarm characteristics and spatial distribution.

Geostatistics may have some relevance to krill but this requires further study.

25. There are likely to be key elements which should be emphasised in the analyses of krill distributions. For example:

(i) scales of aggregation - extreme patchiness at of the distribution of krill at different scales;

(ii) scale effects - e.g. the large-scale stability of strata during the survey period; and

(iii) migration effects - both passive and active - such as the large-scale movement of krill in current systems and behavioural movement such as diurnal vertical migration.

26. The Subgroup identified five types of analytical techniques that could be used for krill surveys.

Standing Stock Estimation

27. The echo-integration survey design generally involves a series of parallel transects with regular or random spacing, run over the area of interest. Mean densities of krill are calculated for each transect, and then weighted values of the transect means are used to calculate total biomass. The design and analysis is usually subject to stratification which may be very important in the final determination of mean biomass.

28. Prior information is essential for the definition of strata and can be:

- fisheries data (identifying regions of high biomass);
- oceanographic and bathymetric information/other surveys.

Adaptive survey techniques, in which an initial rapid survey is performed, may also be used to identify regions for stratification.

29. Survey tracks other than parallel transects have been suggested (radial - e.g. WG-Krill-91/19; zig-zag; concentric ring paths). All will give estimates of the standing stock but problems are encountered with estimation of mean and variance.

Variance Estimation

30. The standard method of estimating variance follows from the generalised method for estimating standing stock described above, and uses weighted transect values of variance (*c.f.* Jolly and Hampton, 1990; in: *Can. J. Fish. Aquat. Sci. 47*: 1282-1291).

31. Dr Murphy pointed out that the variance usually increases with the mean. Where surveys are stratified by krill density more transects should be run over the high density strata.

32. In regard to other survey designs, Dr Tesler briefly described some of the work of the ICES FAST Working Group. In general, this work shows that whilst the use of parallel transects yields statistically robust results, this may not be the case for zig-zag designs. This arises because of the inequality of coverage of the survey area (areas close to the turning points have a higher density of transect paths) and resultant serial correlations.

33. Several members suggested that set against these potential difficulties, there may be logistic advantages with non-parallel transects. Mr Miller drew the attention of the Subgroup to a paper by Jolly and Hampton (*Rapp. P.-v Réun. cons. int. Explor. Mer*, *189*, in press) which shows that zig-zag transects provide a poorer distribution of sampling effort than parallel transects.

34. The Subgroup felt that whilst radial and zig-zag designs may offer some benefits for surveys, the robustness of these methods was less well established than for parallel transect designs and more work on the analytical statistics was required before they should be used.

Distribution of Patches

35. The Subgroup agreed that the definition of aggregation scale in any studies of krill distribution is essential and used Figure 30 of Miller and Hampton (1989: *Biomass Series*) to define the following scales:

	Spatial Scale (length)	Temporal Scale
Patch	10 to 100 km	days to months
Cohesive aggregations		
Superswarms	several km	hours to days
Swarms	several to 10s m	
Dispersed aggregations		
Layers and scattered swarms	many km	
Irregular forms	10s m	

36. The methods for determining vertical characteristics of aggregations from acoustic data are well established (one such method being comprehensively described in WG-Krill-91/16 and 17) and were used to produce the datasets available to the Subgroup.

37. Two problems remain. The first is the interpretation of aggregation data (e.g. swarm radius, thickness and spacing) in relation to patch characteristics (i.e. size and spacing). The second is the problem of using along transect inter-aggregation spacing to derive distributional relationships between aggregations (and ultimately patches) in the horizontal dimension.

38. WG-Krill-91/27 indicated that different spatial resolution of echosounders and different methods used to process acoustic data, may provide systematic bias of mean patch characteristics (such as intercepted swarm length, thickness and interswarm distance).

39. Mr Miller drew attention to the statistical procedures outlined in Hampton (1981) (*Fish. Bull. S. Afr. 15:* 99-108) which can be used to estimate krill standing stock from information on swarm parameters. Information on intercepted length and the number of aggregations-per-unit-area can be used to estimate fractional cover and its variance. Fractional cover in turn is used to estimate standing stock in a survey area if mean aggregation thickness and packing density can also be estimated. The estimator of fractional cover is an unbiased estimate of aggregation intercepted length irrespective of the shape or distribution of aggregation.

40. Furthermore, information on swarm spacing can be used to estimate the mean and variance of the distance between one aggregation and its nearest neighbour in the horizontal dimension. However, certain fundamental assumptions concerning swarm shape are necessary in order to derive this estimator and in addition it is assumed that swarms are randomly distributed.

41. This approach was similar to that outlined in WG-Krill-91/16.

Geostatistical Techniques

42. Geostatistical techniques are means of treating data that take account of spatial correlation within the data. They may be used for the investigation of variance and mapping of spatially distributed data, or for fitting a surface to the data. The volume under the surface may be used to calculate standing stock. WG-Krill-91/8 describes a number of approaches to surface fitting, one of which (Krigeing) is being used by several investigators for analysing acoustic data.

43. Dr Murphy noted that geostatistical methods may need further development for use with acoustic surveys. In general, they are good at mapping conservative data, but acoustically derived mean krill densities are extremely variable and fitting with these techniques is more complex. Mr Miller added that the techniques have been developed for static, geological systems and their application to dynamic systems is not simple. In addition, Dr Murphy described some simulation work that showed that simplistic application of parallel transects when used with Krigeing techniques may distort the resultant surfaces.

44. In the light of the developmental nature of much of this work, the Subgroup could give no advice on different types of approaches to geostatistical techniques, but thought that any work on these lines would be of interest.

Aggregation Shape

45. The Subgroup agreed that information on the shape and relative orientation of aggregations will be important for the successful interpretation of surveys directed at the distribution of patches. It is also important for the development of simulations of survey behaviour (WG-Krill-91/19).

46. Dr S. Nicol (Australia) outlined the difficulties and assumptions involved in the application of techniques for determination of aggregation shape. Aerial photography can cover large areas of water, and the determination of shapes, distribution, spatial relationships and movement is simple, however, it can only be used for surface aggregations (<10 m depth) and the behaviour of these aggregations may be different from deeper aggregations. Sidescan sonar can be used at depth and produces images of aggregation shapes, orientation and relation to each other but is more limited in the area that can be surveyed instantaneously.

47. It was agreed that information on the areal shape and distribution of patches was important for the interpretation of other surveys and simulations, but that these surveys were not routine and the Subgroup could not comment in detail on desired methodologies.

APPLICATION OF TECHNIQUES

48. The Subgroup considered the application of various survey designs to particular tasks under the general headings of (i) application to CEMP predator parameters, and (ii) application to the three scales (macro, meso and micro) (WG-Krill-91/10), with particular reference to the meso-scale estimation of standing stock. Each survey design was defined by descriptions of the Aims and Constraints of the task, the Design Specification of the survey (including logistic considerations) and the Analytical Procedures required for the results.

49. It was emphasised that each of the designs suggested would require rigorous testing before use in the field. The assumptions under Aims and Constraints would need to be examined in detail for their applicability to a specific task, and the suggested survey designs tested (e.g. using simulation studies) to examine the robustness of the results to changes in

krill characteristics. Simulations may also indicate the parameters for which particular designs are not as good.

50. The Subgroup split into two groups chaired by Drs Everson and Murphy, to prepare the survey designs.

51. The suggested Survey Designs are given in Attachment 4. Survey Design 1 addressed the CEMP Parameter A5 (Penguin Foraging Trip Duration) for Adélie and chinstrap penguins. Survey Designs 2, 3 and 4 address the three spatial scales suggested by WG-Krill-91/10.

52. The Subgroup emphasised that the transect spacings suggested in Survey Design 1, Figure 1 were chosen with the assumption that the gradient of krill density runs offshore from the CEMP site, perpendicular to the shelf edge, and the design should therefore minimise the variance between transects.

53. Dr Tesler pointed out that the aspects of survey design addressed by the Subgroup formed only a small part of the overall planning work required for a survey. He suggested that in the light of the comments made by the Subgroup concerning standardisation (paragraph 11) it may be useful to have a combined approach to standardisation of surveys. This would include recommendations for standard methodologies of:

- survey design;
- survey equipment - types and operation;
- processing; and
- analysis.

Some of these recommendations could hold for all areas and methodologies, and some would be more specific.

54. The Subgroup agreed that such a proposal would be valuable and recommended that it be referred to WG-Krill for their consideration.

55. Dr M. Naganobu (Japan) drew attention to his paper (1986) (*Mem. Natl. Inst. Polar Res. Spec. Issue 40*: 194-196) which describes a method that uses survey data on krill biomass, together with temperature integrated over 0-200 m depth to extrapolate the expected krill densities over the whole of the species' range. This method relies on the strong

relationship between krill density and temperature structure which is a result of oceanographic structure (water mass, currents and fronts).

56. The Subgroup recommended that this approach, being a post survey treatment of the data, should be addressed by WG-Krill.

ADOPTION OF THE REPORT

57. The report of the meeting was adopted.

CLOSE OF THE MEETING

58. The Convener thanked the organisers Yugryba (Southern Basin Joint Fishery Enterprise), and the Oreanda Hotel for making facilities available to the Subgroup. He also thanked the rapporteurs and the Secretariat for the speedy preparation of the report.

Table 1: Swarm characteristics described in papers submitted to the meeting of the Subgroup on Survey Design. WG-Krill-91/31 describes the South African data, WG-Krill-91/7 is the Australian data available to the Subgroup, WG-Krill-91/27 is a survey by the USSR.

Year	Area	Mean (Metres)	Range (Metres)	Standard Error	No. of swarms	Reference
Intercepted length						
1981	SW Indian Ocean	17.1	276[4]	0.48	1 567	WG-Krill-91/31
1991	S. Orkneys	10.4		1.14	437	WG-Krill-91/27
1990	Prydz Bay	24.1[1]	3.3 - 642.3	0.045[2]	475	WG-Krill-91/7
1981	S. Atlantic	92.36	20.4-2 915.2	7.82	682	Calculated at the meeting from the dataset provided by FRG
Distance between swarm encounters						
1981	SW Indian Ocean	4 168.5	340 590	473.4	1 567	WG-Krill-91/31
1991	S. Orkneys	2 200.0			437	WG-Krill-91/27
1990	Prydz Bay	82.8[1]	15.7 - 1 279.2	0.040[3]	475	WG-Krill-91/7
1981	S. Atlantic	937.6	1 - 72 366.1	161.02	682	Calculated at the meeting from the dataset provided by FRG
Swarm thickness						
1981	SW Indian Ocean	6.53	36	0.12	1 567	WG-Krill-91/31
1991	S. Orkneys	2.5	-	0.12	437	WG-Krill-91/27
1990	Prydz Bay	28.62	25 - 75	0.346	475	WG-Krill-91/7
1981	S. Atlantic	3.4	1 - 20	0.18	682	Calculated at the meeting from the dataset provided by FRG
Depth of swarm						
1981	SW Indian Ocean	54.08	91	0.52	1 567	WG-Krill-91/31
1991	S. Orkneys	53.5	-	1.24		WG-Krill-91/27
1990	Prydz Bay	57.68	25 - 200	1.75	475	WG-Krill-91/7
1981	S. Atlantic	35.33	10 - 99	1.68	682	Calculated at the meeting from the dataset provided by FRG

[1] Derived from log-transformed data
[2] Standard error of log-transformed data with mean 3.184
[3] Standard error of log-transformed data with mean 4.417
[4] Absolute range value

ATTACHMENT 1

AGENDA

Working Group on Krill
Subgroup on Survey Design
(Yalta, USSR, 18 to 20 July 1991)

1. Introduction

    1.1 Welcome followed by Domestic Arrangements
    1.2 Adoption of the Agenda and Appointment of Rapporteur

2. Background to the Subgroup

    2.1 Aims of the Subgroup
    2.2 Description of Datasets Offered for Analysis

3. Analyses Undertaken

    3.1 Using the Distributed Datasets
    3.2 Other Analyses

4. Review of Specific Analytical Techniques

5. Application of Techniques

    5.1 Application to CEMP
    5.2 Direct Abundance Estimation
    5.3 Other Methods of Abundance Estimation

6. Other Business

7. Adoption of the Report

8. Close of the Meeting.

ATTACHMENT 2

LIST OF PARTICIPANTS

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Subgroup on Survey Design
(Yalta, USSR, 18 to 20 July 1991)

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ATTACHMENT 3

LIST OF DOCUMENTS

Working Group on Krill
Subgroup on Survey Design
(Yalta, USSR, 18 to 20 July 1991)

Meeting Documents:

WG-KRILL-91/7	CHARACTERISTICS OF KRILL SWARMS FROM PRYDZ BAY D.J. Agnew and I.R. Higginbottom (Australia)
WG-KRILL-91/8	DEFINITION OF THE PROBLEM OF ESTIMATING FISH ABUNDANCE OVER AN AREA FROM ACOUSTIC LINE-TRANSECT MEASUREMENTS OF DENSITY Kenneth G. Foote and Gunnar Stefánsson (Norway)
WG-KRILL-91/10	ON CONSTRUCTION OF MULTIDISCIPLINARY AND STOCK ASSESSMENT SURVEYS AS WELL AS ON COLLECTION OF MATERIAL ON *EUPHAUSIA SUPERBA* AND ENVIRONMENTAL CONDITIONS IN THE FISHING AREAS AND ADJACENT WATERS R.R. Makarov and V.V. Maslennikov (USSR)
WG-KRILL-91/12	REPORT OF THE BIOLOGIST-OBSERVER FROM THE COMMERCIAL TRAWLER *GRIGORY KOVTUN*, SEASON 1989/90 A.V. Vagin (USSR)
WG-KRILL-91/16	ESTIMATION OF DISTRIBUTION CHARACTERISTICS OF THE FISHING OBJECTS FROM SHOAL LINEAR CROSS-SECTIONS (METHODICAL DIRECTIONS) Y.V. Kadilnikov (USSR)
WG-KRILL-91/17	AUTOMATED DATA COLLECTION AND PROCESSING SYSTEM RELEVANT TO FISHING OBJECT DISTRIBUTION Y.V. Kadilnikov, O.M. Khandros and Y.A. Starovoyt (USSR)
WG-KRILL-91/19	SMALL SCALE KRILL SURVEYS: SIMULATIONS BASED ON OBSERVED EUPHAUSIID DISTRIBUTIONS D.J. Agnew (Secretariat) and S. Nicol (Australia)

WG-KRILL-91/20 NOTE ON ESTIMATING ABUNDANCE FROM ACOUSTIC DATA ON INDIVIDUAL KRILL AGGREGATIONS
I. Hampton and D.G.M. Miller (South Africa)

WG-KRILL-91/21 SOME COMMENTS ON THE PROCEDURE FOR TESTING ESTIMATORS OF KRILL ABUNDANCE WHICH UTILISE SURVEY DATA
D.S. Butterworth, D.L. Borchers and D.G.M. Miller (South Africa)

WG-KRILL-91/27 KRILL AGGREGATION CHARACTERISTICS IN SOUTH ORKNEY ISLAND AREA IN APRIL 1990
P.P. Fedulov *et al.* (USSR)

WG-KRILL-91/26 WHEN WILL THE INFORMATION REQUIRED FOR RATIONAL MANAGEMENT OF THE KRILL FISHERY BECOME AVAILABLE AND WHAT SHOULD CCAMLR DO IN THE MEANTIME?
Stephen Nicol and Andrew Constable (Australia)

WG-KRILL-91/28 POSSIBLE APPROACH TO KRILL MOVEMENT ESTIMATION BY HYDROACOUSTIC OBSERVATIONS
P.P. Fedulov (USSR)

WG-KRILL-91/29 TARGET STRENGTHS OF KRILL AT 136 AND 20 KHZ
S.M. Kasatkina (USSR)

WG-KRILL-91/30 ANALYSES OF ACOUSTIC LINE-TRANSECT DATA FROM THE WATERS AROUND SOUTH GEORGIA: ESTIMATION OF KRILL (*EUPHAUSIA SUPERBA* DANA) BIOMASS
E. Murphy, I. Everson and A. Murray (UK)

WG-KRILL-91/31 KRILL AGGREGATION CHARACTERISTICS: SPATIAL DISTRIBUTION PATTERNS FROM HYDROACOUSTIC OBSERVATIONS
D.G.M. Miller and I. Hampton (South Africa)

Other Documents:

WG-CEMP-91/4 TEMPORAL AND SPATIAL SCALES FOR MONITORING CEMP PREDATOR PARAMETERS (WG-CEMP)

ATTACHMENT 4

SELECTED SURVEY DESIGNS

SURVEY DESIGN 1

1. Aims

1.1 Objective:

Determine availability of krill within foraging range of Adélie and chinstrap penguins in the Antarctic Peninsula Integrated Study Region of CEMP and to relate it to Predator Parameter A5 (Foraging Trip duration).

1.2 Primary type of information required:

Time series of standing stock estimates

2. Constraints

2.1 Time and space scales:

Rectangle extending 50 km offshore and 50 km either side of study colony (the area is therefore 50 x 100 km) for Adélie penguin and 25 km offshore and 25 km either side for chinstrap penguin.

It is assumed that the study colony is situated in the centre of an approximately straight coast.

Time series of surveys to be made within the two-month period 15 December to 15 February.

2.2 Type of survey:

Replicated survey with approximately ten replicates.

2.3 Is stratification advised Y/N: Yes

If Yes indicate basis for stratification:

Stratification is based on distance from the colony. Two strata are suggested, a rectangle for higher intensity sampling based on the chinstrap penguin foraging range (25 km) and a lower intensity stratum based on the Adélie penguin foraging range (50 km). It is assumed that the 50 km range stratum includes all of the 25 km range stratum.

3. Design

3.1 Transects:

Series of randomly spaced parallel transects running offshore. A suggested general scheme is shown in Figure 1.

The transects to be sampled in order against the local current direction.

During replicate surveys the same or a different random set may be surveyed.

Each replicate survey to begin in the same part of the polygon.

3.2 Logistics:

The total distance steamed for one acoustic survey is estimated to be 800 km = 450 n. miles.

Estimated time budget:

A. Acoustic Survey

Vessel Speed	Time	Vessel Days[1]
8 knots	56 hrs	3.5
7 knots	64 hrs	4
6 knots	75 hrs	4.7

B. Net Hauls (?) 10 hrs 0.5

C. Weather and other contingency (20%)

Total period for one survey varies from 5 to 6.5 days depending on vessel survey speed.

Ten surveys could be undertaken according to this regime during the course of one season.

4. Analytical procedures

5. Comments

A. The area is not well charted, particularly close inshore. This will pose problems for operating the vessel close inshore. It will also mean that the amount of krill available to predators will be underestimated.

B. It is advisable that the survey be integrated into broader-scale surveys.

C. Pack ice may be a problem in some years particularly early in the season.

D. The same survey design, but using regularly spaced transects, may also be appropriate for investigation of the distribution of krill aggregations.

[1] Survey confined to period 8 hours either side of noon (SC-CAMLR-IX, Annex 6, paragraph 103)

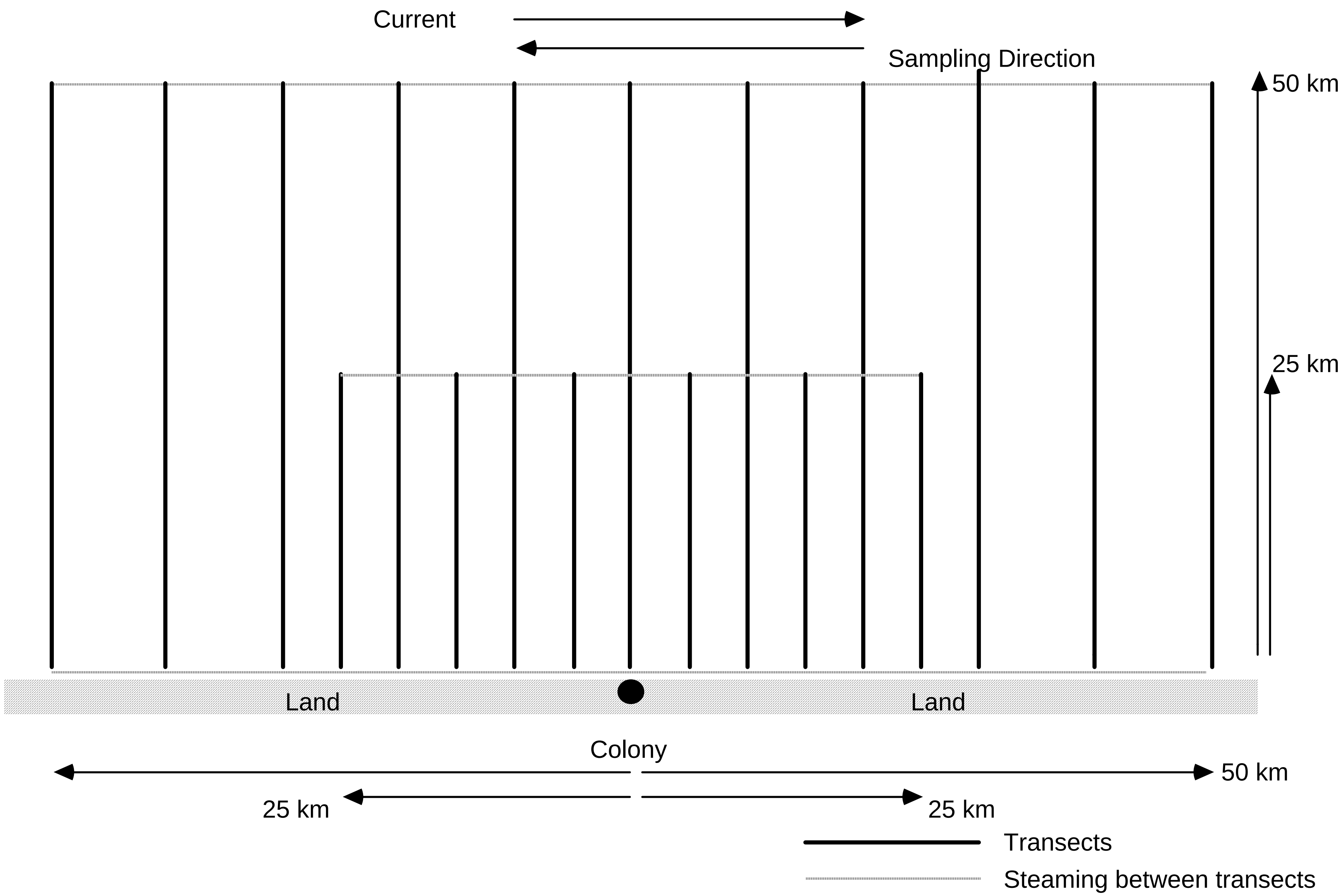

Figure 1: Sampling design to monitor krill biomass in relation to a land-based colony of penguins (CEMP Standard Method A5). In practice sampling grid at the spacing frequency illustrated would be composed of randomly spaced transects.

SURVEY DESIGN 2: Micro-survey

1. Aims

1.1 Objectives:

- characterise spatial distribution of krill aggregations;
- investigate aggregation dynamics of krill;
- estimate parameters for fishery/predator search patterns.

1.2 Primary type of information required:

- swarm dimensions;
- spacing, shape;
- depth distribution;
- diurnal changes.

2. Constraints

2.1 Time and space scales:

- a few to 10s km and hours to days;
- need for continuous sampling over a 24-hour period.

2.2 Survey information (available at planning stage):

On the basis of larger scale surveys at the mesoscale a restricted region would have been identified.

2.3 Type of survey:

Repeated regular grid survey. Time stations - to look at diurnal changes. Shape of swarms obtained by off transect sampling. Where patch drifting is involved then off transect sampling is likely to be most appropriate.

3. Design

Dependent on scales of aggregations would require:

- nets for demographic analyses and target ID;
- CTD - vertical profiles,
  - oceanographic data;
- ADCP[1] - data on currents;
- underwater photography/television/remotely operated vehicle;
- *in situ* TS measurements.

4. Analytical procedures:

- swarm dimensions and spacing statistics;
- mapping;
- biological characteristics of swarms;
- TS data in relation to orientation;
- time series data;
- image processing of shape.

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1 Acoustic Doppler Current Profiler

SURVEY DESIGN 3: Meso-survey

1. Aims

1.1 Objective:

Determine the standing stock of krill at the mesoscale (10s to 100s km). For example in the vicinity of South Georgia.

1.2 Primary type of information required:

Standing stock estimate.

2. Constraints

2.1 Time and space scales:

- survey to be completed within 15 to 30 days;
- the survey to cover shelf area and some distance further offshore, 50 to 100 miles.

2.2 Survey information (available at planning stage):

- historical datasets available for survey area;
- information on locations of high fishing activity;
- bottom topography;
- other information, e.g. water mass frontal zones, satellite sea surface temperature in real time.

2.3 Type of survey:

Adaptive stratified single acoustic survey in a season.

First Phase: to determine location of krill aggregations and temperature regime. Requires underway on board monitoring of sea temperature and other parameters, e.g. fluorescence and bottom topography and SiO_2.

Second Phase: might be stratified using the following:

- standing stock - increased effort in and around regions of high krill biomass;
- increased effort in particular bathymetric regions;
- temperature - increased effort in region of water colder than zero degrees;
- increased effort in areas of ‘traditional’ krill fishing grounds;
- routine monitoring should include net sampling for acoustic target identification and demographic biological characteristics of krill and also hydrography to characterise water masses and investigate other features of importance in determining krill distribution.

3. Design

3.1 Transects:

First phase

Regular spaced parallel transects to give even coverage of sampling. Transects perpendicular to the contours of krill density. In the South Georgia region this probably involves running on-shelf to off-shelf transects.

Probable 5- to 10-day time period allocated to this phase. Allowing approximately 600 n miles of transects.

Second phase

Parallel transects randomly or regularly spaced within strata.

Highest intensity of sampling in high density strata identified from phase one.

3.2 Logistics:

Problems could include presence of ice, weather. Five to ten days during the first phase; 20 to 25 days during the second phase.

4. Analytical procedures:

- analyses of demographic parameters, for TS calculations;

- mapping of distribution;

- area weighted estimates of standing stock.

SURVEY DESIGN 4: Macro-survey

1. Aims

1.1 Objective:

Improve understanding of krill movement and macro-scale, distribution - (100 to 1 000 km).

1.2 Primary type of information required:

- hydrographic investigations. Water mass specification - confluence position;
- krill demography and biomass;
- plankton community structure and seasonal state

2. Constraints

2.1 Time and space scales:

40 days per survey repeated two- to four-times to investigate seasonal variation. To cover area influenced by major circulatory features. (100s to 1 000s km).

2.2 Survey information (available at planning stage):

- satellite information;
- topography;
- historical information from survey data for region - e.g. water masses characterisation;
- historical krill data - from surveys and the fishery.

2.3 Type of survey:

- transects irregularly spaced across the confluence region or major circulatory feature;

- probably 100 to 300 n miles transects - against the flow.

Other data could include:

- net samples for plankton and target I.D.;

- acoustics when under-way;

- vertical and horizontal water mass sampling;

- hydro-chemistry;

- biological data on krill;

- primary production.

3. Design

3.1 Transects:

- 12 to 14 transects;

- length 120 to 300 n miles;

- spacing 150 to 250 n miles.

3.2 Logistics:

- weather / ice could cause problems;

- real time satellite information would be a major component;

- stability of large scale feature over time-scale of survey is important and may require adaptive transect layout.

3.3 Analysis could include:

- vertical profiles of all parameters along transect;

- large scale gross feature map;

- multivariate analyses of water mass and biological parameters;

- major pathways of krill movement;

- geostrophic measurements and analyses.

Comments: It would be useful to obtain estimates of flow rates from moored ships or through the deployment of drifting buoys.

APPENDIX E

SPECIFICATION OF FURTHER CALCULATIONS OF FACTORS RELATING YIELD TO SURVEY BIOMASS ESTIMATES

APPROACH

There is considerable uncertainty about values for a number of the parameters needed for these calculations. Rather than give the results for different combinations of possible values, these results will be 'integrated' over the ranges considered to incorporate the uncertainty about each parameter (termed the 'prior' distribution for each parameter). Such computations yield a 'posterior' distribution for the quantity of interest - in this case the ratio of the yield to the biomass estimate.

SPECIFICATIONS

$Y = \lambda M B_o$
$B_o = f\, B_s$

where **f** is a factor that adjusts the survey assuming that it does not cover the complete distribution of the biomass of the stock;
B_s is biomass from survey.

Posterior distributions are required for two quantities:

(i) $\gamma = \lambda\, M$ i.e. $Y = \gamma\, B_o$
(ii) $\delta = \lambda\, Mf$ i.e. $Y = \delta\, B_s$

Prior distribution and assumption parameters are as follows:

(i) Growth curve:
Fixed - as specified by Rosenberg, Beddington and Basson (1986) (*Nature 324*: 152-154);
Growth - over three months (November to January).

(ii) Fishing season:

Three options: (a) 3 months: December to February (e.g. Japanese fishery);

(b) 6 months: April to September (e.g. Soviet fishery in Subarea 48.3);

(c) uniform throughout the year.

(iii) Natural mortality:

Uniform throughout the year

M = *U* [0.4,1.0]

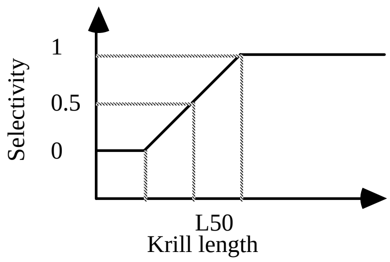
where ***U*** indicates a uniform distribution over the range shown.

(iv) Age-at-first capture:

Express in terms of length and convert these to age using the growth equation.

'width' = 10 mm

Length at 50% vulnerability, l_r^{50} = U[38,42 mm]



The values for 'width' and for the centre point of the $\boldsymbol{l_r^{50}}$ range were determined from inspection of Figure 2 of WG-Krill-91/12.

(v) Age at maturity:

Similar for to (iv) above: 'width' = 12 mm

l_m^{50} = U[34,40 mm]

The values for 'width' and the centre point of the $\boldsymbol{l_m^{50}}$ range were determined from data in Siegel (1986) (*Mitt. Inst. Seefisch. 38*: 1-244. Hamburg).

(vi) Biomass survey:

Ages surveyed: $a_+ = 1^+$ (fixed)

Survey c.v.: $\sigma_S = 0.3$ (fixed)

(vii) Recruitment variability:

Recruitment c.v.: $\sigma_R = U[0.4,0.6]$

(viii) Incomplete survey coverage:

$f = U[1,4]$

OUTPUT

Posterior distributions for γ and δ corresponding to a 10% probability over a 20-year period that $\mathbf{B_{sp}/K}$ drops below $\mathbf{D_{crit}}$ are required, where:

$D_{crit} = 0.1, 0.2, 0.3, 0.4, 0.5, 0.6$

The corresponding distributions for this probability in the absence of any fishing are also to be evaluated. Distributions are to be shown in tabular form (values at each integral 10% point), and as plotted probability distribution functions.

$\mathbf{B_{sp}}$ is the average spawning biomass over the December to March period in the presence of a constant annual catch of krill; **K** is the corresponding value for zero catch, i.e. the average spawning prior the exploitation of the resource. Calculations are to be carried out on a discrete basis at half-monthly intervals.

APPENDIX F

CALCULATION OF THE 'THRESHOLD LEVEL' IN STATISTICAL AREA 48

(Delegation of the USSR)

1. Calculations were made using the following formula:

$$Y_t = yB_s \quad (1)$$

where **Y_t** = 'threshold level';
B_s = krill biomass in Statistical Area 48;
y = proportion of **B_s** exploitable without negative impact on krill population and dependent species.

2. Parameter evaluations

2.1 $$B_s = k\,B^0_s \quad (2)$$

where **B_s** = biomass assessment from hydroacoustic surveys during FIBEX in the Statistical Area 48 taken to be 2.65 million tonnes (Miller and Hampton, 1989);
k = correction coefficient introduced as the result of a review of the target strength of krill within the length range 35 to 55 mm. In accordance with calculations of Tesler and Kasatkina based on results of Subgroup discussions on the matter, **k** = 5.7.

2.2 Coefficient y = 0.1 (Yamanaka, 1983*)

Note: the value of this coefficient is apparently heavily underestimated because feeding area of predators does not completely overlap krill fishing areas (WG-CEMP-91/25).

3. Results

B_s = 15.1 million tonnes; Y_t = 1.5 million tonnes.

4. Result evaluations

There is a good chance that the obtained **Y_t** is heavily underestimated (possibly several times).

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* Yamanaka, I. 1983. Interaction among krill, whales and other animals in the Antarctic ecosystem. *Mem. Natl. Inst. Polar Res.*, Spec. Issue No. 27: 220 - 232

ANNEX 6

REPORT OF THE WORKING GROUP ON FISH STOCK ASSESSMENT

(Hobart, Australia, 8 to 17 October 1991)

REPORT OF THE WORKING GROUP ON FISH STOCK ASSESSMENT
(Hobart, Australia, 8 to 17 October 1991)

INTRODUCTION

1.1 The meeting of the Working Group on Fish Stock Assessment (WG-FSA) was held at the CCAMLR Headquarters, Hobart, Australia from 8 to 17 October 1991. The Convener, Dr K.-H. Kock (Germany) chaired the meeting.

1.2 The Convener welcomed participants to the meeting. Several intending participants had not arrived for the start of the meeting. It was therefore adjourned for a day in anticipation of their arrival and also to allow participants time to read all the tabled papers.

GENERAL MATTERS AND APPOINTMENT OF RAPPORTEURS

2.1 A List of Participants is given in Appendix A.

2.2 The following were appointed rapporteurs:

Dr I. Everson (UK), Agenda Items 1 to 6;
Conveners of Assessment Groups, Agenda Item 7; and
Dr D. Agnew (Secretariat), Agenda Items 8 to 11.

2.3 In accordance with a decision reached last year, all papers delivered to the Secretariat prior to the start of the meeting were accepted as working papers. Due to unforeseen travel difficulties, Drs K. Shust and P. Gasiukov (USSR), both of whom had notified their intention to participate in the meeting, were unable to be present at the start. They had informed the Secretariat that they intended to table several papers but copies had not been received by the deadline. Copies of four of these papers had been received by the Convener and he tabled them on behalf of Drs Shust and Gasiukov. One further USSR paper was only available as a summary and abstract. This was accepted in this abbreviated form (WG-FSA-91/23) even though participants had no information with which to clarify the method or substantiate the figures presented.

2.4 The Working Group re-emphasised its decision of the last meeting namely, papers should be submitted in a complete form rather than a summary and:

- papers that arrive at the Secretariat later than the day before the meeting will not be considered at that meeting; and

- the deadline for submission of papers for consideration at the meeting will be re-named 'the recommended date for submission'. Papers submitted by this date will be distributed prior to the meeting.

ADOPTION OF THE AGENDA

3.1 The adopted Agenda is attached as Appendix B, and a List of Documents presented to the meeting is attached as Appendix C.

THE CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION

4.1 WG-FSA emphasised the need for a scheme of international scientific observation for the collection of data. The deployment of observers would improve data collection generally and some data, essential for WG-FSA assessments, could only be collected in this way. It was stressed, however, that data collected under the scheme would not be a substitute for fisheries data requested from Members.

4.2 Discussion centred on two aspects of the scheme: firstly on practical aspects of the implementation of the scheme; and secondly on the technical details of the information that is required.

4.3 Concern was expressed that the amount of work requested of observers should not exceed the amount reasonably to be expected from individuals working at sea. It was agreed that a list of priority observations should be drawn up to assist observers with making decisions concerning data collection. This proposed list of priority observations, along with explanations, would need to be included in an observer's manual.

4.4 Decisions on the priority to be assigned to different aspects of the observation program will need to be made based on several criteria such as, whether:

(i) the stock under consideration was considered to be particularly vulnerable and was one for which only limited information was available;

(ii) the information needed from the fishery was considered vital for WG-FSA to undertake assessments;

(iii) there are critical uncertainties that might be clarified by observations at sea; and

(iv) the only reasonable way to collect the data was from observations at sea.

4.5 Consideration needs to be given to the organisation of individual components of the observation scheme because while some topics might be addressed adequately by a limited series of observations, others might require a more or less continuous series over many years.

4.6 The Working Group agreed that haul-by-haul data should be collected as a routine activity. Furthermore it was considered that activities under the scheme, for the time being, should be allocated to fisheries in the following order of priority:

(i) *Champsocephalus gunnari*;
(ii) longline fishery for *Dissostichus eleginoides*;
(iii) by-catch of juvenile fish in the krill fishery; and
(iv) *Electrona carlsbergi*.

4.7 Observations from the *C. gunnari* fishery were assigned the following priorities:

(i) representative length frequency distributions;
(ii) observations on sex and maturity stage;
(iii) collections of otoliths for age determination;
(iv) observations on by-catch species; and
(v) the incidental mortality of predators (birds and seals).

4.8 Observations from the *D. eleginoides* longline fishery were assigned the following priorities:

(i) representative length frequency distributions;
(ii) observations on sex and maturity stage;
(iii) incidental mortality of avian predators due to longline fishing; and

(iv) loss rate of fish from hooks; catching efficiency of different hook sizes and types; observations on the condition of fish on capture (for tagging experiments).

4.9 The major priority for observations of by-catch of juvenile fish in the krill fishery is to examine sub-samples of the catch and to obtain specimens of individual fish. A lower priority for observations would be to obtain qualitative information on fishing conditions such as krill swarm size, depth and degree of aggregation, when juvenile fish were most prevalent in the catches.

4.10 The major priorities for observations on *E. carlsbergi* would be to describe how the fishery operates and also to determine whether there was a significant by-catch of other species. Although an observer would be expected to collect biological data from this fishery these data were not considered to be critical for stock assessment at the present stage.

4.11 Following the 1991 meeting of the Working Group on Krill (WG-Krill), the Secretariat had prepared draft formats for use by observers on commercial fishing vessels (SC-CAMLR-X/8). The paper presented a series of draft forms for the collection of data from all fisheries. These are included here as Appendix D.

4.12 The proposed scheme is designed to operate in a hierarchical form. The top format in this scheme is Format 0 which provides the Observer Summary Information; below this are formats related to the krill, finfish (trawls) and finfish (longline) fisheries.

4.13 Format 0 (Observer Summary Information) was considered essential as it contains key information for the other formats. Additional specific points for inclusion in this format were:

(i) provision for recording a range of different activities such as: fishing, searching, transit, vessel stationary, etc.;

(ii) an indication as to whether the fishfinder was operational;

(iii) reporting of time in a standard form such as GMT; and

(iv) an indication of position fixing equipment type (e.g. satellite navigator, GPS*).

4.14 It was recognised that obtaining this information would entail a great deal of work on the part of the observer. Much of the information would, however, be available from the ship's logbook.

4.15 Formats 1, 2 and 3 relate to the krill fishery and were not discussed by WG-FSA.

4.16 Format 4 relates to observation on predators. It was felt that provision should be made for the incorporation of the following information on type of predator activity with respect to the vessel operations:

(i) aggregation of predators in the area of fishing operations; and
(ii) predators interacting with fishing gear.

4.17 Format 5 concerns length, sex and maturity of finfish. WG-FSA agreed that the format for length frequencies should include categories for immature as well as male and female fish. Maturity stages could be included into a table of similar structure to the length frequency table. These tables could also include mean weights for each category. The format should also make provision for information concerning the collection of scales and otoliths for age determination.

4.18 Information on the age of fish cannot be collected by observers during routine work at sea, and, if this item is excluded, most of Format 6 becomes redundant. Information on mean weights can be incorporated into Format 5 as outlined above.

4.19 Format 7 provides for the collection of data from longline fishing. The length composition in the catch is highly dependent on the hooks used in the fishery (WG-FSA-91/11). It was agreed that hooks should be specified in terms of brand name, pattern and size number.

4.20 The Secretariat was requested to redraft the proposed reporting formats in the light of comments made at the meeting.

4.21 To facilitate consistent methods of data collection WG-FSA agreed that a manual should be produced to provide precise protocols for data collection. Some ideas for inclusion

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* Global Positioning System

in such a manual are outlined in SC-CAMLR-X/8. WG-FSA made the following further points for inclusion in a revised form:

(i) sampling commercial fish species: change from ‘30 fish’ to ‘a representative sample’; and

(ii) otolith and scale sampling: samples of otoliths or scales from at least five fish should be taken from each size class.

4.22 The Secretariat was thanked for preparing the draft formats and protocol for discussion and, in consultation with Drs G. Duhamel (France), M. Vacchi (Italy), Kock and Shust, was requested to prepare a manual to be distributed to observers. The manual for observers in the Kerguelen fishery would provide a helpful example.

APPROACHES TO CONSERVATION

New and Developing Fisheries

5.1 In response to questions raised at the 1989 meeting of the Commission, the Working Group in 1990 outlined the types of information that would be necessary to provide advice on the management of new and developing fisheries.

5.2 The Working Group identified the following information that would be required for it to assess the initial catch level (SC-CAMLR-IX, Annex 5, paragraph 289):

‘(i) biological information from comprehensive research/survey cruises, such as distribution, abundance, demographic data and information on stock identity;

(ii) details of dependent and associated species and the likelihood of them being affected in some way by the proposed fishery;

(iii) the nature of the proposed fishery, including target species, methods of fishing, proposed region and any minimum level of catches that would be required to develop a viable fishery; and

(iv) information from other fisheries in the region or similar fisheries elsewhere in the world that may assist in the evaluation of potential yield.’

5.3 Also at the 1990 meeting of the Working Group it was proposed that (SC-CAMLR-IX, Annex 5, Appendix D, paragraph 27):

> 'Members who intend to start a fishery should provide CCAMLR with the following information:
>
> - the proposed fishing operation, including target species, methods of fishing, proposed region and any minimum level of catches that would be required to develop a viable fishery; and
>
> - details of the stock size, abundance, demography (e.g. growth parameters, size and age at sexual maturity).'

5.4 The Working Group felt that this remains a valid summary of the information requirements and noted that the Commission, at its last meeting, had begun consideration of a draft conservation measure for the regulation of new fisheries which included these requirements.

5.5 Discussion of the draft conservation measure is to be continued at the 1991 meeting of the Commission with initial attention focussing on suitable definitions for new and developing fisheries.

5.6 The Working Group felt that different types of new fisheries could be defined in terms of the target species, the location of the fishery and the type of fishing gear to be used. Using the definition prepared by the Secretariat in CCAMLR-X/6, the Working Group recommended the following definitions:

> A new fishery is a fishery on a species using a particular fishing method in a statistical subarea for which:
>
> (i) information on distribution, abundance, demography, potential yield and stock identity from comprehensive research/surveys or exploratory fishing have not been submitted to CCAMLR;
> or
>
> (ii) catch and effort data have never been submitted to CCAMLR;
> or

(iii) catch and effort data from the most recent two fishing seasons have not been submitted to CCAMLR.

Interaction of other Components of the Ecosystem
(e.g. Birds, Mammals) with Fisheries

5.7 Evidence was presented that significant mortality of flying birds is being caused by trawl fisheries in the Kerguelen Islands area (SC-CAMLR-X/BG/14) and in the sub-Antarctic trawl fishery on squid conducted by Soviet vessels under agreement with New Zealand (SC-CAMLR-X/BG/4). The effect was such that if there are not changes in the New Zealand squid trawl fishery, it was estimated that the NZ white-capped albatross could become extinct within the next 32 years.

5.8 There is likely to be a problem of bird mortality wherever there are high concentrations of seabirds associated with trawl fisheries. The main cause of mortality is due to the birds flying into and being hit by the netsonde cable when it whips up and down due to the pitching of the fishing vessel. The effect is greatest whilst the net is being hauled. The birds do not see the cable because they are concentrating on trying to catch fish escaping from the net. The greatest effect is likely to be in fisheries targetting smaller fish species such as *C. gunnari* and Myctophidae.

5.9 Recent technological advances have meant that, for many, but not all operations, netsounders operating by an acoustic link are available. These types of netsounder, having no direct cable link from the transducer to the ship, do not cause injury to birds. It was suggested that the cost of changing from a cable system to an acoustic system might be too expensive for some operators. WG-FSA considered ways that netsounder cables might be modified to minimise injury to birds. It was suggested that a larger diameter cable or one fitted with high visibility streamers might be effective. These modifications would cost money and, in the long term, might be similar to the cost of a system operating through an acoustic link.

5.10 The Working Group agreed that wherever possible in commercial fisheries the use of netsonde cables should be phased out.

5.11 A further cause of mortality to flying birds is due to the birds taking the baits from longlines (SC-CAMLR-X/BG/14). It is known that this can be reduced by the use of a 'tori' pole (CCAMLR-IX/BG/14 Rev. 1) but there is no indication that this equipment has been used in longline fisheries within the CCAMLR Convention Area.

Prey Requirements for Krill Predators

5.12 WG-FSA noted that the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP) is undertaking an analysis of prey requirements for krill predators (Annex 7, paragraphs 6.1 to 6.26). Krill is a significant component in the diet of many fish species and WG-FSA felt that predation on krill by fish ought to be included in that analysis.

5.13 WG-FSA agreed to investigate predator/prey interactions involving fish for incorporation into the CEMP analysis and requests WG-CEMP to keep it (WG-FSA) informed of developments in this field.

5.14 There is evidence that in some years (e.g. the 1990/91 season and possibly the 1977/78 and 1983/84 seasons) the presence of *Euphausia superba* in the South Georgia subarea has been reduced (WG-FSA-91/29 and WG-CEMP-91/37). In addition to the direct effect on food availability to the fish, this may have the further effect of causing larger predators to switch from krill to fish for food.

5.15 Until now, this information has been largely anecdotal, but the assessment of stocks, especially of *C. gunnari*, in the previous season can be helped in these cases by having details on the diet, foraging range and breeding success of these predators so that some input on the environmental influences on the stocks, as distinct from fishing effects, is available. Such data from the CEMP Program or other sources should be available to WG-FSA for its meetings.

5.16 WG-FSA-91/8 provides information on the daily food intake of nine high-Antarctic fish species which is a crucial parameter in estimating, for example, prey requirements. The Working Group noted the importance of this type of data in taking account of dependent and related species in the formulation of management advice. It recommended that further such studies be undertaken.

By-Catch of Young and Larval Fish in the Krill Fishery

5.17 Discussion during the 1990 meeting of WG-FSA indicated that there is a potential problem whereby significant numbers of juvenile fish might be taken during commercial fishing operations.

5.18 WG-KRILL-91/25 had indicated that the problem is probably confined to certain localised shelf areas. There are also indications that the problem is least when krill catch rates are highest.

5.19 The problem is likely to be greatest in nursery ground areas for young fish. The region close to the shelf break in Prydz Bay is one where significant numbers of *Pleuragramma antarcticum* occur and also where there has been commercial krill harvesting taking place (WG-FSA-91/35). There is likely to be a significant effect on juvenile channichthyids if the krill fishery extends onto the shelf.

5.20 Notwithstanding the results reported in the two papers referred to above, the Working Group noted that little new information is available on the identification of specific nursery areas for fish. The Commission (CCAMLR-IX, paragraph 4.19) has requested that such areas be identified. At this stage the Working Group felt unable to provide advice on specific locations. The collection of information aimed at identifying fish nursery grounds close to krill fishing areas is urgently required.

REVIEW OF MATERIAL FOR THE MEETING

Data Requirements

6.1 Data submissions were incomplete at the start of the meeting and, although some data were provided during the meeting, the data were still incomplete when the analyses were undertaken. Indications of the data submitted and gaps in the dataset are shown in SC-CAMLR-X/BG/2.

6.2 Various data were specifically requested by the Working Group in 1990 (SC-CAMLR-IX, Annex 5, Appendix I). Data submitted to the Secretariat in response to this request are listed in Appendix E.

6.3 Many of the requests of the Working Group had not been addressed. The Working Group noted that the majority of the biological data submitted to the Secretariat had been from research cruises, and reiterated its requirement for biological data from the commercial fisheries.

Catch and Effort Statistics

6.4 STATLANT data had been received at the beginning of the meeting from all Members known to be engaged in commercial fishing with the exception of USSR who had submitted an interim note of total catch for some species. During the course of the meeting, STATLANT data was submitted by the USSR.

Size and Age Composition

6.5 Representative size frequency distributions were available from standing stock surveys undertaken at South Georgia and the South Orkneys (WG-FSA-91/14 and 33).

6.6 Data were presented on size composition from the *D. eleginoides* longline fishery of the USSR and from the Polish trawl fishery, both in Subarea 48.3. No data were available from other commercial fisheries.

Other Available Biological Information

6.7 The diet composition and feeding intensity of *C. gunnari* around South Georgia in early 1991 are described in WG-FSA-91/29. Both the proportion of krill *(E. superba)* in the stomachs and the feeding intensity were uncommonly low in a period when energy-rich food is needed for the final maturation of the gonads.

6.8 Sexual maturation of *C. gunnari* was studied by macroscopic and microscopic examination of gonads (WG-FSA-91/7). Evidence was presented in support of the hypothesis that a high proportion of mature fish failed to spawn. It is concluded that the underlying cause is probably due to a shortage of krill.

6.9 Genetic population structure of *C. gunnari* in waters from around South Georgia, South Orkneys and Heard Island was examined using allozyme enzyme electrophoresis (WG-FSA-91/22). Compared with 1990, there was a reduction in genetic variation between South Georgia and Shag Rocks. The authors conclude that genetic data 'supports the notion of migration between areas (South Georgia and South Orkneys). Such an assertion must however, be corroborated with additional data at other biological levels'. There are major genetic differences between *C. gunnari* from the Atlantic sector and those of Heard Island.

6.10 The vertical migration of *C. gunnari* was described based on acoustic observations on the South Georgia shelf (WG-FSA-91/6). During daytime the fish are concentrated on the bottom whilst at dusk they migrate into the water column.

6.11 An analysis of longline catches of *D. eleginoides* from the west coast of Chile indicated that the fishery was moving southwards as stocks became depleted. It is suggested that there may be significant mixing of this species over its geographical range from Chile, the Patagonian shelf and South Georgia (WG-FSA-91/10).

Mesh/Hook Selectivity and Related Experiments Affecting Catchability

6.12 Studies on catches of *D. eleginoides* indicated that the type and size of hook has a strong effect on the sizes of fish caught (WG-FSA-91/11). Circular hooks appear to be more effective at catching fish although this may be due to this pattern of hook being better able to retain bait and large fish.

6.13 No studies on mesh selection of nets were reported.

Assessments Prepared by Member Countries

6.14 Assessments prepared by Member countries are considered in the relevant paragraphs of the assessment section of this report.

Standardisation of Survey Trawls

6.15 Comparisons have been made between the trawl nets used during recent surveys around South Georgia (WG-FSA-91/16 and 21). The net used on the *Professor Siedlecki* (P32/36) in 1989 and *Falklands Protector* (FP-120) in 1991 have similar characteristics. The net used by *Hill Cove* (HC-120) had lower wings and probably a wider spread than originally reported which may have caused an overestimation of standing stock.

6.16 No information was available on the nets used during the recent USSR surveys. WG-FSA recommended that calibration of these nets should be undertaken as soon as possible.

6.17 It was suggested that a calibration of the different nets might be obtained by comparison of catches of non-commercial species.

ASSESSMENT WORK

7.1 Summaries of the assessments presented in the following section are given in Appendix J.

South Georgia (Subarea 48.3)

7.2 The history of catches taken in the South Georgia subarea is given in Table 1 and Figure 1. The figure demonstrates how fishing has shifted from *Notothenia rossii* which was the target species in the beginning of the fishery, to *C. gunnari* and *Patagonotothen guntheri*[*] from the second half of the 1970s and *D. eleginoides* and *E. carlsbergi* from the second half of the 1980s onwards.

7.3 The depletion of a number of stocks, the high variability in recruitment of *C. gunnari*, the establishment of TACs by CCAMLR and the targetting of new species have led to a high variability in annual catches.

7.4 The total catch of all species in 1990/91 was 82 423 tonnes which was twice the catch taken in 1989/90. This was primarily due to a 3.5-fold increase in the catch of *E. carlsbergi* to 78 488 tonnes. This species made up 95% of the total catch in Subarea 48.3.

7.5 Despite a TAC of 26 000 tonnes for *C. gunnari* set by the Commission in 1990 (Conservation Measure 20/IX), only 93 tonnes of *C. gunnari* were taken mostly in research vessel catches. The only known commercial trawl fishing was carried out by a Polish trawler between 22 December and 15 January taking 41 tonnes of *C. gunnari* (WG-FSA-91/36) (see paragraph 7.22).

7.6 Catches of *D. eleginoides* in the longline fishery of 2 394 tonnes were in accordance with the TAC of 2 500 tonnes set by the Commission for the period commencing on 2 November 1990 (Conservation Measure 24/IX).

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[*] Based on recent findings, the name has been changed from *Patagonotothen brevicauda guntheri* to *Patagonotothen guntheri* (Dewitt *et al.*, 1990)

Table 1: Catches of various finfish species from Subarea 48.3 (South Georgia subarea) by year. Species are designated by abbreviations as follows: SSI (*Chaenocephalus aceratus*), ANI (*Champsocephalus 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	SSI	ANI	SGI	ELC[e]	TOP	NOG	NOR	NOS	NOT	OTHERS	TOTAL
1970	0	0	0	0	0	0	399704	0	0	0	399704
1971	0	10701	0	0	0	0	101558	0	0	1424	113713
1972	0	551	0	0	0	0	2738	35	0	27	3351
1973	0	1830	0	0	0	0	0	765	0	0	2595
1974	0	254	0	0	0	0	0	0	0	493	747
1975	0	746	0	0	0	0	0	1900	0	1407	4053
1976	0	12290	0	0	0	4999	10753	500	0	190	28732
1977	293	93400	1608	0	441	3357	7945	2937	0	14630[a]	124611
1978	2066	7557	13015	0	635	11758	2192	0	0	403	37626
1979	464	641	1104	0	70	2540	2137	0	15011	2738[b]	24705
1980	1084	7592	665	505	255	8143	24897	272	7381	5870	56664
1981	1272	29384	1661	0	239	7971	1651	544	36758	12197[c]	9167
1982	676	46311	956	0	324	2605	1100	812	31351	4901	89036
1983	0	128194	0	524	116	0	866	0	5029	11753[d]	146482
1984	161	79997	888	2401	109	3304	3022	0	10586	4274	104742
1985	1042	14148	1097	523	285	2081	1891	1289	11923	4238	38517
1986	504	11107	156	1187	564	1678	70	41	16002	1414	32723
1987	339	71151	120	1102	1199	2844	216	190	8810	1911	87882
1988	313	34620	401	14868	1809	5222	197	1553	13424	1387	73794
1989	1	21359	1	29673	4138	838	152	927	13016	55	70160
1990	2	8027	1	23623	8311	11	2	24	145	2	40148
1991	2	92	2	78488	3641[f]	3	1	0	0	1	82423

[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 *Electrona carlsbergi*
[f] Includes 1 440 tonnes taken before 2 November 1990

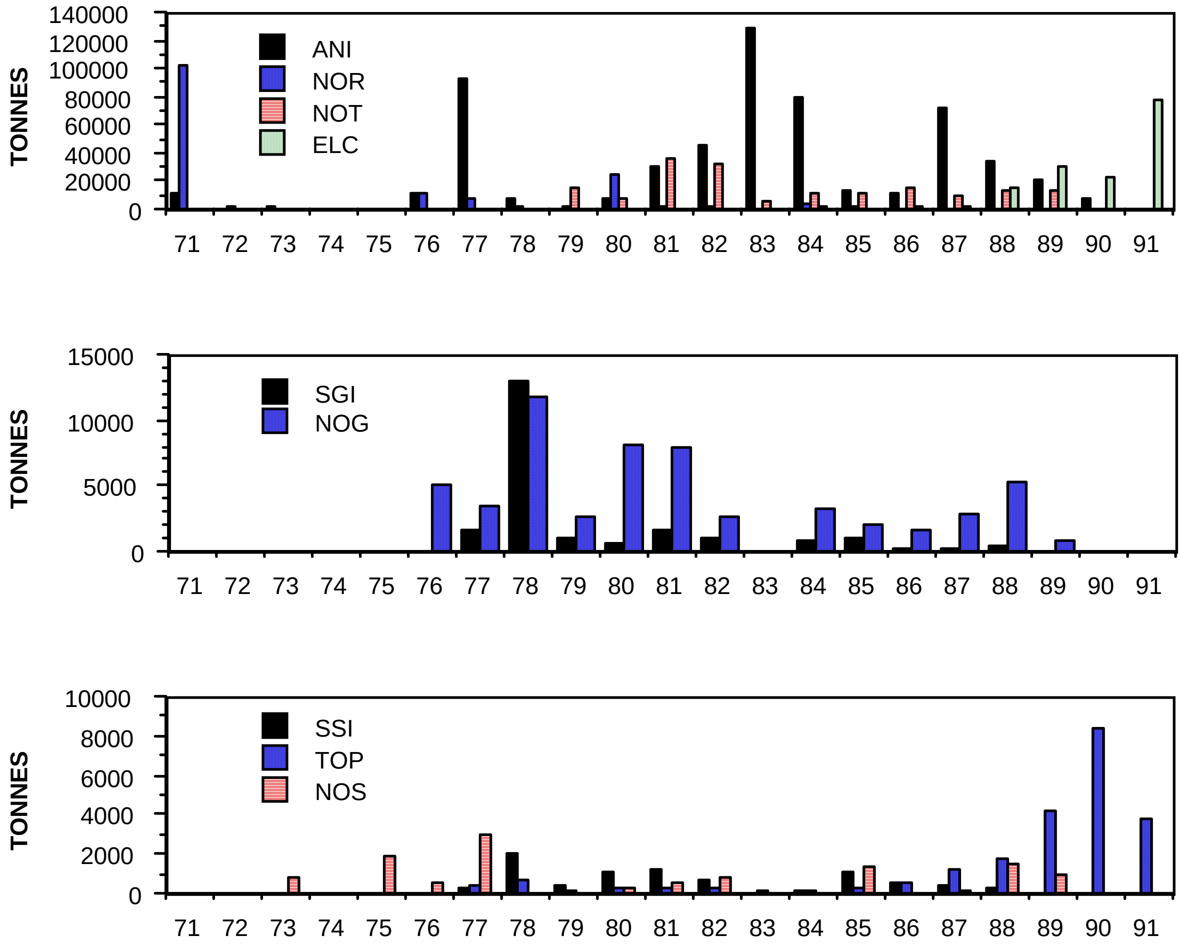

Figure 1: Catches of major species in Subarea 48.3.

7.7 Reported catches of other demersal species, such as *N. rossii*, *Notothenia gibberifrons*, *Pseudochaenichthys georgianus* and *Chaenocephalus aceratus* were in the order of a few tonnes only and originated exclusively from research vessels. Directed fishing on these species was prohibited in 1990/91 (Conservation Measures 3/IV and 22/IX).

Notothenia rossii (Subarea 48.3)

7.8 This species was severely affected by fishing in the early 1970s. The Commission's conservation measures in force since 1985 (Conservation Measures 2/III and 3/IV) have prohibited fishing of *N. rossii* and aimed to keep the by-catches of the species to a level as low as possible. Reported catch in 1990/91 was only 1 tonne and was unlikely to have been higher due to the absence of commercial trawling in the subarea.

7.9 Length compositions from research vessel catches (*Falklands Protector* and *Atlantida*) did not exhibit significant differences to previous years, i.e. length compositions consisted mostly of 40 to 65 cm fish with mean lengths of 50 to 53 cm (WG-FSA-91/23 - see paragraph 2.3 above, and WG-FSA-91/14). Biomass estimates from these two surveys were 4 295 tonnes (CV 49%) and 10 022 tonnes (CV 57%), which was in the range of biomass estimates from previous seasons. This suggests that the stock remains at a low level.

Management Advice

7.10 In view of the current low level of the stock of *N. rossii*, all conservation measures for this species should remain in force.

Patagonotothen guntheri (Subarea 48.3)

7.11 Conservation Measure 23/IX prohibited directed fishing on this species in the 1990/91 season. No catch of *P. guntheri* has been reported to CCAMLR.

7.12 Two new biomass estimates from bottom trawl surveys were available to the Working Group:

Period	Biomass (tonnes)	CV%	Source
Jan/Feb 1991	584	45	WG-FSA-91/14
Apr/May 1991	16 365	32	WG-FSA-91/23 (see paragraph 2.3 above)

The biomass estimate varied by an order of magnitude. The CV of the April/May 1991 estimate appears to be comparatively small, but variation was very high in the depth stratum in which *P. guntheri* is known to be most abundant (50 to 150 m). However, due to the benthopelagic mode of life of this species, the Working Group reiterated findings from assessments in previous years that any biomass estimate from a bottom trawl survey is likely to be an underestimate.

7.13 No new information on natural mortality and recruitment in this species had been submitted to CCAMLR. At last year's meeting it was noted that the only catches of *P. guntheri* that have been reported to CCAMLR as fine-scale data are from the South

Georgia area in 1987/88, an area where this species has not been found by research surveys (SC-CAMLR-IX, Annex 5, paragraph 143 and CCAMLR-IX, paragraph 13.24), Members viewed this with great concern as it introduces doubt as to the accuracy of fine-scale data reported to CCAMLR .

Management Advice

7.14 The very low level of fishing in 1989/90 and the absence of fishing in 1990/91 should have resulted in an increase of the biomass of this species. However, information crucial for assessing the state of *P. guntheri*, such as biomass estimates, estimates of natural mortality and recruitment values and fine-scale distribution of catches, are unknown for recent years. As the species is short-lived, the current state of the stock depends critically on the strength of the year classes which have recruited to the stock in the most recent years.

7.15 The Working Group therefore recommended that the present conservation measure should be retained until the information mentioned above becomes available which would allow a re-assessment of the stock to be made.

Notothenia squamifrons (Subarea 48.3)

7.16 A by-catch provision of 300 tonnes (Conservation Measure 13/VIII and 20/IX) and the prohibition of a directed fishery (Conservation Measure 22/IX) have been in force since 1989. The species was only taken in research vessel catches in 1990/91 and catches are unlikely to have exceeded a few tonnes.

7.17 No new information on this species has become available to the Working Group. The Working Group reiterated its statement from 1990 that despite the long catch history of this stock since 1971/72, very little information on length and no information on catch-at-age, recruitment or mortality estimates has been submitted to CCAMLR. The Working Group was therefore unable to assess the state of this stock.

Management Advice

7.18 In the absence of information which would allow an assessment of the stock, the conservation measures presently in force should be retained.

Champsocephalus gunnari (Subarea 48.3)

7.19 Four conservation measures are currently in force with respect to *C. gunnari*. These comprise a mesh size limitation of 90 mm to apply from 1 November 1991 (Conservation Measure 19/IX), a limitation of the total catch in Subarea 48.3 for the 1990/91 season (Conservation Measure 20/IX), the prohibition of a directed fishery on the species between 1 April and 4 November 1991 (Conservation Measure 21/IX) and a catch reporting system in the 1990/91 season (Conservation Measure 25/IX).

Catches Reported

7.20 Data submitted to CCAMLR for 1990/91 were:

Member	Reported Catch (tonnes)	
Poland	41	Commercial
United Kingdom	3	Research
USSR	49	Research

7.21 Assessments performed at the 1990 meeting of WG-FSA indicated that there was a substantial stock of *C. gunnari* in Subarea 48.3, capable of supporting a TAC of between 44 000 and 64 000 tonnes (SC-CAMLR-IX, Annex 5, paragraph 139). The Scientific Committee suggested that the lower end of this range should be extended to reflect the uncertainty associated with the assessment and the possibility of high by-catch of *N. gibberifrons*.

Commercial Catch During 1990/91

7.22 The total reported catch of *C. gunnari* in Subarea 48.3 during 1990/91 was 93 tonnes, 52 tonnes of which was taken by two research surveys in the area. Commercial vessels targetting on *C. gunnari* in Subarea 48.3 during December and January failed to find any commercial concentrations and shifted their operations further south in search of krill. FV *Lepus* operated on the fishing grounds around South Georgia and Shag Rocks from

22 December 1990 to 15 January 1991, yielding a total catch of 30.5 tonnes*. No commercial concentrations were found during this period, which has represented the peak fishing period in previous years. A report on the activities of the Polish commercial fishing vessel *Lepus* is provided in WG-FSA-91/36.

Fishery Independent Surveys

7.23 The results of two bottom trawl surveys in Subarea 48.3 have been reported to the Working Group. A UK survey on *Falklands Protector* during January/February 1991 is reported in WG-FSA-91/14 and preliminary results from a USSR survey during April and May 1991 are reported in WG-FSA-91/23. The results of the *Falklands Protector* have been reported according to the recommendations in SC-CAMLR-IX, Annex 5, Appendix F. The only data available from the *Atlantida* survey were summary biomass estimates and preliminary discussion of the results (Table 2).

Table 2: Estimated biomass from the surveys in 1990/91.

Survey	Estimated Biomass (tonnes)	CV (%)
Falklands Protector WG-FSA-91/14		
January/February 1991		
South Georgia	22 285	16
Shag Rocks	3 919	75
Total	26 204	16
Atlantida WG-FSA-91/23		
April/May 1991		
South Georgia	172 920	44
Shag Rocks	19 224	23
Total	192 144	44

7.24 There is a considerable difference between these estimates. The magnitude of the *Atlantida* survey estimate (172 920 tonnes, CV of 44% at South Georgia and 19 224 tonnes, CV of 23% at Shag Rocks) appears to contradict evidence from the commercial fishery that no commercial concentrations were present in Subarea 48.3 from December to February. The degree to which the fish were aggregated and the distribution pattern during the *Atlantida* survey is currently not known. At the time of the *Atlantida* survey it is possible that the distribution of fish was significantly influenced by the onset of the spawning season.

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* This catch of 30.5 tonnes is from the report of the survey undertaken by the FV *Lepus* whereas a total catch of 41 tonnes was reported in the STATLANT submission and by five-day reporting periods under Conservation Measure 25/IX.

7.25 The catches during the *Falklands Protector* survey (WG-FSA-91/14) were dominated by fish of lengths 12 to 19 cm, suggesting that the population at South Georgia was dominated by 1 year olds, possibly indicating a strong year class coming into the fishery in 1991/92. No size distribution from the *Atlantida* survey is currently available.

7.26 The *Akademik Knipovich* survey in 1989/90 produced a stock size estimate for South Georgia of 878 000 tonnes (SC-CAMLR-IX, Annex 5). The *Atlantida* survey in 1990/91 produced an estimate of 172 920 tonnes (WG-FSA-91/23), suggesting a drop in biomass of about 80%. The *Hill Cove* survey estimate for South Georgia in 1989/90 was 95 405 tonnes (WG-FSA-91/15) and the estimate from the *Falklands Protector* survey in 1990/91 was 22 285 tonnes (WG-FSA-91/14), suggesting a drop in biomass of about 77%. These direct comparisons should only be regarded as approximate indicators of change in stock size due to large CVs and possible differences in catchability between surveys. A summary of the results of all surveys is given in Table 3.

Table 3: Reported catches and summary of biomass estimates from surveys in Subarea 48.3.

Season	Reported Catch (tonnes)	Stock Assessment Surveys				Source
		South Georgia		Shag Rocks		
		Biomass	CV%	Biomass	CV%	
1984/85	14 144	15 821	101			SC-CAMLR-IV/BG/11
1984/85		17 232				SC-CAMLR-IX[1]
1985/86	11 107					
1986/87	71 151	151 293	95	62 867	84	Balguerías *et al.*, 1989[2]
1986/87		50 414	18	10 023	55	SC-CAMLR-VI/BG/12
1986/87		51 017		4 229		SC-CAMLR-IX[1]
1986/87		47 312	-			Sosinski and Skora, 1987
1987/88	34 620	15 086	21	1447	78	SC-CAMLR-VII/BG/23
1987/88		15 716		509		SC-CAMLR-IX[1]
1987/88		17 913	-			Sosinski (unpubl.)
1988/89	21 356	21 069	50			WG-FSA-89/6
1988/89		22 328				SC-CAMLR-IX[1]
1988/89		31 686	45			Parkes (unpubl.)[3]
1989/90	8 027	95 405	63	279 000[4]	83	SC-CAMLR-IX, Annex 5
1989/90		878 000	69	108 653	31	"
1989/90		887 000	31			"
1990/91	92	22 285	16	3 919	75	WG-FSA-91/14
1990/91		172 920	44	19 225	23	WG-FSA-91/23

1 Calculated at WG-FSA-90 to take account of new sea bed areas in WG-FSA-90/8

2 Semipelagic trawl used as a bottom trawl

3 Data from *Professor Siedlecki* survey, February 1989 re-worked according to model 3 in WG-FSA-90/13 and using seabed areas in WG-FSA-90/8

7.27 Dr Gasiukov pointed out that another interpretation was possible if the trawl surveys carried out in seasons 1989/90 and 1990/91 are considered as independent measurements of the same biomass value. These observations indicate a large degree of uncertainty in estimates of the status of the stock using trawl surveys: in 1989/90 total biomass estimates for Subarea 48.3 were between 374 405 and 986 653 tonnes, and in 1990/91 between 26 204 and 192 144 tonnes.

Population Dynamics

7.28 There are indications from both the commercial fishery and scientific surveys that there has been a significant reduction in stock size between 1989/90 and 1990/91. Simple cohort projections from 1989/90 to 1990/91 based on reported catches and normal levels of natural mortality do not account for the magnitude of this apparent reduction. There are a number of explanations which should be considered:

(i) significant unreported fishing mortality during the latter part of 1989/90 and early 1990/91;

(ii) significant increase in natural mortality over the assumed normal level (0.48 to 0.56);

(iii) significant emigration of fish from Subarea 48.3 to other areas; and

(iv) bottom trawl surveys of the type conducted in recent years may not accurately reflect the abundance of this species.

7.29 With regard to (i), there is no evidence of significant unreported fishing mortality of *C. gunnari* in the period 1989/90 to 1990/91.

7.30 With regard to (ii), there is evidence from various sources that there were some peculiarities in Subarea 48.3 during the 1990/91 season, which could lead to an increase in natural mortality above the usual level. Evidence from the *Falklands Protector* survey reported in WG-FSA-91/29 indicates that krill, the preferred prey of *C. gunnari*, was in short supply during the survey and the fish were relying on food with a lower calorific value (e.g. *Themisto gaudichaudii*). In addition other predators which normally rely on krill, such as black-browed albatross, macaroni penguins and fur seals, have shown poor breeding success at South Georgia in 1990/91. Other predators which do not rely on krill (e.g. grey-headed albatross) have bred successfully. If this situation were characteristic of the first half of 1990/91 it is possible that *C. gunnari* were suffering from a food shortage and predators (e.g. fur seals) normally targetting krill shifted their attention to finfish, particularly *C. gunnari*. The commercial catch of krill in Subarea 48.3 during 1990/91 was approximately 40 000 tonnes which is about 50% of the 1989/90 level.

7.31 WG-FSA-91/7 reports evidence from the *Falklands Protector* survey that the reproductive performance of adult *C. gunnari* in the period leading up to spawning was poor, possibly as a result of poor feeding conditions. 60% of the fish sampled during the *Atlantida* survey (April/May) were in stage III according to the same scale as used on the *Falklands Protector* survey. At this time of year a greater proportion of fish might be expected to be at maturity state IV or V if the maturation process were progressing normally.

7.32 It is possible that a large-scale emigration of *C. gunnari* from Subarea 48.3 has occurred, although movements of this species between shelf areas were thought to be limited (e.g. WG-FSA-90/10). WG-FSA-91/22 presents an analysis of the genetic variability of *C. gunnari* in Antarctic waters during 1990/91 and reports that, for instance, insufficient genetic difference between Subareas 48.3 (South Georgia and Shag Rocks) and 48.2 (South Orkney Islands) was detected to refute the possibility that fish have moved between these two areas. The precise nature of such a migration is unknown, but it could be in response to changes in food availability, which might be the result of changes in oceanographic conditions. WG-FSA-90/30 presents a preliminary investigation of the relationship between sea surface temperature and seasonal changes in abundance of *C. gunnari* at South Georgia, but no clear relationship was detected.

7.33 Changes in genetic variability between 1989/90 and 1990/91 described in WG-FSA-91/22 are thought to be indicative of both abrupt changes in population size and increased mobility of individuals.

7.34 Suggestions were made in the Working Group that significant numbers of *C. gunnari* from Subarea 48.3 could have migrated as far as the South Orkney Islands in Subarea 48.2 (WG-FSA-91/22). If this were the case then adult fish absent from the population at South Georgia during the *Falklands Protector* survey might be expected in that area.

7.35 The results of a bottom trawl survey around the South Orkneys during January/February 1991 are presented in WG-FSA-91/33. The catches of *C. gunnari* during this survey were larger than expected and the standing stock was estimated to be in the region of 10 000 to 40 000 tonnes, depending upon the method of stratification. The length distribution of the catch during this survey indicates a predominance of larger fish (length 35 to 48 cm), although this may be the result of few samples being taken in shallow water, where the proportion of smaller fish is generally greater.

7.36 With regard to (iv), the Working Group agreed that changes in biomass estimates from only a few trawl surveys do not necessarily indicate any substantial change in stock size because the estimates themselves are subject to considerable uncertainty. However, some Members observed that, taken in conjunction with the apparent absence of fishable concentrations at the usual peak of the fishing season, the poor condition of specimens and the low abundance of krill, the decline in survey biomass estimates is suggestive of a real change in the abundance of the stock.

Assessments Presented at the Meeting

7.37 Two assessments of *C. gunnari* in Subarea 48.3 have been presented. WG-FSA-91/15 presents a VPA tuned to bottom trawl survey abundance indices between 1986/87 and 1990/91 (Laurec-Shepherd method), which estimates population size in July 1990 (start of 1990/91) to be between 32 000 and 41 500 tonnes. Catch levels for 1991/92, based on $\mathbf{F_{0.1}}$ are in the region of 8 000 to 14 000 tonnes. This paper suggests that a decline in recruitment of 1 year olds and spawning stock abundance has occurred over recent seasons. WG-FSA-91/27 presents a VPA tuned to both standardised catch/effort indices by age group between 1982/83 and 1989/90 and survey abundance indices between 1984/85 and 1990/91 (adaptive method). This estimates population size at the start of 1990/91 to be 184 000 tonnes and advises a TAC of 59 400 tonnes based on $\mathbf{F_{0.1}}$.

7.38 The two assessments give very different results (Figure 2). This is mainly because of the different indices and standardisation used to tune the VPAs, but also involves the VPA fitting procedures and minor variations of input data for catch-at-age and mean weights-at-age.

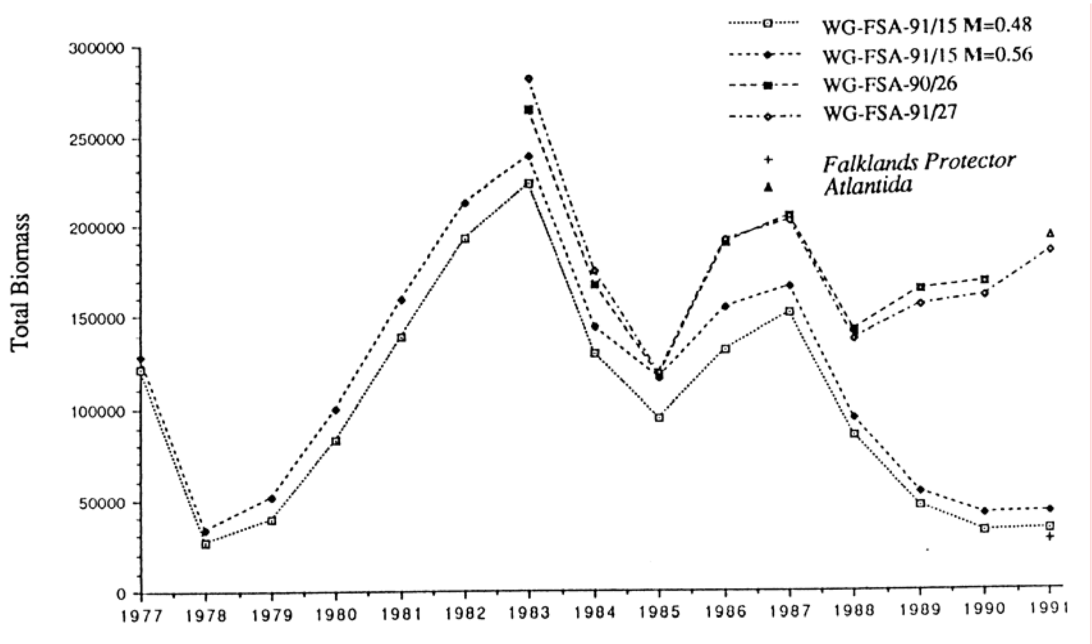

Figure 2: Comparison of total biomass from VPAs presented to the Working Group in 1990 and 1991.

7.39 The catch-at-age data used in the two assessments were different in some years due to differences in the application of age/length keys and length distributions. The catch-at-age in WG-FSA-91/15 was taken from previous analyses performed at the Working Group (WG-FSA-90/5), but due to the absence of data from the commercial fishery, information for years 1989/90 and 1990/91 was derived from surveys. The catch-at-age in WG-FSA-91/27 was the same as in WG-FSA-91/15 for seasons 1986/87 to 1988/89, but differed in other years.

7.40 Dr Gasiukov pointed out that this difference had been discussed at the Working Group's meeting in 1989. It was noted that the catch-at-age structure used in WG-FSA-91/15, determined over a number of years and based solely on two age/length keys leads to biased assessments of age-specific yield (SC-CAMLR-VIII).

7.41 Although it was not possible to resolve differences between the two catch-at-age series, this was not the major source of variation between the results of the two analyses.

7.42 The survey indices used in WG-FSA-91/27 for 1989/90 and 1990/91 combined the biomass estimates from both South Georgia and Shag Rocks, but used estimates for South Georgia only from 1984/85 and 1988/89, leading to an inconsistent series of abundance indices. In addition, the inclusion of a semipelagic trawl in the survey from 1986/87, with the possible difference in catchability, adds further inconsistency to the series. The 1991 result from the *Falklands Protector* survey was not included.

7.43 Dr Gasiukov pointed out that WG-FSA-91/15 only employed data from trawl surveys in the South Georgia area which does not reflect the status of the *C. gunnari* stock in its entire distribution area. Information has not been taken into account from Shag Rocks where a significant proportion of the stock may be located. Moreover, this part of the stock may vary disproportionately over different years. For example, this part comprised 37% in 1989/90 and 15% in 1990/91. Therefore, the abundance indices in WG-FSA-91/15 are not representative of the status of the *C. gunnari* stock. Results from trawl surveys carried out by RV *Akademik Knipovich* (1989/90) and *Atlantida* (1990/91) were not included.

7.44 Dr Gasiukov further noted that the standardisation of trawl survey-based abundance indices used to tune the VPA in WG-FSA-91/27 used the adaptive algorithm and presupposes the calculation of residuals using the values standardised according to the month in which the trawl survey was carried out.

7.45 The standardising of indices using equation (3) of WG-FSA-91/15 is suspect because values of different dimensions were used for $\mathbf{N_a}$ and $\mathbf{C_{ai}}$.

$$N_a = N_{at} e^{[m(t-1)/12]} + \sum_{i=1}^{t-1} C_{ai} e^{[m(t-i-1)/12]}$$

where **a** = age group
i = sequential month number (July = month 1)
t = month at the start of the survey
M = natural mortality rate
$\mathbf{N_a}$ = standardised index of abundance (number of fish-at-age **a** on 1 July)
$\mathbf{N_{at}}$ = index of abundance at the time of survey
$\mathbf{C_{ai}}$ = catch by age group per month.

Thus, the abundance indices presented in WG-FSA-91/15 are biased and do not reflect the abundance dynamics of *C. gunnari* in Subarea 48.3.

7.46 In the work presented in WG-FSA-91/15 a selected series of surveys using bottom trawls at South Georgia were used for tuning the VPA. Surveys were selected on the basis that they represented a consistent series of abundance indices which were representative of changes in the size of the population of *C. gunnari* in Subarea 48.3. WG-FSA-91/16 presents the details of the bottom trawls used during these surveys and suggests that, with the possible exception of the HC-120 trawl used during the *Hill Cove* survey of 1989/90 (WG-FSA-90/11 Rev. 1) the catchability of the trawls was consistent. There was insufficient information available for the trawls used during the *Akademik Knipovich* and *Anchar* surveys of 1989/90 (WG-FSA-90/29 and 30) to allow the same comparison. Indices from Shag Rocks were not included due to the absence of data for 1988/89 and the higher degree of uncertainty associated with those available for other years (see Table 3).

7.47 The survey indices used were weighted by the inverse of the variance of the stratified mean haul, leading to a reduction of the influence of estimates with a high degree of uncertainty. This would tend to automatically down-weight high survey estimates with large variances. As a result the 1989/90 abundance index from the *Hill Cove* survey has very little influence on the tuning of the VPA abundance estimate. This is, however, a real result which should not be ignored, although some weighting related to the precision of the estimates is desirable. A better approach might be to weight the survey estimates by the inverse of the square of the CV.

7.48 Dr Gasiukov stated that the weighting factors presented in WG-FSA-91/15 fundamentally lead to an underestimation of the size of the *C. gunnari* stock in years of high abundance and biomass which was especially so for the biomass estimate in 1989/90 and to a large extent influence the stock assessment for 1990/91.

7.49 In WG-FSA-91/27 an attempt was made to tune the VPA using both CPUE and survey indices. The concept of including all of the available information in the model has merit. In addition, the method takes account of the precision of the indices by weighting the relative abundance indices. However, a comparison of the results in WG-FSA-91/27 with those presented in WG-FSA-91/26, which was tuned to CPUE indices only, suggests that the inclusion of the survey indices in the assessment model had very little influence on the VPA. It appears that the application of the adaptive method in WG-FSA-91/27 placed undue weight on the CPUE indices.

7.50 Dr Gasiukov pointed out the fundamentally divergent approaches to *C. gunnari* stock assessment applied in WG-FSA-91/15 and 27. The first of these documents only uses limited information from selected trawl surveys while the second employs an approach based on the integrated use of observation data obtained from various sources and including CPUE values over a number of years from fishing vessels as well as trawl survey data for the seasons 1984/85 to 1990/91. Also, if several surveys were undertaken in certain years (e.g. in 1989/90) this is also taken into consideration in the calculation.

7.51 In WG-FSA-91/27 the total effort data from the commercial fishery was used with the catch-at-age matrix to CPUE derive indices for six age classes over eight years, a total of 48 indices. A total of seven trawl survey indices were used from the period 1985 to 1991. The relative weighting of the alternative CPUE indices and trawl survey results was based on the values of the CV. The trawl surveys were assigned an average CV of 0.4, while the CPUE data in WG-FSA-90/26 gave a mean CV of 0.319. The weighting factors therefore were 1 for CPUE indices and 0.89 for trawl survey indices.

7.52 There is a problem with the application of the adaptive approach in WG-FSA-91/27 concerning the minimisation of the sum of squares. The squared deviations of the 48 indices of CPUE using a weighting factor of 1 have been combined with seven trawl survey indices with a weighting factor of 0.89. The CPUE series therefore dominates the analysis and not surprisingly the results in WG-FSA-91/27 closely follow those of WG-FSA-90/26 (Figure 2).

Assessments Made at the Working Group

7.53 A proposal to run a VPA, using Laurec-Shepherd tuning, with both the survey indices from WG-FSA-91/15 and the standardised CPUE indices from WG-FSA-91/27 was investigated. Unfortunately this could not be done with the program (MAFF VPA program version 2.1) in its current form due to: (i) the lack of a CPUE index for 1990/91 (the most recent year); and (ii) the inability of the program to accept separate series of weights for the separate regressions of the two indices. The VPA was re-worked by the Working Group in an attempt to see what influence the different tuning methods had on the results and allow the recommendation of appropriate management advice.

7.54 Two separate VPA runs were made, the first tuned to survey indices presented in WG-FSA-91/15, the second tuned to CPUE indices presented in WG-FSA-90/26. Details of the input data are presented in Appendix F.

7.55 Analysing these input data Dr Gasiukov referred to a number of studies undertaken in recent years (Zh. Frolkina and R. Dorovskikh, 1989; Zh. Frolkina and R. Dorovskikh, 1990; P. Sparre, 1990; P. Gasiukov and R. Dorovskikh, 1991) which support a value of 0.56 for the natural mortality coefficient. Calculations based on $\mathbf{M} = 0.48$ lead to a lower estimate of the *C. gunnari* biomass and also to a 20% decrease in $\mathbf{F}_{0.1}$. This in turn produces a significantly reduced value of TAC.

7.56 Figure 3 illustrates the total estimated biomass of age 2+ from these two runs. Results from run 1 show a similar pattern to the assessment in WG-FSA-91/15 and results from run 2 show a similar pattern to the assessment in WG-FSA-91/27. There is a difference between the two runs in the most recent years.

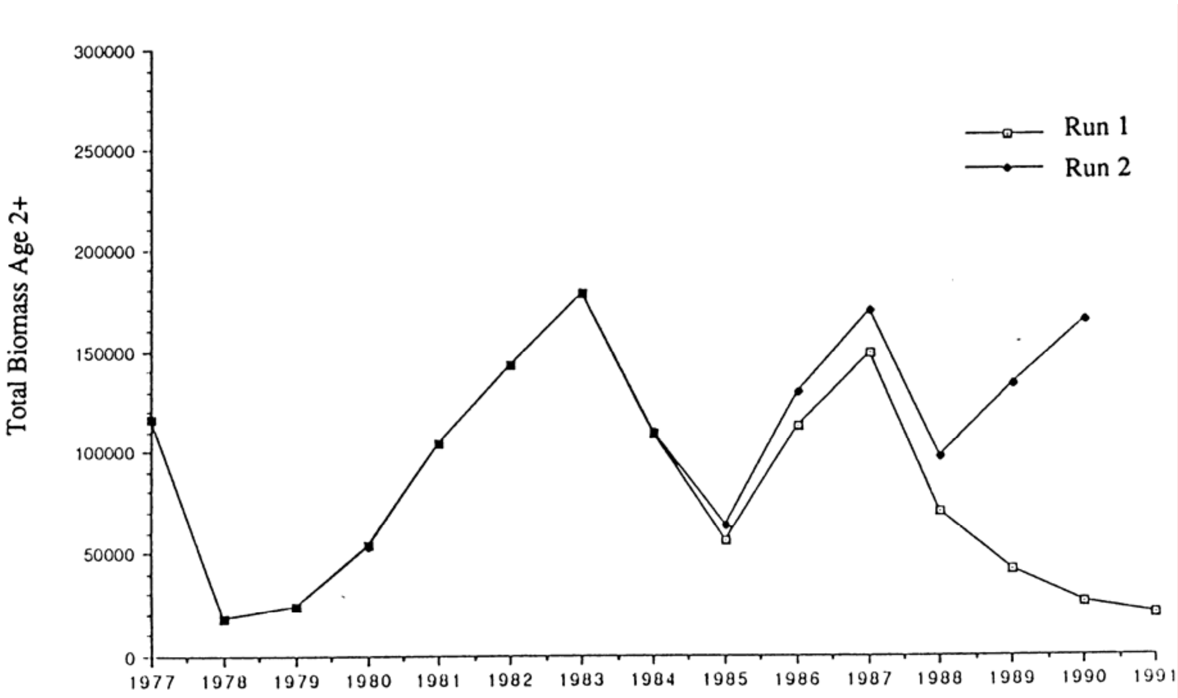

Figure 3: Biomass of *C. gunnari* for both assessment runs: run 1 tuned to survey indices, and run 2 tuned to CPUE indices.

7.57 Y/R analyses presented in WG-FSA-91/15 and 27 provide estimates of $\mathbf{F_{0.1}}$ summarised in Table 4.

Table 4: Values of $\mathbf{F_{0.1}}$ based on Y/R analyses.

Selectivity	**M** = 0.48	**M** = 0.56	Source
Knife edge:			
$\mathbf{t_c}$ = 1 year	0.27	0.32	WG-FSA-91/15
$\mathbf{t_c}$ = 2 years	0.39	0.44	"
$\mathbf{t_c}$ = 3 years	0.54	0.64	"
$\mathbf{t_c}$ = 4 years	0.74	0.84	"
Partial recruitment:			
80 mm mesh (WG-FSA-90/27)	0.44	0.51	WG-FSA-91/15
90 mm mesh (WG-FSA-91/27)	-	0.65	WG-FSA-91/27

7.58 In accordance with Conservation Measure 19/IX, the minimum mesh size permitted in the fishery targetting *C. gunnari* will increase from 80 mm to 90 mm on 1 November 1991. WG-FSA-91/27 presents a theoretical assessment of selectivity by a 90 mm mesh assuming selectivity is described by the logistic curve, the correct estimation of selectivity by the 80 mm mesh, and growth according to the von Bertalanffy growth equation. Estimated coefficients of partial recruitment are given in Table 5:

Table 5: Change in coefficients of partial recruitment estimated to apply to the change in mesh size.

Age Group:	1	2	3	4	5	6
Partial recruitment (80 mm)	0.04	0.42	1.0	1.0	1.0	1.0
Partial recruitment (90 mm)	0.01	0.15	0.77	0.98	1.0	1.0

7.59 Some Members felt that high catches of 2 year olds taken by the 80 mm mesh in the past (e.g. SC-CAMLR-VII, Annex 5, Table 1), however, suggest that the coefficient of partial recruitment for that age may be underestimated, particularly at high catch rates (Slosarczyk *et al.*, 1989). Assumption that future exploitation will not take a significant proportion of 2 year olds, even with the 90 mm mesh, is unrealistic. A more conservative approach would be to consider $\mathbf{F_{0.1}}$ for knife edge selection at a $\mathbf{t_c}$ of 2 years.

7.60 Dr Gasiukov felt that using $\mathbf{t_c}$ = 2 in the knife-edge selection is not consistent with Conservation Measure 19/IX which sets a 90 mm mesh size from 1 November 1991. Calculations in WG-FSA-91/27 show that the partial recruitment coefficient for the age group 2 would decrease three-times and be equal to 0.15 of the value for fully exploited age groups.

7.61 Therefore using $\mathbf{F_{0.1}}$ at $\mathbf{t_c}$ = 2 would decrease the coefficient $\mathbf{F_{0.1}}$ two-times; this would not be the optimal fishing regime.

Projections

7.62 Population projections were prepared assuming $\mathbf{M}$ = 0.48, $\mathbf{t_c}$ = 2 years and the catch in 1991/92 to be equivalent to exploitation at the $\mathbf{F_{0.1}}$ level (0.39). A mean value of recruitment was assumed: mean over the period 1985/86 to 1989/90 for projection 1 (from run 1) and mean over the period 1985/86 to 1988/89 for projection 2 (from run 2). The algorithms used for the cohort projections are as shown in WG-FSA-91/15.

7.63 The results of the projections are set out in Table 6. VPA run 1 is projected forwards from July 1990 (start of 1990/91) and VPA run 2 is projected forwards from July 1989 (start of 1989/90). The latter projection involves one more season and therefore includes a higher degree of uncertainty.

Table 6: Results of projections using cohort analysis (numbers x 1 000). Biomass values assume mean weights-at-age in WG-FSA-91/15.

Projection 1 from VPA run 1:							
Age Class	Population Numbers	Catch-at-Age 1989/90	Population Numbers July 1990	Catch-At-Age 1990/91	Population Numbers July 1991	Catch ($\mathbf{F_{0.1}}$) (tonnes) 1991/92	Population Numbers July 1992
1			289 863	2	289 863	0	289 863
2			47 076	215	179 361	4 308	179 362
3			29 962	242	28 961	1 416	75 144
4			31 081	86	18 350	1 508	12 133
5			1 036	4	19 165	2 335	7 688
6			518	2	638	106	8 029
Total Biomass (tonnes)			26 938		41 834	9 672	47 291

Projection 2 from VPA run 2:							
Age Class	Population Numbers	Catch-at-Age 1989/90	Population Numbers July 1990	Catch-At-Age 1990/91	Population Numbers July 1991	Catch ($\mathbf{F_{0.1}}$) (tonnes) 1991/92	Population Numbers July 1992
1	791 488	240	791 488	2	791 488	0	791 488
2	192 860	6 195	489 571	215	489 758	11 762	489 760
3	622 567	31 920	114 465	242	302 769	14 805	205 185
4	39 571	1 967	360 125	86	70 639	5 805	126 846
5	2 842	96	22 939	4	222 772	27 137	29 594
6	30	1	1 683	2	14 191	2 361	93 331
Total Biomass (tonnes)	156 626		195 833		236 779	61 870	200 428

7.64 Exploitation at $\mathbf{F_{0.1}}$ produces catches in the 1991/92 season of 9 672 tonnes in projection 1 and 61 870 tonnes in projection 2.

Interpretation of the Assessments

7.65 Figure 4 illustrates the pattern of recruitment over time for the two VPA runs. The pattern for both runs shows considerable variation. The use of the mean over the period 1985/86 to 1988/89 for the projection of run 2 may over-estimate future recruitment given the very large value in 1987/88.

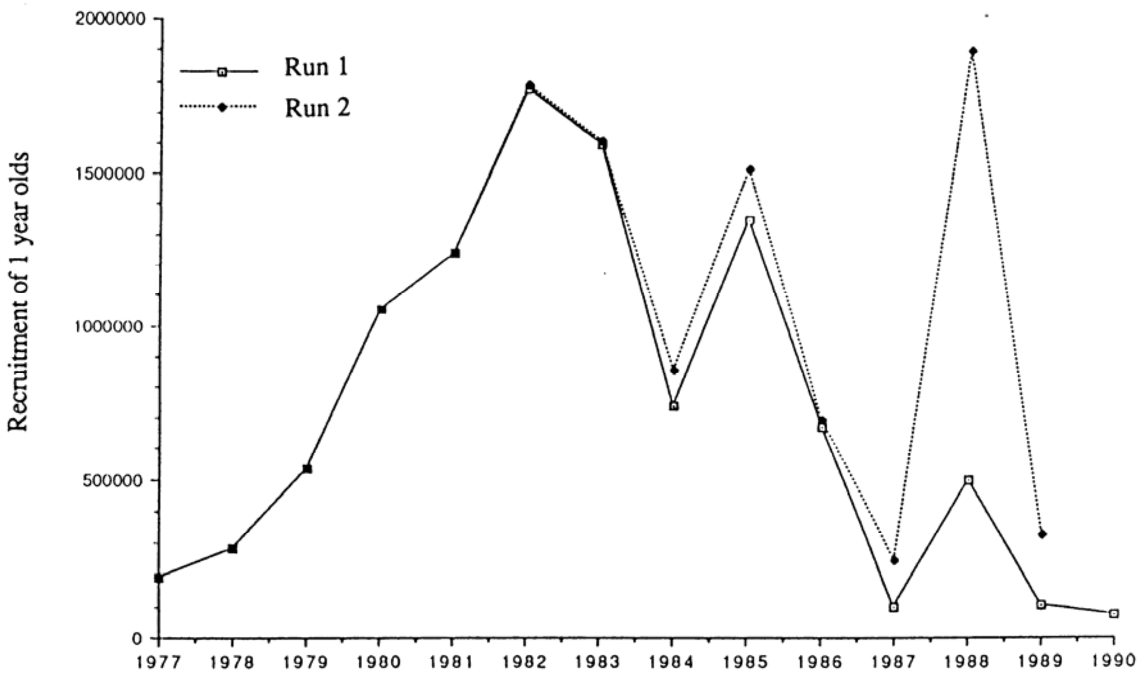

Figure 4: Recruitment (age 1) of *C. gunnari* for both assessment runs.

7.66 The projections in Table 6 depend critically on the size of the recruiting age classes. Observations from the 1991 trawl survey (UK) suggest that the 1 year old age class was abundant in 1991; these 1 year old fish will begin to recruit into the fishery as 2 year olds next year.

7.67 The size of the 1 year old age class in 1992 is not critical to this assessment as the fishery in 1991/92 will not rely on these smaller fish. Because of the importance of recruitment in the projection model, prediction of the population size more than one year ahead becomes unreliable. This shows the value of trawl surveys for estimating the abundance of pre-recruits in the year preceding catches for which a TAC is set. In the absence of any independent abundance estimate, the mean recruitment based on the VPA results could be used. This is not a conservative approach, however, as it assumes no trend in recruitment has occurred, and there is no clear relationship between stock size and recruitment.

7.68 Dr Gasiukov drew to the attention of Working Group members, discrepancies between estimates of recruitment in run 1 and the results of trawl survey observations presented in Table 4 of Appendix F.

7.69 While a tendency towards a decrease in abundance of age group 1 may be evident from these particular VPA results, then trawl survey data indicate the converse; recruitment in 1988/89 is from 10- to 20-times higher than in seasons 1986/87 and 1987/88; and in 1990/91 is 10-times greater than in seasons 1986/87 and 1987/88.

7.70 Dr Gasiukov felt that this is the result of an inadequately tuned VPA which in the terminal year uses only the results of a UK trawl survey and disregards survey results from 1988/89 and the results of trawl surveys by RV *Atlantida* in 1990/91.

7.71 The results of the trawl surveys from 1987 to 1991 (Table 4 of Appendix F) can be used to look at the relative frequency of age classes and compare them to the pattern of recruitment seen in the VPA results. In the 1989 survey, the 1 year old cohort was abundant, whereas the VPA suggests a large 2 year old cohort. This anomaly is of major concern for this assessment.

7.72 There are two important factors to consider when interpreting the results of the VPA:

(i) the catch of 2 year old fish in 1989 by the commercial fishery could indicate that a very abundant year class entered the fishery or alternatively, it could suggest that the fishery targetted younger fish or the older age classes were not abundant; and

(ii) there is uncertainty whether catches in 1989 were in fact strongly dominated by the 2 year old cohort. The age distribution of the catch for 1989 used in the VPA was determined by application of an age/length key from Polish data. The use of an age/length key from Soviet data gives a different distribution of age classes in the catch.

7.73 Dr Gasiukov stated that the suggestion that the predominance of two year old fish in catches in 1989 is the result of a very abundant year-class is the more plausible. This fact is substantiated by the size structure of catches from the RV *Hill Cove* trawl survey in 1990, presented in Figure 2 of WG-FSA-90/26.

7.74 The uncertainties concerning the catch-at-age data input to the VPA and the effect this has on the assessment make the current status of the *C. gunnari* stock unknown. The alternative VPA models presented show quite different trends in the most recent years. However, in terms of recruitment, the trawl survey data which are based on a random design should more accurately reflect the true pattern of year class strength in the population.

7.75 The variability in year class strength of *C. gunnari* is such that large fluctuations in stock size are likely. These year to year changes in biomass can be minimised by retention of more age classes in the population by fishing at a lower exploitation rate. Although this may reduce the yield from the stock over a number of years it will increase the stability of the population and the fishery by reducing dependence on the recruiting year class.

7.76 The apparent abundance of the 1 year old cohort in 1991 suggests that the fishery could operate more successfully in 1992 on 2 year old fish. However, the large number of fish projected from the VPA in previous assessments (particularly from the cohort spawned in 1988) cannot be relied upon to sustain the fishery. In 1990/91, these fish were not located in abundance by the fishery. Although the *Atlantida* survey detected fish in abundance during April/May 1991, no length or age composition data were available from this survey.

7.77 Dr Gasiukov felt that uncertainty in estimates is to a large extent determined by the fact that the trawl survey data used do not adequately reflect the status of the *C. gunnari* stock: this can be seen in Figure 5. This leads to a significant underestimation of the stock in WG-FSA-91/15 and run 1. It is worth noting the discrepancies existing between both the above calculations and stock assessment results obtained by the Working Group in 1990 and independent biomass estimates obtained by three research vessels in 1990. There is good agreement between results of stock assessment in 1990 and VPA results in WG-FSA-91/27 and run 2. This leads one to conclude that there is a greater degree of robustness in the latest estimates. The correlation coefficient for the relationship between mean weighted fishing mortality coefficients of the major age groups and fishing effort in these estimates equals 0.72 (WG-FSA-90/26) (Figure 6). The above is the rationale for including in management advice the TAC given in WG-FSA-91/27 and run 2.

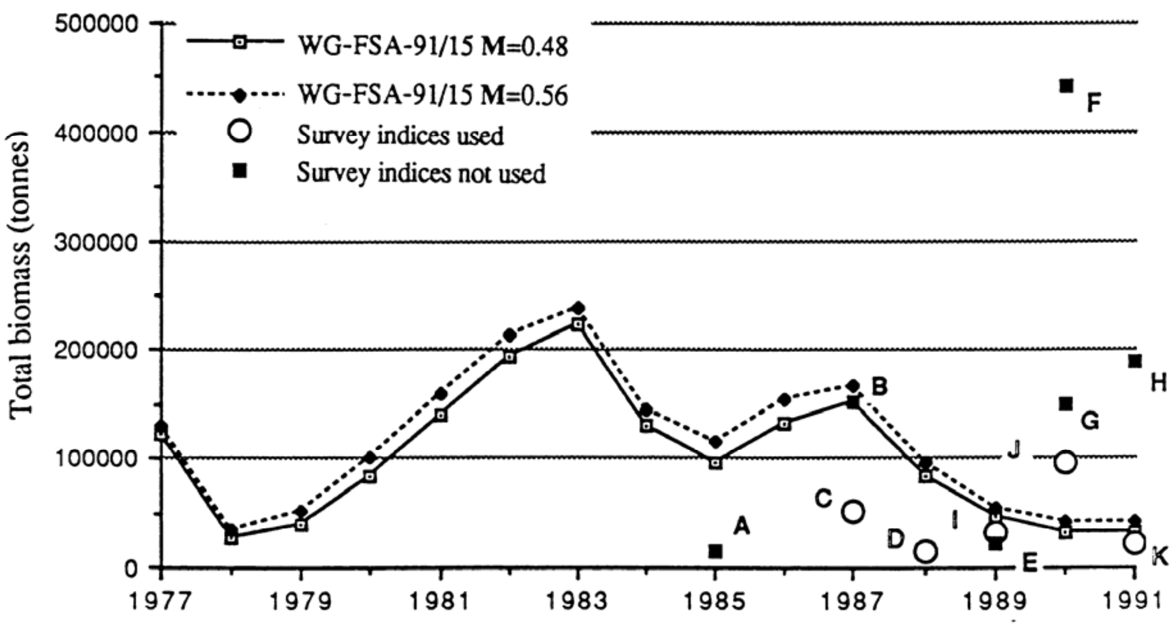

Figure 5: WG-FSA-91/15. Total biomass from VPA and from surveys used in tuning.

Note: Open circles represent survey biomass estimates, not standardised indices used in run 1.

A - Kock *et al*., 1985
B - Balguerías *et al*., 1989
C - SC-CAMLR-VI/BG/12
D - SC-CAMLR-VII/2
E - WG-FSA-89/6
F - SC-CAMLR-IX
G - SC-CAMLR-IX
H - WG-FSA-91/23
I - Unpublished
J - WG-FSA-90/11
K - WG-FSA-91/14

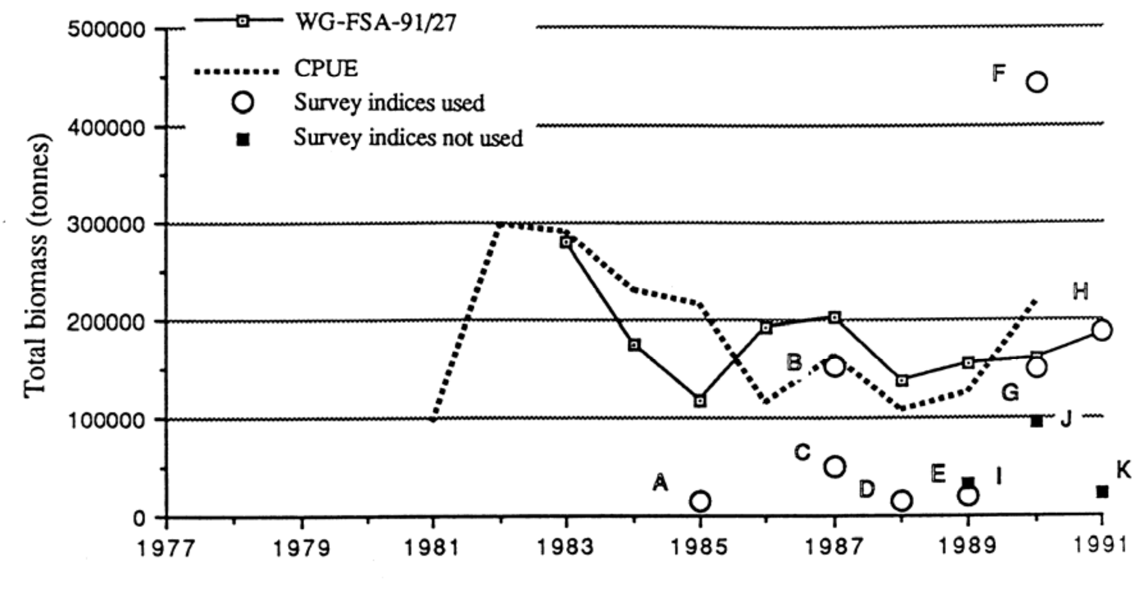

Figure 6: WG-FSA-91/27. Total biomass from VPA. CPUE and survey biomass used in tuning.

7.78 Some Members expressed the opinion that although there are uncertainties associated with results from all trawl surveys, they do provide the most reliable basis for assessing the state of the stocks.

Management Advice

7.79 Assessments presented to the Working Group and performed during the meeting provide a wide range of possible catch levels in 1991/92 based on the $\mathbf{F_{0.1}}$ management strategy (8 400 to 61 900 tonnes).

7.80 Dr Gasiukov suggested that the highest value could form the basis for a TAC.

7.81 Other Members felt that a much more conservative level would be appropriate considering the uncertainties associated with the current population size, year class strength, and future recruitment.

7.82 The by-catch of other species in the pelagic trawl fishery may have implications for the TAC of *C. gunnari* in 1991/92. This problem was identified in paragraph 3.42 of SC-CAMLR-IX with regard to the by-catch of *N. gibberifrons* and discussed in this report (paragraph 8.10).

7.83 No new information was presented to the Working Group concerning mesh selectivity of *C. gunnari*. The Working Group had no reason to suggest changes to the mesh regulation size of 90 mm in Conservation Measure 19/IX.

7.84 Assessment of the implications of a re-introduction of commercial bottom trawling in Subarea 48.3 on the by-catch of demersal fish species is given in paragraphs 7.189 to 7.197. The Working Group endorsed the ban on the use of bottom trawls in the directed fishery for *C. gunnari* in Subarea 48.3 (Conservation Measure 20/IX).

7.85 The Working Group supported the continuation of Conservation Measure 21/IX imposing a closed season for *C. gunnari* in Subarea 48.3 between 1 April until the end of the Commission meeting in 1992.

Dissostichus eleginoides (Subarea 48.3)

7.86 In accordance with Conservation Measure 24/IX, the total catch of *D. eleginoides* for the period 2 November 1990 to the end of the Commission meeting in 1991 was limited to 2 500 tonnes. Conservation Measures 25/IX and 26/IX, relating to the reporting of catch, effort and biological data, were also in force.

7.87 Data from five-day reporting periods were submitted. No haul-by-haul data (Conservation Measure 26/IX) have been submitted for the 1990/91 season. Length frequency data (Conservation Measure 26/IX) have been submitted for some months but not yet for the entire period.

7.88 Catch levels of *D. eleginoides* in Subarea 48.3 since 1988 are summarised in Table 1. The reported catch taken in 1990/91 consisted of 1 440 tonnes caught before the meeting of the Commission and 2 394 tonnes caught since 2 November 1990. All catches reported in 1990/91 were taken by longlining.

7.89 Two assessments by Members were presented to the Working Group. The assessment in WG-FSA-91/20 is based on estimates of young fish obtained from two bottom trawl research surveys, projected forward to allow estimation of the exploitable biomass. The assessment presented in WG-FSA-91/24 is based on a generalised cohort analysis of size composition in the catches.

7.90 It was pointed out that the projected biomass figures presented in WG-FSA-91/20 were likely to be over-estimates since only natural mortality was considered in the projection procedure. These were essentially estimates of future biomass and only indicated current biomass under the assumption that the observed levels of young fish could be considered as average.

7.91 Some Members expressed concern that not all fish in the water column are sampled by a bottom trawl. It was pointed out that this effect should be minimised since all trawls were made during the day when fish are less dispersed in the water column. Results did, however, indicate that because of the depth distribution of individuals (small specimens predominate in shallow water and the greatest number of large fish are found in deeper waters), bottom trawl surveys are likely to underestimate the total standing stock but that young fish are likely to be relatively well represented and may therefore give some indication of future recruitment to the fishery.

7.92 It was suggested that there may be migration or mixing of the species along the Patagonian slope toward the Antarctic Peninsula and South Georgia. If this was the case, the surveys would only be sampling young fish of part of the total population. There is currently no information to suggest whether or not there is migration. The Working Group felt that further work on this matter would be useful.

7.93 WG-FSA 91/20 also presented results of an attempt at estimating natural mortality between age-group 2 in 1989/90 and age group 3 in 1990/91. The estimate was found to be unrealistically large and although many possible explanations could be given there was no further information to suggest which was the most likely.

7.94 Drs Gasiukov and Shust felt that it was important to highlight the impossibly high estimate of natural mortality derived by comparison of the abundance estimates from the two surveys. This unsuccessful attempt demonstrates that the input data used have a very high degree of uncertainty (CV of biomass estimates of *D. eleginoides* during the 1990/91 survey was 97%: WG-FSA-91/14). As the same input data from trawl surveys are used for further calculations of TAC. This results in the same level of uncertainty. It becomes particularly clear when results obtained from two years are compared (see Table 8).

7.95 Other Members were of the opinion that, whereas the estimate of natural mortality based on direct comparison of data from two surveys would be very imprecise, the projections use the data from one survey at a time with independent estimates of natural mortality from previous analyses by the Working Group (SC-CAMLR-IX, Annex 5, paragraph 157). These projections were therefore considered to be valid.

7.96 It was pointed out that the CVs of the survey estimates were very high, particularly in the most recent year (WG-FSA-91/14). There is also a large difference between estimates for 1990 and 1991, which is due to a single large catch of large fish obtained in the 1991 survey. This is discussed further in WG-FSA-91/20. Estimated biomass from bottom trawl surveys around Shag Rocks since the beginning of the fishery (WG-FSA-91/14) which consisted primarily of immature fish is between 400 and 20 000 tonnes, indicating a very large range. Adult fish are mostly found in the water deeper than 500 m, beyond the range of the trawl surveys.

7.97 Attention was drawn to the fact that the highest catch level of 8 311 tonnes was very close to and even greater than some of the biomass estimates. It was recognised that the estimates from surveys could not be considered as estimates of total exploitable biomass for the reasons outlined above (paragraph 7.91).

7.98 Members felt that it was preferable to use a dynamic rather than an equilibrium approach in assessing the status of this stock. However, not enough information was available to enable such an approach in this case.

7.99 With respect to the assessment presented in WG-FSA-91/24 the following comments were made. It was pointed out that the analysis was not tuned to independent data but run under the assumption that the fishing mortality in the most recent year (1990/91) was equal to the long-term average fishing mortality. This choice is relatively arbitrary, but was made in the absence of any information on the magnitude of terminal **F** values. The Working Group also recognised that it would be inappropriate to tune the analysis to survey estimates because of the problems outlined above (paragraphs 7.91 and 7.96).

7.100 The author indicated that the iterative procedure always converged to the same value, irrespective of starting values and that there was good agreement between values of fishing mortality for 1988/89 and 1990/91, years in which total catch levels were very similar. This was interpreted as indicating satisfactory tuning.

7.101 Other Members felt that the tuning was driven by the assumption about terminal **F** values and that agreement between catch levels and **F** values in 1988/89 and 1990/91 could only be expected if actual population levels were also similar.

7.102 It was noted that a set of age determinations was used to obtain the growth curve that was used to divide the catches at size into nominal age classes and that variability in growth rates between years could affect this 'slicing' of length frequency distributions. The Working Group agreed that more age/length data for this species were needed and that a larger number of individuals (than the 218 used in this analysis) should be sampled for age determination.

7.103 The author pointed out that although a set of age determinations was used the fitted growth curve gives a good approximation to the data (WG-FSA-91/24, Figure 2). A functional regression was used to obtain the growth curve and a jack-knife procedure was used to estimate the SD of the parameter estimates. The sensitivity of results from the generalised cohort analysis to differences in the growth function were also investigated.

7.104 There was a large difference between the weight and age of the largest fish caught in the longline fishery used in WG-FSA-91/20 and 24. WG-FSA-91/24 uses age determinations which identify fish of weight 23 kg as about 23 years of age.

7.105 WG-FSA-91/20 uses von Bertalanffy growth parameters and a length-weight relationship. These parameters imply that fish of weight 23 kg are about 18 years of age. Dr Gasiukov stated that these parameters also imply that a fish of length 170 cm and of weight 56 kg would be 50 years old and that this seems unlikely to him.

7.106 These disparities in size-at-age suggest that if the age determinations are reliable, there is still some uncertainty about estimates of growth parameters.

7.107 The Working Group also felt that size selectivity of longline gear may affect estimates of demographic parameters. Paper WG-FSA-91/11 indicated that the type and size of hook has a strong effect on the sizes of fish caught. It was suggested that experiments using straight and circular hooks should be done to investigate this matter further.

7.108 A description of the fishery in the most recent year (1990/91) was presented in WG-FSA-91/34. The document included graphs of catch-per unit-effort (CPUE) for the period October 1989 to August 1991. Data for the most recent period were from the five-day reports, whereas data for the previous years were from STATLANT B data.

7.109 The CPUE series in WG-FSA-91/34 showed a sharp decline in 1991 and the Working Group felt that this warranted further investigation. During the meeting, the STATLANT B data for 1991 became available, which enabled the Working Group to construct a CPUE index based on number of hooks rather than number of ship days as used in WG-FSA-91/34. Figure 7 shows that, over the period considered (October 1989 to June 1991), there have not been any large changes in catch-per-unit-effort. The seasonal pattern in 1990/91 is similar to that in 1989/90 but seems to be at a slightly lower level.

7.110 It was noted that the CPUE series suggests that it is unlikely that the population size is increasing. This is contrary to the results from the generalised cohort analysis (WG-FSA-91/24) which indicates an increase in population size.

7.111 The Working Group drew attention to the fact that no change in the CPUE does not necessarily reflect no change in population abundance. A small decrease in CPUE may be associated with a relatively large decrease in population size when CPUE is proportional to a power function of population size.

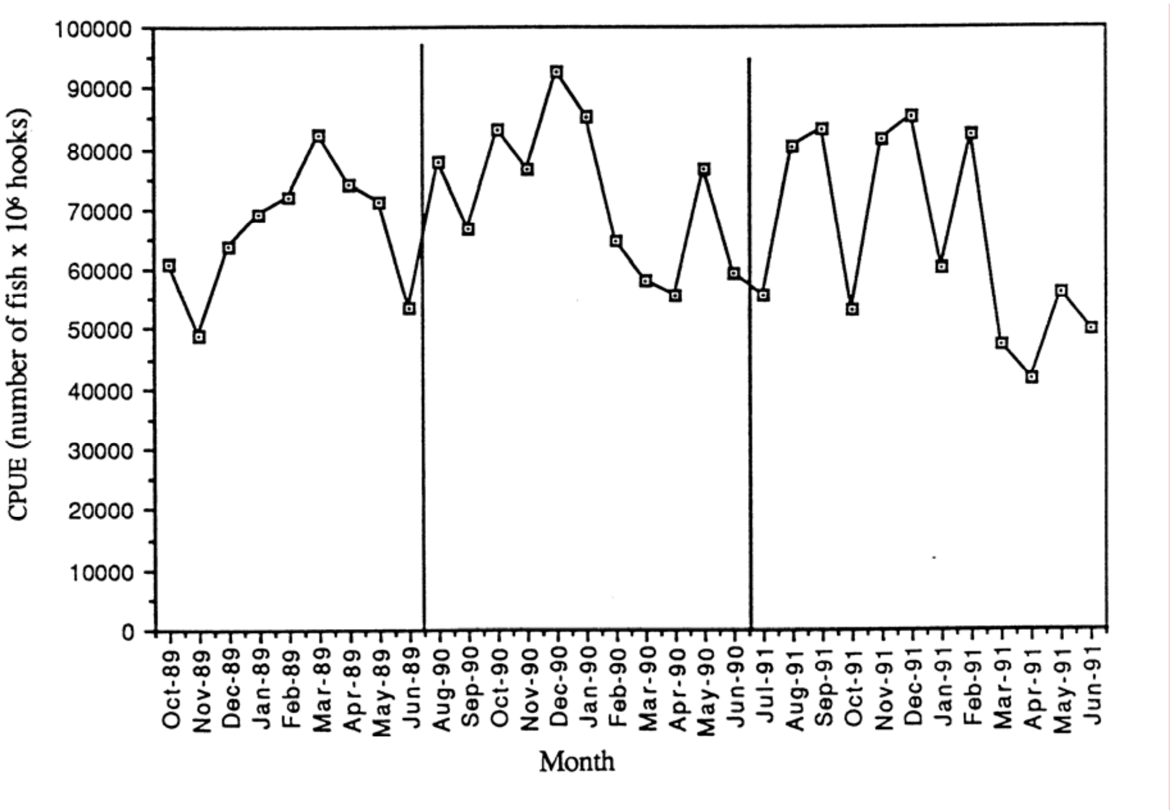

Figure 7: CPUE (numbers per million hooks) for *D. eleginoides* calculated from STATLANT B data assuming a mean weight of 10.82 kg/fish, a weight which was derived from the five-day reporting period data.

7.112 It was also pointed out that the five-day reporting data seems to suggest that the fleet moves from one fishing location to another within the season. This movement of the fleet may confound any change in CPUE that may otherwise be detected. Attention was also drawn to results presented in WG-FSA-91/10.

7.113 Three types of analyses were attempted on the CPUE data from the longline fishery. Prior to 1989, most of the catch was taken by trawlers and these CPUE data are therefore not directly comparable to recent data. First, a simple deLury model (Chapman, 1972) with the assumption of constant recruitment was considered. This model (model 1) involves a simple linear regression of monthly CPUE on the catches, discounted for natural mortality (Appendix G).

7.114 Figures of these data show that the linear relationship between CPUE and discounted catches is very weak and suggest that the relationship may be curvilinear rather than linear. This is not surprising since it is well documented that CPUE (particularly from longline fisheries) may be related to the population abundance by a power function rather than a linear relationship (Mangel, 1985).

7.115 The second and third deLury type models were based on log transformations of the data and the following relationship between CPUE and population abundance, **N**:

$$CPUE_t = q.(N_t)^a$$

The second model (model 2) assumed **a** = 1 (and is therefore similar to the first model, except for the fitting criterion used), whereas the third model (model 3) estimated an **a** value, as well as initial population abundance.

7.116 Figure 8 illustrates the log likelihood function for models two and three over a range of initial population sizes, **N**(1). In both cases the likelihood curve is almost flat with respect to **N**(1) indicating a very bad fit of the model to the data. Figure 9 also illustrates that the fit of the model to the data is not very good and shows that there is not much difference between the model which assumes **a** = 1 and that which estimates '**a**'. The estimated **a** value is 0.04. This value is so low that it suggests that there is very little relationship between CPUE and population size.

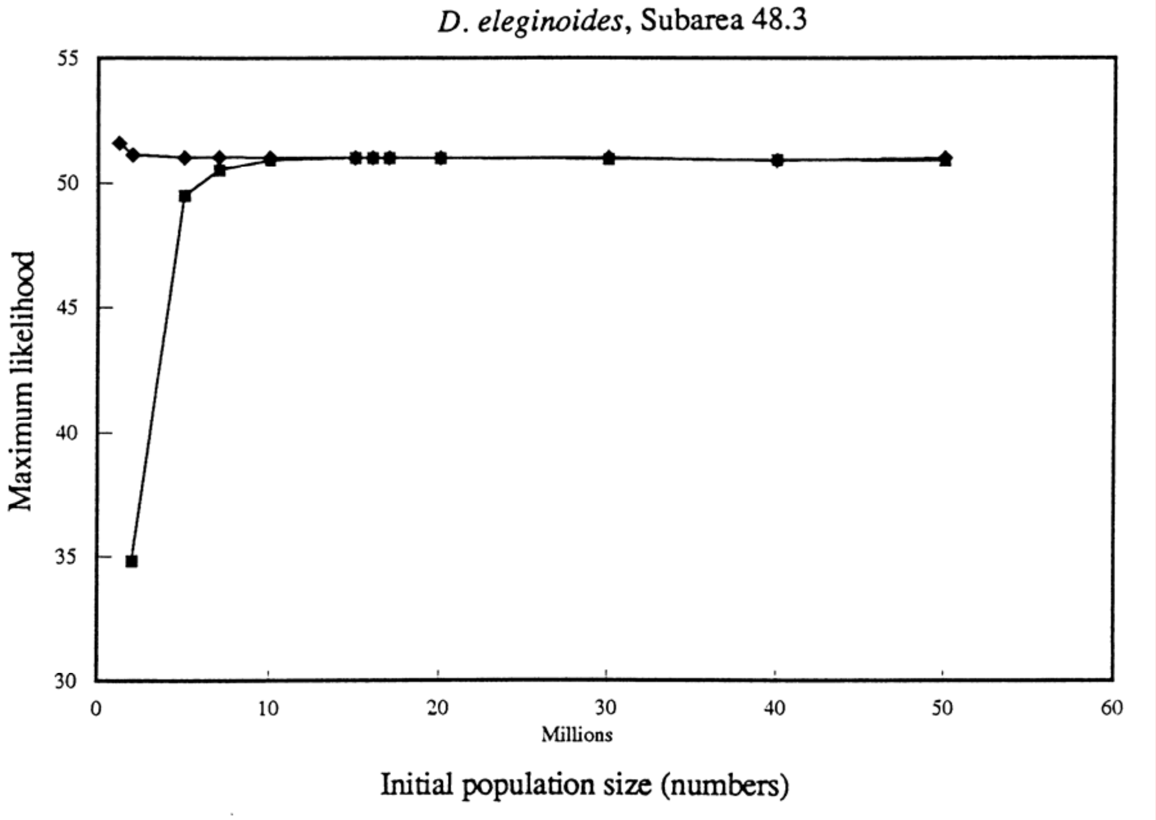

Figure 8: Log likelihood function for the model CPUE = qN^a where **a** = 1 (- -) and where **a** is fitted (-→-).

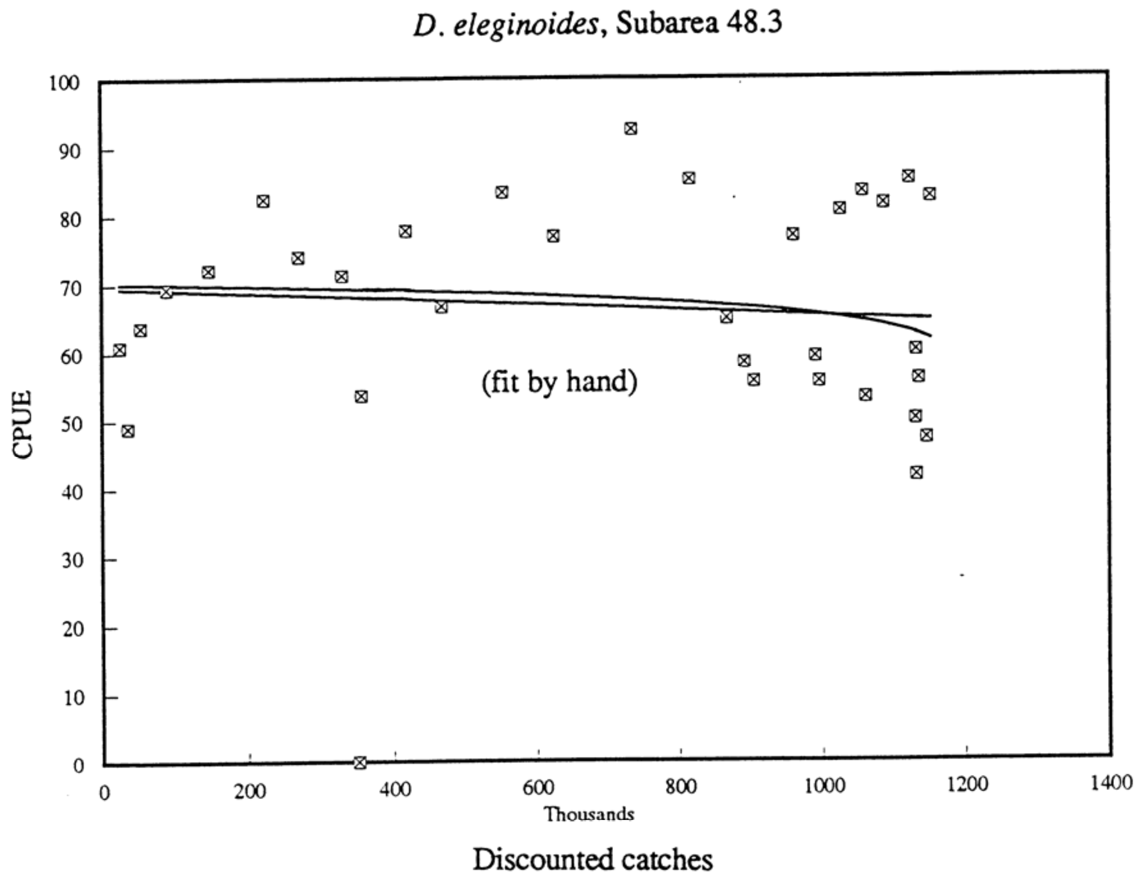

Figure 9: Maximum likelihood fit of the relationship between discounted catches and CPUE when modelled as CPUE = qN and CPUE = qN^a.

7.117 The Working Group also investigated the degree of correlation between the CPUE and discounted catches when only data from the most recent two years (1989/90 and 1990/91) or the single year (1990/91) were used with the simple, linear deLury model (model 1, Appendix G). The correlation coefficients were significant at the 5% level in both cases and the best fit was obtained when only one year's data were used.

7.118 Drs Gasiukov and Shust drew attention to the large discrepancies between the estimates derived from the two methods of calculation when using the data from the two year period (1989/90 and 1990/91) as opposed to one year (1990/91). It demonstrates that the method is highly sensitive to the input data which, in consequence, leads to a high degree of uncertainty in the results. The absence of sufficient robustness in the method means that it should not be used for practical calculations.

Table 7: Results of CPUE analysis using model 1. The regression is for CPUE in month t+1 (numbers/million hooks - see Figure 7), on discounted catches, **D(t)**, the sum (from month 1 to month **t**) of catches in numbers, discounted for natural mortality.

Data	Intercept	Slope	Correlation Coefficient	Sample Size	Significance Level
M = 0.06					
1989/90, 1990/91	82 899	-0.022	0.435	22	0.05
1990/91 only	88 126	-0.113	0.696	11	0.05
M = 0.18					
1989/90, 1990/91	83 370	-0.024	0.424	22	0.05
1990/91 only	88 461	-0.119	0.691	11	0.05
Estimates of initial biomass from the above analyses:					
	M = 0.06	**M** = 0.18			
Biomass July 1989	40 771	37 586			
Biomass July 1990	8 438	8 043			

7.119 Given the reservations expressed in paragraph 7.91 regarding the movement of the fishing fleet from one fishing location to another within Subarea 48.3, it would be more appropriate to analyse haul-by-haul data taking location into account. Although the submission of these data was required by Conservation Measure 26/IX they were not available to the Working Group. It is essential that the haul-by-haul data be submitted and analysed to investigate the spatial and seasonal variability. Standardisation of effort indices should also be attempted.

7.120 Table 8 summarises estimates of exploitable biomass and proposed catch levels for 1991/92 from assessments prepared by Members and those prepared at the meeting. It is important to note that those from the CPUE analysis can only be used as approximate estimates of current abundance since estimates relate to the biomass at the time of the first data point used in the analysis.

Table 8: Estimates of exploitable biomass (in tonnes) and proposed catch levels (in tonnes) for 1991/92.

	M = 0.06		**M** = 0.18	
	Biomass	Proposed catch	Biomass	Proposed catch
WG-FSA-91/20				
1989/90 survey	609 353	11 700	158 847	9 150
1990/91 survey	47 897	919	13 786	794
WG-FSA-91/24				
Cohort analysis			84 154	8 819
CPUE analysis				
Based on two years data	40 771	2 324	37 586	4 849
Based on one years data	8 438	481	8 043	1 037

NOTE: WG-FSA-91/20 catch levels based on MSY - calculations
WG-FSA-91/24 catch levels based on $\mathbf{F_{0.1}}$ - calculations
CPUE analysis catch levels based on $\mathbf{F_{0.1}}(\mathbf{M} = 0.06) = 0.06$, $\mathbf{F_{0.1}}(\mathbf{M} = 0.18) = 0.15$.

7.121 A further caveat with respect to the CPUE analyses is that when applied to a data series which does not start at the beginning of exploitation, recruitment may be underestimated. If the ratio between the pristine population and that at the start of the data series can be assumed to be close to 1, this effect will be very small. At this stage there is not enough information available to determine what this ratio would be in the case of this species.

7.122 Calculations of $\mathbf{F_{0.1}}$ were used to estimate the expected ratio between yield (at $\mathbf{F_{0.1}}$) and the initial, unexploited, recruited biomass, as well as the equilibrium, exploited biomass. This allows calculation of the biomass levels that would be required to sustain a catch level of 9 000 tonnes per annum (Table 9).

Table 9: Standing stock to support a catch level of 9 000 tonnes, what do the UNEXPLOITED and EQUILIBRIUM EXPLOITED recruited biomass levels have to be to sustain this catch under $\mathbf{F_{0.1}}$:

	M = 0.06 ($\mathbf{F_{0.1}}$ = 0.06)	**M** = 0.18 ($\mathbf{F_{0.1}}$ = 0.15)
UNEXPLOITED biomass	391 000	205 000
Equilibrium EXPLOITED biomass	158 000	70 000

NOTE: Age at recruitment = 8 years.

Further Data Requirements

7.123 The Working Group did not have enough information to decide on the relative reliability of the different methods used to obtain biomass estimates for *D. eleginoides*. This implies that it is very difficult to make an objective decision about the reliability of the various biomass estimates in Table 8. The Working Group suggested that simulation studies to investigate the performance of different types of analyses should be conducted (also see paragraph 8.26).

Management Advice

7.124 The wide range of estimates given in Table 8 reflects the large degree of uncertainty associated with the biomass level of *D. eleginoides* in Subarea 48.3.

7.125 It is important to note that the highest proposed catches (or TACs) are very close to the lowest estimates of biomass. It is obvious that if a high TAC is set when the actual biomass is relatively low, the stock may be seriously affected.

7.126 The range of possible estimates of TAC is listed in Table 8 and shown in Figure 10.

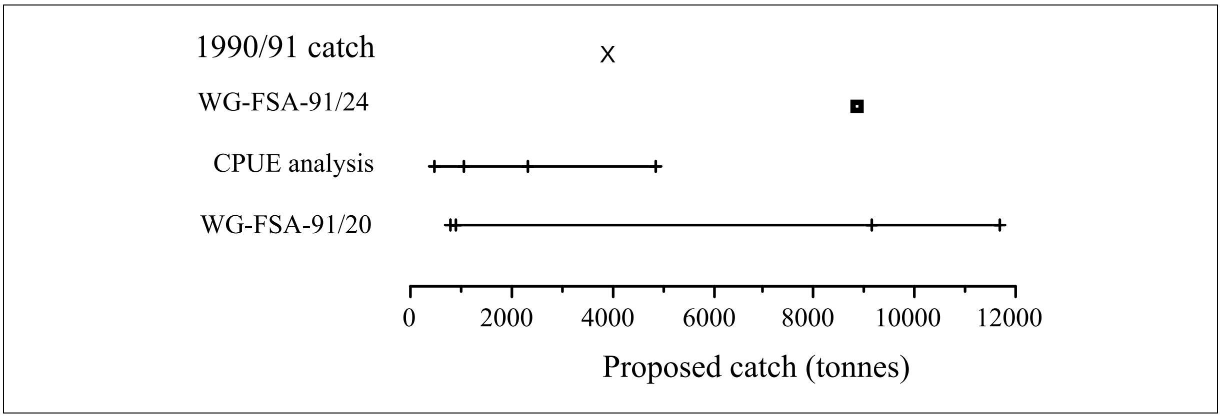

Figure 10: Ranges of proposed catches given in Table 8.

7.127 Drs Gasiukov and Shust stated that, as there is considerable uncertainty in the projection approach (WG-FSA-91/20) and the estimates based on analysis of CPUE data by the deLury method, the range of possible estimates of TAC should be as follows:

Higher	8 819 (WG-FSA-91/24)
1990/91 Catch	3 800

7.128 Other Members felt that there was at this stage no objective basis for preferring any specific part of the range (see paragraph 7.123).

Electrona carlsbergi (Subarea 48.3)

7.129 Catches of myctophids, consisting mainly of *E. carlsbergi*, have been reported from Subarea 48.3 since 1983 (see Figure 11). The Working Group noted the rapid expansion of the fishery since 1987. In the last year, 1990/91, the reported myctophid catch was 78 488 tonnes, a three-fold increase on the previous year.

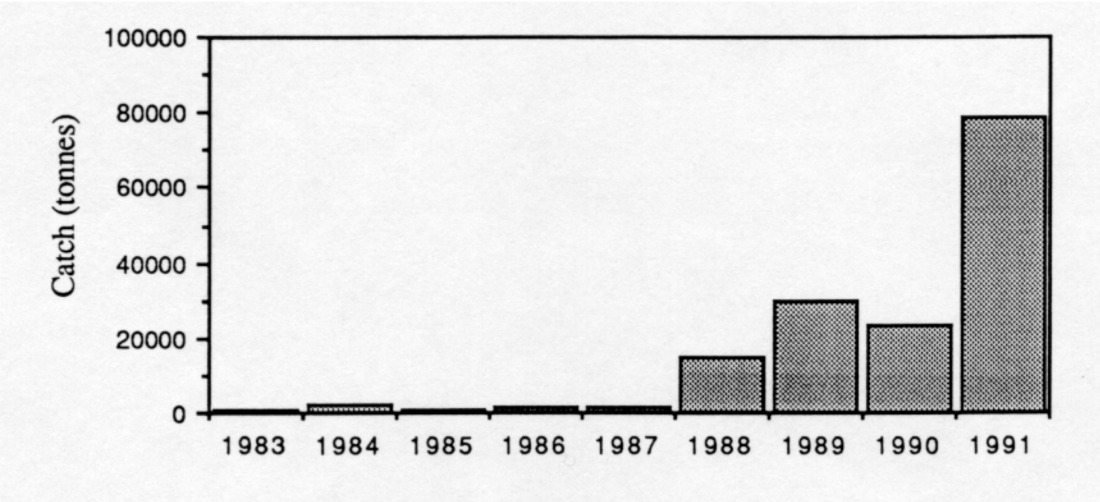

Figure 11: Catches of *E. carlsbergi* in Subarea 48.3.

7.130 Fine-scale data from 1988 and 1990 indicate that catches were concentrated around Shag Rocks and South Georgia respectively (CCAMLR-SB/91/3). In 1988 the concentration of catches was associated with a known concentration of myctophids over the shelf break at Shag Rocks (WG-FSA-90/19). The fine-scale data indicate that a similar occurrence may have occurred over the shelf break region to the northwest of South Georgia in 1990, although no survey data are available for this area. No fine-scale data has been submitted to CCAMLR for 1989 and 1991.

7.131 The length composition of the catch is available for 1990. This indicates that most *E. carlsbergi* caught in 1990 were between 60 and 80 mm in length. Length composition data from surveys in 1979 (WG-FSA-90/23), 1987/88 (WG-FSA-90/21) and 1989 (WG-FSA-90/21) show that fish of this species found in Subarea 48.3 have mostly been between 65 and 85 mm in length, corresponding to age class 2 (WG-FSA-90/21). Older fish are mostly found to the north of Subarea 48.3, north of the Polar Front (WG-FSA-90/21). The spawning stock consist of fish aged three and above. Consequently, the fishery is taking mostly juvenile fish.

7.132 The state of knowledge of this stock has been summarised in Annex 5, SC-CAMLR-IX. No other information on *E. carlsbergi* has been submitted since then. An assessment of potential yield from this fishery is presented below. A number of assumptions have had to be made due to the absence of important data or as a result of incomplete data.

Recent Acoustic Surveys

7.133 Only one survey (1987/88) has been reported in Subarea 48.3. This survey concentrated in two areas, the first in the northwest quarter of Subarea 48.3 covering 60 000 square miles, and the second around Shag Rocks covering 7 200 square miles. The estimates for the two areas for myctophids generally were 1 200 000 tonnes and 160 000 tonnes respectively (WG-FSA-90/19). For the purposes of estimating catch levels, there are five major problems with these data:

(i) there have been no biomass surveys since the escalation in fishing in 1988;

(ii) there is little information on the spatial variability in the stock of *E. carlsbergi* during these surveys. The CV in these standing stock estimates is unknown;

(iii) variation in recruitment is unknown. As a result, the biomass estimate could be substantially different from both the current abundance of the stock and the average unexploited biomass;

(iv) the biomass in the Shag Rocks region is likely to have been overestimated due to non-random survey design in the form of a deviation from a straight line transect that followed the shelf break south of Shag Rocks, thus over-representing a high density patch of myctophids in the survey; and

(v) although some information on the species composition of high density patches encountered during the acoustic surveys is presented in WG-FSA-90/19, there is no information on how myctophids were discriminated from krill in the acoustic data.

7.134 The biomass estimates provided in WG-FSA-90/19 have been used to calculate possible catch levels for this species. Although, these estimates do not have associated estimates of sampling variability, wide experience of acoustic surveying indicates that coefficients of variation in the range 0.1 to 0.5 are usual. For example, biomass estimates presented for acoustic surveys of krill ranged from 0.06 to 0.72 with a mean value of 0.36 (Post-FIBEX Acoustic Workshop, Table IX, *Biomass Report Series No. 40*). The CV of the myctophid biomass estimates was assumed to be 0.3.

Stock Identity

7.135 Survey results indicate a predominance of immature fish south of the Polar Front and mature fish north of the Polar Front. There is no evidence to conclude that the immature stock of *E. carlsbergi* in Subarea 48.3 has become permanently isolated from the reproductive stock in the sub-Antarctic waters north of the Polar Front (SC-CAMLR-IX, Annex 5). Similarly, there is no evidence that these 2 year olds will not return to the spawning stock and reproduce in their lifetime. An alternative explanation could be that immature individuals become temporarily segregated from the adult stock as part of their life history in this region. Without evidence to substantiate the expatriation of 2 year olds from the reproductive stock or that these individuals will not reproduce in their lifetime, the Working Group assumed that the cohort of 2 year old *E. carlsbergi* within Subarea 48.3 comprised the complete age 2 cohort of the stock with full potential to reproduce as they grow.

Y/R Analysis

7.136 Y/R analyses were carried out using the CCAMLR standard Y/R program. No direct observations on weight-at-age were available, and so these were estimated using length-at-age data and length-weight relationships. Two age/length keys from Subareas 48.4 and 48.6 were available in the CCAMLR database. As these did not appear to be calculated from data stratified by length, they were pooled and used to estimate the mean and variance of length-at-age. However, the distribution of lengths-at-age for age class 2 was wide and somewhat skewed, and this may be symptomatic of difficulties in age determination. The resultant means and SDs of length-at-age are given in Table 10. There were no distributions of length-at-age available for age classes 1 and 5+. For age class 1, the mean of all lengths-at-age 1 obtained from different samples (WG-FSA-90/21) was used and for the 5+ age class, the average of the $\mathbf{L}_\infty$ estimates was used.

Table 10: Weights-at-age for *E. carlsbergi* in Statistical Area 48.

	a (x 10^{-5})	b	Age				
			1	2	3	4	5+
Length - mean (mm)			47.90*	77.82	85.22	90.67	95.00+
SD			-	5.10	3.38	2.33	-
Weight (1) (gm)	2.081	2.94	1.81	7.64	9.91	11.90	13.58
Weight (2) (gm)	1.704	2.99	1.80	7.79	10.14	12.21	14.00
Weight (3) (gm)	4.596	2.75	1.92	7.37	9.40	11.15	12.62
Weight (4) (gm)	5.947	2.70	2.05	7.66	9.74	11.52	13.01

* Length = Mean for age 1 from Table 3 of WG-FSA-90/21

\+ Length = Mean of $\mathbf{L}_\infty$ from Table 4 of WG-FSA-90/21

7.137 Weight-length relationships were available in WG-FSA-90/21, by sex for Antarctic and sub-Antarctic samples. The mean weights-at-age (**W**) were estimated by the following formula:

$$W = aL^b + 0.5s^2ab(b-1)L^{b-2}$$

where **L** and **s** are the mean and SD of the length-at-age respectively. The values of **a** and **b** are from WG-FSA-90/21 and reproduced in Table 10 along with the four resultant sets of weight-at-age. The four different sets were used in the Y/R analysis to determine the sensitivity of the results to uncertainty in weight-at-age.

7.138 The value of natural mortality used was **M** = 0.86, given in WG-FSA-90/23. The sensitivity of the results to uncertainty over **M** was examined using **M** = 0.65 and **M** = 0.9 (the Y/R program was not able to obtain solutions for **M** higher than 0.9). Fishing mortality was assumed to apply to only 2 and 3 year old fish, with relative selectivities 1.0 and 0.2 respectively.

7.139 The results of the Y/R analysis are given in Table 11. It is clear that the values of $\mathbf{F_{0.1}}$ are very high, and would result in heavy depletion of the spawning stock-per-recruit, with a consequent high probability of recruitment failure. Basing TACs on $\mathbf{F_{0.1}}$ for this species is not an appropriate management policy. Accordingly, it was decided to calculate TACs using the fishing mortality for which the spawning biomass per recruit would be reduced to 50% ($\mathbf{F_{50\%SSB}}$). This average level of spawning stock escapement should be sufficient to avoid declines in recruitment. The total stock biomass would average about 80% of the mean unexploited biomass. This should limit the impact of the fishery on dependent predators. A lower **F** value is also preferred in short-lived fish so as to reduce the possibility of stock collapse due to fluctuations in recruitment.

Table 11: Summary of Y/R analysis.

Weight Curve	**M**	$\mathbf{F_{0.1}}$	SSB*	$\mathbf{F_{50\%SSB}}$
(1)	0.86	2.825	5%	0.64
(2)	0.86	2.825	5%	0.64
(3)	0.86	2.825	5%	0.64
(4)	0.86	2.825	5%	0.64
(1)	0.65	2.525	6%	0.62
(1)	0.90	2.825	5%	0.64

* Spawning stock biomass-per-recruit as a percentage of the level in the unexploited stock

7.140 The values of $\mathbf{F}_{50\%SSB}$ for the different sets of weight-at-age and **M** values are also given in Table 11. These values are robust against the apparent uncertainty in weight-at-age and against a range of values of **M**. TACs are calculated using $\mathbf{F}_{50\%SSB} = 0.64$.

Calculation of TAC

7.141 TACs are calculated for the two geographic scales for which there are estimates of stock biomass. The smaller scale covers the region around Shag Rocks, where there is a concentration of fish over the shelf break. The second scale covers the larger survey which covered a substantial proportion of Subarea 48.3. However, the region around South Georgia, where the fishery concentrated in 1990, has not been covered in either survey.

7.142 For each geographic scale, TACs have been calculated for a range of probabilities that the fishing mortality would exceed the selected level. The results are presented in Table 12. Because of uncertainty in the estimate of stock size, a given calculated TAC will not result in exactly the intended fishing mortality. The table shows for example, that if a TAC for the large area of Subarea 48.3 was set at 398 000 tonnes, there would be a 50% probability that the intended fishing mortality would be exceeded. On the other hand, if that TAC was set at 245 000 tonnes, the probability of exceeding the intended fishing mortality would be only 5%.

Table 12: Calculated TACs for *E. carlsbergi* in Subarea 48.3, for various probabilities that the given TAC will result in fishing mortality exceeding the intended value (0.64), for the two survey biomass results. The 1 200 kilotonne survey applies to a large proportion of Subarea 48.3, while the 160 kilotonne estimate applies to a restricted region around Shag Rocks.

Probability	TAC for 1 200 kt Biomass	TAC for 160 kt Biomass
5%	245	32.7
10%	273	36.3
20%	310	41.4
30%	341	45.5
40%	369	49.2
50%	398	53.0
60%	428	57.1
70%	463	61.7
80%	509	67.8
90%	579	77.2
95%	643	85.8

Management Advice

7.143 The basic data available to assess the stock in Subarea 48.3 are incomplete, and therefore considerable uncertainty surrounds the assessment. The catches in the fishery have expanded threefold since 1990, from 23 623 to 78 488 tonnes. Fine-scale catch and effort data were not available to the Working Group in time to be used in the assessments. Analyses of biological data have been reported in papers to the Working Group, but the data have not yet been submitted for inclusion in the CCAMLR database. The Working Group urges that these data be submitted.

7.144 An analysis of Y/R shows that the management policy of setting TACs based on $\mathbf{F_{0.1}}$ is not appropriate for this fishery. A level of fishing mortality which allows 50% escapement in the spawning stock has been used to calculate a range of possible TACs (given in Table 12). These TACs have been calculated to allow for uncertainty in survey biomass estimates to be taken into account by the Commission when setting the TAC. If a TAC were to be based on the large-scale survey, and such catches were to be taken, they should be distributed over the area, and not be entirely taken out of one or two concentrations of fish. If only the concentrations near the island shelf breaks are to be fished, considerably lower TACs (of the order of magnitude illustrated by the Shag Rocks assessment) should be set, so as to limit the impact of the fishery on local predators.

7.145 In view of the Commission's request for advice on the potential yield of the fishery as a matter of urgency (CCAMLR-IX, paragraph 4.27 - but see also discussion under Data Requirements, paragraphs 8.7 to 8.8 below), some Members viewed the assessment presented here as being the best scientific evidence available on the potential yield of *E. carlsbergi* in Subarea 48.3. Given the unquantified uncertainties they felt that initial TACs should be set at the low end of the ranges in Table 12. This is also important because of the scarcity of information on the possible effects of the fishery on dependent predators.

7.146 Dr Shust indicated that in his view significant uncertainties are associated with flux factors affecting the distribution of the *E. carlsbergi* stock in the area concerned. Such fluxes would affect the estimation of the available standing stock due to concentration of fish in the region as well as the possible incursion of fish from elsewhere (e.g. from north of the Polar Front). Current biomass estimates would underestimate the stock size as the total distribution range of the stock is unknown, althoug it is larger than the area surveyed.

7.147 In reply, other members of the Working Group pointed out that the estimation of flux factors in mobile species such as *E. carlsbergi* is difficult and may take some time. Consequently, considerable uncertainty is likely to be associated with the dynamics of the stock for some time to come. Given the situation, the majority of Working Group members favoured a conservative approach to the setting of catch levels for this species. They noted that some attempt had been made to take flux factors into account in the calculations of the TACs (paragraphs 7.142 to 7.144 above) by assuming that the biomass estimate applied to only part of the stock.

7.148 Since the fish are taken with small mesh nets (about 25 mm) in near shelf waters, there is a possibility that juvenile fish of other species will be taken as a by-catch. Information on any such by-catch should be reported, using protocols similar to those for the krill fisheries.

7.149 If the fishery is to continue at the high level of the last season, it is recommended that further surveys be conducted in order to improve biomass estimates and to begin to assess the level of recruitment variability in the stock. These surveys should also cover the region around South Georgia. Further attention should be paid to the design and conduct of the surveys to ensure that a proper random design is followed. The surveys should also be designed to identify the distribution and structure of the stock in relation to the Polar Front and other subareas.

7.150 The Working Group reiterates the request from last year (SC-CAMLR-IX, Annex 5, paragraph 183) that a high priority should be given to developing a methodology for the design of myctophid biomass surveys and the subsequent analysis of data. The Working Group noted that it may be possible to draw on the developments in this area by WG-Krill. Further problems that need to be addressed in these acoustic surveys are the need to determine the acoustic target strength for myctophids and the development of routine techniques for discriminating between myctophids and krill in acoustic data.

Notothenia gibberifrons (Subarea 48.3)

7.151 Total catches of *N. gibberifrons* decreased from 838 tonnes in 1988/89 to 11 tonnes in 1989/90 and to only 3 tonnes in 1990/91. Decreased catches were due to prohibition of directed fishing on this species (Conservation Measure 22/IX) and a prohibition of bottom trawling in the subarea (Conservation Measure 20/IX) rather than reduced abundance (see below). During 1989/90 and 1990/91, no commercial landings of *N. gibberifrons* were reported, the entire catches were taken during research fishing.

7.152 Since there were no commercial catches reported using semipelagic trawls, no new information on by-catches of *N. gibberifrons* in the *C. gunnari* fishery could be made available to the Working Group as offered at the Ninth Meeting of the Commission (CCAMLR-IX, paragraph 13.16 and paragraph 8.10 of this report).

7.153 Trawl survey biomass estimates useful for assessment purposes were available for 1984/85 and 1986/87 to 1990/91 (WG-FSA-91/14 and WG-FSA-91/23). Surveys conducted during other years were judged to be less reliable for *N. gibberifrons* because of sampling problems or because no CV was available.

7.154 As indicated in Table 13, two biomass estimates were available for 1989/90 and 1990/91 and were averaged for assessment work. Where available, survey biomass estimates for the Shag Rocks area and the rest of Subarea 48.3 were combined.

Table 13: Survey biomass of *N. gibberifrons*.

Year	Subarea 48.3	CV (%)	Shag Rocks	CV (%)	Total	CV (%)
1984/85	15 762	28	-	-	15 762	28
1986/87	13 544	15	363	45	13 907	15
1987/88	7 189	13	609	10	7 798	12
1988/89	8 510	17	-	-	8 510	17
1989/90	12 417	28	267	39	12 684	27
1989/90	21 891	23	-	-	21 891	23
Average for 1989/90					17 288	18
1990/91	28 224	18	117	34	28 341	18
1990/91	22 541	12	-	-	22 541	12
Average for 1990/91					25 441	11

7.155 A re-analysis of data used for last year's assessment was presented to the Working Group in WG-FSA-91/26. The analyses in WG-FSA-91/26 used two different approaches to tuning VPAs for *N. gibberifrons*. The first approach treated survey biomass estimates as measures of absolute abundance (the 'survey q = 1' approach) while the other treated survey biomass estimates as measures of relative abundance (the 'survey q ≠ 1' approach). Survey q, in this context, is the constant of proportionality that relates survey estimates to absolute biomass (i.e. survey biomass ∗ survey q = absolute biomass).

7.156 Some Members felt that an 'added sums of squares test' could be used to determine if the 'survey q ≠ 1' model in WG-FSA-91/26 was significantly better than the 'survey q = 1' model.

7.157 Other Members felt that this test was invalid.

7.158 There was also some disagreement about the degrees of freedom associated with the two models and required for the test. Dr Gasiukov expressed the opinion that both models ($q = 1$ and $q \neq 1$) have the same degrees of freedom. Other Members said that this is not the case and that the model assuming $q \neq 1$ has one less degree of freedom than that assuming $q = 1$.

7.159 The results from the test are presented in the table below. Sums of squares and degrees of freedom for the survey $q = 1$ and survey $q \neq 1$ models were obtained from Table 3 in WG-FSA-91/26. The result (**F** = 0.89), which follows the **F** distribution with 1 and 3 degrees of freedom, was not statistically significant. According to this test, the survey $q \neq 1$ model was not significantly better than the survey $q = 1$ model.

Model	Degree of Freedom	Sum of Squares	Mean Square
$q = 1$	4	1.85	0.46
$q \neq 1$	3	1.44	0.48
	F = (1.85 - 1.44) / 0.46 = 0.89		

7.160 Dr Gasiukov argued that the two models have the same degrees of freedom because q is a function of the unknown parameter (**N_{at}** or **F_{ay}**) in the terminal year. In this case the same table would be:

Model	Degree of Freedom	Sum of Squares	Mean Square
$q = 1$	4	1.85	0.46
$q \neq 1$	4	1.44	0.36

This shows that the final mean square estimate is almost 25% less when $q \neq 1$ than when $q = 1$.

7.161 Work performed at the meeting was based on the data presented in WG-FSA-91/26 and biomass estimates from bottom trawl surveys in 1990/91 (see paragraph 7.155 above). Two approaches, one assuming survey $q = 1$ and the other assuming survey $q \neq 1$, were used to obtain biomass estimates of *N. gibberifrons* during 1990/91 and TACs for 1991/92. There were minor differences between the models and those in WG-FSA-91/26 due to software availability but these differences had little impact on results (this was verified by testing models on data in WG-FSA-91/26).

7.162 Natural mortality was assumed to be 0.125 in all analyses. Ages 2 to 16 were included and age 16 was not treated as a 'plus group'.

7.163 The survey q = 1 model was fitted by adjusting the terminal **F** in a traditional VPA until the sum of squared differences between log predicted biomass and log survey biomass estimates was minimised. Partial recruitment of young fish to the fishery was assumed to be the same as in WG-FSA-91/26 and prior analyses (partial recruitment = 0.2, 0.3, 0.5, 0.7 and 0.8 and 1.0 for ages 2 to 7+).

7.164 The survey q ≠ 1 model was fitted using the Laurec-Shepherd algorithm tuned to effective fishing effort data. Effective fishing effort was estimated from the ratio of total landings and survey biomass and then used to construct indices of abundance for all age classes (2 to 16) in the analyses. Inverse SDs (scaled to 1.0 in 1990/91) from the survey biomass estimates were used in the Laurec-Shepherd algorithm to weight the fishing effort data for individual years (Table 14). Inverse SDs, rather than inverse variances, were used as weights because variances resulted in too great a disparity among weights for different years.

Table 14: Input values for the VPA tuned to survey biomass converted to effective effort.

Year	Survey Biomass	Total Landings	Effective Effort	Weighting Factor
1984/85	15 762	2 081	0.132	0.66
1986/87	13 907	2 844	0.205	1.4
1987/88	7 798	5 222	0.670	3.1
1988/89	8 510	838	0.0985	2.0
1989/90	17 288	11	0.000636	0.95
1990/91	25 441	3	0.000118	1.0

7.165 Some Members felt that weighting by the inverse square of the CV would have been more appropriate because of the positive relationship between the magnitudes of variance and that of the survey biomass estimate that is often observed (Hennemuth, 1976).

7.166 The Laurec-Shepherd algorithm used for the survey q ≠ 1 approach was applied to biomass indices for 15 age classes. This meant that 15 values of q (one for each age class) were estimated. The algorithm does not output a single value of q comparable to that in WG-FSA-91/26 (see paragraph 7.154 above) but a value was readily obtained from the output using:

$$\hat{q} = \exp\left[\left(\sum ln\mathrm{I}_t - \sum ln\mathrm{A}_t\right)/\,\mathrm{N}\right],$$

where $\mathbf{I}_t$ is predicted biomass from the model for year **t**, $\mathbf{A}_t$ is survey biomass in year **t** and **N** = 6 is the number of years with survey biomass estimates. The formula was obtained by differentiating the sum of squared differences between log predicted biomass and log survey biomass estimates with respect to q, setting the result equal to zero and solving for q.

7.167 Parameter estimates for the two models were:

	q = 1	q ≠ 1
Survey q	-	1.23
1990/91 **F** (mean ages 2 to 15)	0.0002	0.0004

The estimate of survey q = 1.23 indicates that total biomass levels are, on average, 23% larger than survey biomass estimates.

7.168 Estimates of biomass, fishing mortality and recruitment obtained using the two approaches were similar for years up to 1987/88 but diverged in later years (Table 15 and Figure 12).

Table 15: Biomass, mean fishing mortality and recruitment of *N. gibberifrons* from VPA runs with q = 1 and q ≠ 1.

	q = 1			q ≠ 1				
Year	Biomass	$\bar{F}_P$	Recruits	Biomass[1]		$\bar{F}_P$	Recruits[1]	
1985/86	12 745	0.10	25 069	10 878		0.11	31 235	
1986/87	14 029	0.11	24 387	12 216		0.12	45 017	
1987/88	14 167	0.20	24 079	13 483		0.19	64 611	
1988/89	11 422	0.09	21 474	13 583	(11 895)	0.09	82 811	(16 533)
1989/90	13 639	0.01	27 451	21 569	(18 427)	0.02	135 505	(16 533)
1990/91	17 135	0.0001	24 664	43 168	(30 919)	0.0003	425 386	(16 533)

1 Figures in brackets are revised values

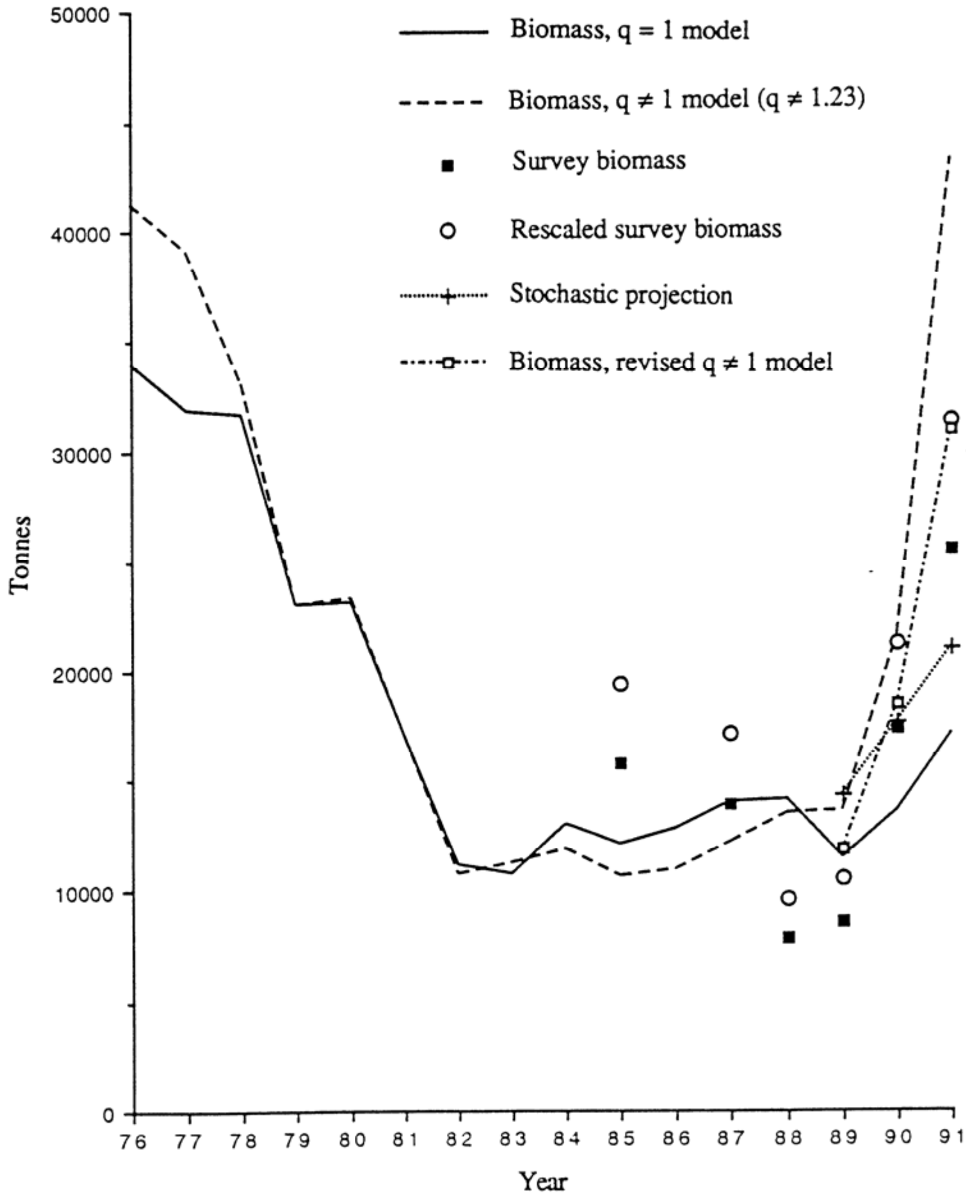

Figure 12: Biomass estimates for *N. gibberifrons* in Subarea 48.3 from the survey q = 1 and q ≠ 1 (revised and original) models. Survey biomass estimates are given in original and rescaled (divided by the survey q = 1.23) units. The scaling factor adjusts survey biomass estimates to match VPA biomass estimates from the q ≠ 1 model. Also shown are results from a stochastic simulation for 1988/89 to 1990/91 (see paragraph 7.174).

7.169 There were significant differences between the biomass estimates for 1989/90 and 1990/91 obtained using the survey q = 1 and survey q ≠ 1 models due to differences in recruitment estimates for later years. In particular, very large recruitment estimates for 1989/90 to 1990/91 from the survey q ≠ 1 model resulted in very large biomass estimates for these years.

7.170 Some Members suggested that this problem may have been due to the use of research survey age composition data in recent years when total catches were very low since the Laurec-Shepherd algorithm assumes constant age partial recruitment patterns over time.

7.171 The Working Group recognised that recruitment estimates obtained from VPA analyses for recent years are often unreliable and decided to substitute average recruitment during 1975/76 to 1987/88 for recruitments during 1988/89 to 1990/91 estimated directly by the VPA. It was not necessary to make this correction to estimates of recent biomass from the survey q = 1 model because they were similar to the average for earlier years.

7.172 A simulation procedure (parametric re-sampling, Efron, 1982) was used to estimate a 95% confidence interval for the estimate of survey q from the Laurec-Shepherd procedure. First, predicted biomasses were obtained from the model fitted to the original data. Fifty sets of simulated effort data were then obtained by converting predicted population biomass levels to predicted survey biomass levels (survey biomass = population biomass / 1.23) and multiplying each predicted survey biomass by a random number. Random numbers were log-normally distributed with mean zero and log scale variance chosen to match the arithmetic CVs reported for the original survey biomass estimates.

7.173 The SD for the estimate of survey q from the re-sampling procedure was 0.50 and the 95% interval ranged from 0.23 to 2.23. The relatively large size of the confidence interval indicates that the estimate of survey q was imprecise and the fact that the confidence interval included 1.0 indicates that the survey q ≠ 1 model was not significantly better than the q = 1 model for *N. gibberifrons* given current data.

7.174 The CCAMLR stochastic population projection program was used to determine the maximum rate at which *N. gibberifrons* in Subarea 48.3 could have increased from the low level in 1987/88. Recruitments for simulations were obtained by bootstrapping recruitment estimates from the survey q = 1 model for 1975/76 to 1988/89. Initial numbers of fish in each age group during 1987/88 (needed to start the projection) were taken from the survey q = 1 model. As indicated above, both the survey q = 1 and the q ≠ 1 models gave similar recruitment and abundance estimates up to 1988/89. Fishing mortality in 1988/89 to 1990/91 was assumed to have been very low (0.0001) to enable the population to grow at its maximum rate. Age-specific maturity, partial recruitment, and weight data were the same as used in the two VPA models.

7.175 Mean simulated population biomass in 1990/91 (21 081 tonnes, 1 000 simulations) was in closer agreement with the biomass estimate from the survey q = 1 model than with the estimate from the survey q ≠ 1 model (Figure 12). This result lends some additional support to the biomass estimate for 1990/91 from the survey q = 1 model.

7.176 Standard CCAMLR software was used to estimate biomass and TACs for 1991/92 assuming: (i) age specific partial recruitments described above, (ii) $\mathbf{F_{0.1}} = 0.0935$, (iii) $\mathbf{M} = 0.125$ and (iv) average recruitment of two year olds during 1991/92. Two scenarios were considered, one with age specific biomasses for 1990/91 and mean recruitment from the survey q = 1 model and the other with age specific biomass levels for 1990/91 and mean recruitment from the survey q ≠ 1 model.

	q = 1	q ≠ 1
Mean recruitment	19 718	16 533
Biomass 1990/91	17 135	30 919
Biomass 1991/92	20 867	57 945
TAC for 1991/92	1 502	3 025

Management Advice

7.177 Members of the Working Group could not agree on which assessment model was more reliable and which level of TAC for *N. gibberifrons* should be recommended for 1991/92. Some thought that a TAC of 1 502 tonnes from the q = 1 model was most appropriate while others thought that a TAC of 3 025 tonnes from the q ≠ 1 was most appropriate.

7.178 It was agreed, however, that the TAC could only be obtained by bottom trawling which would result in by-catch of other species in Subarea 48.3 (see paragraphs 7.189 to 7.197). It was also agreed that the potential effects on other species should preclude direct fishery by any fishing method for *N. gibberifrons* in 1991/92. Some Members felt the by-catch in the pelagic fishery for *C. gunnari* should be limited to 500 tonnes of *N. gibberifrons* (see Conservation Measure 20/IX).

7.179 Dr Shust suggested that in view of the calculation of the TAC based on the q = 1 model, a by-catch limit of 1 500 tonnes could be recommended.

Chaenocephalus aceratus and *Pseudochaenichthys georgianu*s (Subarea 48.3)

7.180 Reported catches of both species have been only several tonnes since 1989/90 in accordance with conservation measures set by the Commission allowing only a by-catch of 300 tonnes of each of the two species. Prior to this regulation of the fishery, catches of these two species have only been reported by Poland, the German Democratic Republic and Bulgaria, but never by the Soviet Union, although the species were a regular by-catch in the bottom trawl fishery. In 1990, the Working Group attempted to reconstruct the fishery by re-allocating 75% of the catch of 'Pisces nei' reported by the Soviet Union to the two species in the same proportion as these species were reported in the Polish catches (see SC-CAMLR-IX, Annex 5, paragraphs 191 to 197).

7.181 VPA analysis in 1990 suggested that both stocks reached their lowest level of abundance in 1987 and increased in size from then, in particular since 1989/90. This upward trend is also apparent from the two biomass estimates available from the 1990/91 season:

C. aceratus
13 474 tonnes (CV 15%) (Falklands Protector, WG-FSA-91/14)
18 022 tonnes (CV 15.3%) (Atlantida, WG-FSA-91/23)

P. georgianus
13 948 tonnes (CV 19%) (Falklands Protector, WG-FSA-91/14)
9 959 tonnes (CV 15.4%) (Atlantida, WG-FSA-91/23).

This upward trend in stock sizes is likely to be due to the prohibition of bottom trawling in Subarea 48.3 (Conservation Measure 20/IX) and the resulting low or negligible by-catch of these species in the pelagic fishery and the prohibition of a directed fishery on these species (Conservation Measure 22/IX).

7.182 Although biomass estimates were similar, length compositions show considerable differences between the two surveys, in that the proportion of sexually mature fish in the catch was much higher for both species in the *Falklands Protector* survey than in the *Atlantida* survey (see Figures 13 and 14). The most likely reason is that the *Atlantida* survey which took place during the spawning season in April and May, missed part of the spawning stock which had migrated inshore for spawning.

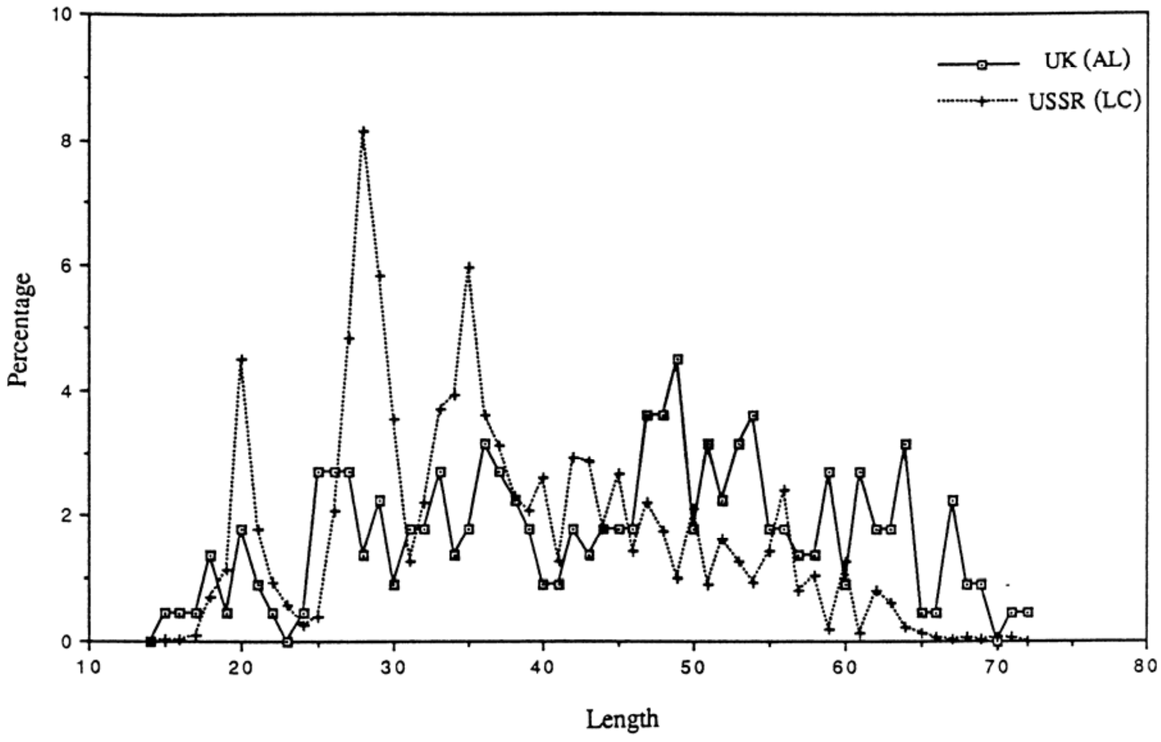

Figure 13: Length frequency *C. aceratus* from *Falkland Protector* (UK) and *Atlantida* (USSR) surveys.

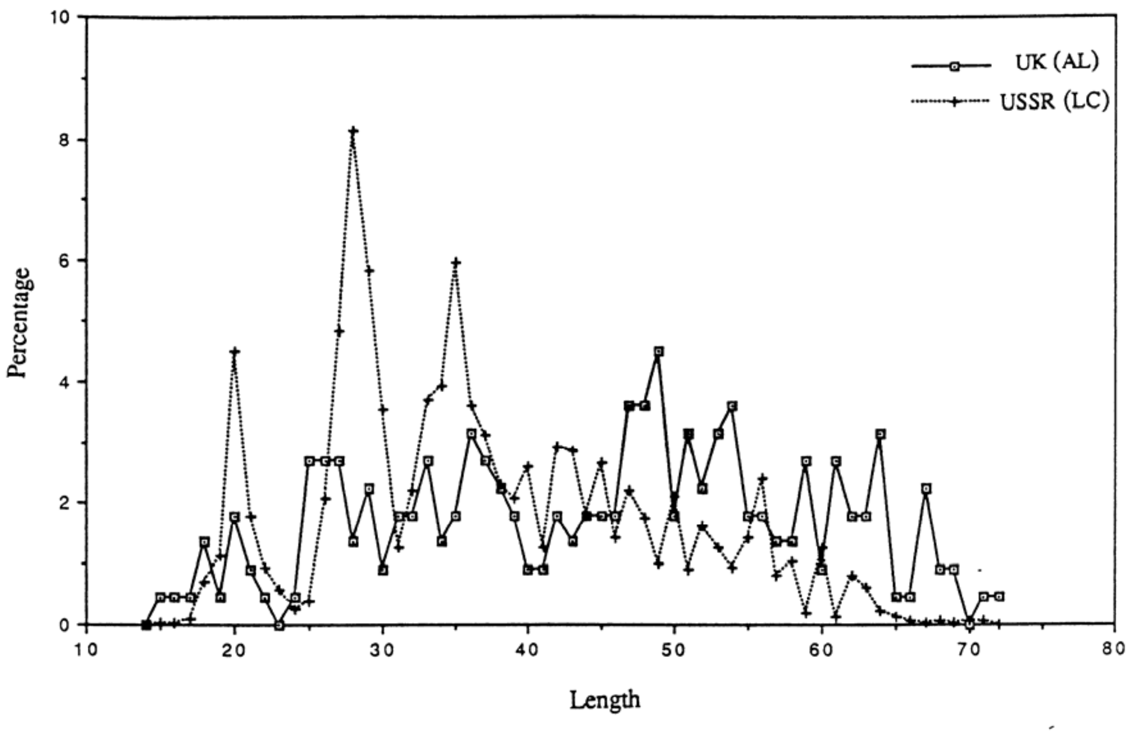

Figure 14: Length frequency *P. georgianus* from *Falkland Protector* (UK) and *Atlantida* (USSR) surveys.

7.183 Allowing for an under-representation of spawners in the *Atlantida* survey, the two biomass estimates for *P. georgianus* appear to be very similar while the difference between the two stock size estimates for *C. aceratus* is likely to be larger than apparent from a figure of 5 000 tonnes alone.

7.184 Given these reservations, the biomass estimates suggest that current stock sizes are 30% of the initial level in *P. georgianus* and 80 to 90% in *C. aceratus* (see SC-CAMLR-IX, Annex 5, paragraphs 200 to 201).

Management Advice

7.185 To estimate potential yield for the 1991/92 season projected catches for the 1990/91 season (SC-CAMLR-IX, Annex 5, Tables 9 and 10, p. 196) were adjusted in proportion to the difference of the 1990 and 1991 research vessel surveys. The multiplication factors and the projected catches at $\mathbf{F_{0.1}}$ (and also 50% of $\mathbf{F_{0.1}}$ in *P. georgianus*) were:

Species	Multiplication Factor	Projected Catch 1991/92 (tonnes)
P. georgianus	1.33	4 756
P. georgianus	50% $\mathbf{F_{0.1}}$ 1.33	2 717
C. aceratus	1.1	1 757

7.186 However, as the new information available did not allow for refinement of the 1990 analysis, the Working Group reiterated two important conclusions from the 1990 meeting:

(i) the outcome of the analysis of *P. georgianus* was largely affected by the reliability of ageing in this species. If the true growth rate of this species is much lower than assumed in the 1990 analysis, as some investigations from the 1970s suggested, this could change estimates of $\mathbf{M}$, $\mathbf{F_{0.1}}$ and recruitment considerably (SC-CAMLR-IX, Annex 5, paragraph 206); and

(ii) the stock of *C. aceratus* appears to be very vulnerable to overfishing at relatively low levels of fishing effort. The spawner-recruit relationship and low initial stock size suggest that stock may not sustain a high yield when it recovers (SC-CAMLR-IX, Annex 5, paragraph 207).

7.187 Given the uncertainties surrounding estimates of $\mathbf{F_{0.1}}$, recruitment and mortality, particularly in *P. georgianus*, management at $\mathbf{F_{0.1}}$ for both stocks appears to be inappropriate at the present stock size. As neither species can be taken without a significant by-catch of other species, such as *N. gibberifrons*, a possible reopening of a directed fishery on these species would bear implications for other species which have to be taken into account. This is presented in more detail below (paragraph 7.194 to 7.196).

7.188 It is therefore recommended that the current prohibition of a directed fishery and a by-catch provision continue to be applied to these two species. Most Members felt that this should be at the current level of 300 tonnes for each species. Dr Shust suggested that in light of the trend in biomass, it should be increased to 500 tonnes for each species.

General Management Advice (Subarea 48.3)

General Considerations on the Re-opening of a Directed Fishery and the Application of TACs to 'By-catch' Species in Subarea 48.3

7.189 Since 1989, the Commission has implemented conservation measures which prohibited:

- the use of bottom trawls in the subarea;
- directed fishing on the 'by-catch' species *N. gibberifrons*, *P. georgianus* and *C. aceratus*; and
- the catch of more than 500 tonnes of *N. gibberifrons* and 300 tonnes each of *P. georgianus* and *C. aceratus* as by-catch in the fishery on *C. gunnari*.

7.190 Reported catches of all three species have become negligible since then.

7.191 All three stocks exhibited an upward trend in stock size since 1989 which is likely to be attributable to the conservation measures implemented by the Commission.

7.192 Although stocks of *N. gibberifrons* and *P. georgianus* appear still far from having recovered, a re-opening of the fishery on one or all of these species might be considered. As this is likely to occur by bottom trawling, the possible effect of bottom trawling on target and by-catch species has been reconsidered by the Working Group (see also SC-CAMLR-VII, Annex 5, paragraph 65).

7.193 Due to the under-reporting or non-reporting of these species by the Soviet fishery, the Working Group was able only to utilise data from the Polish bottom trawl fishery from 1980 to 1982 and 1985 to 1988. This was combined with estimates of potential yields at $\mathbf{F_{0.1}}$ and $\mathbf{F_{max}}$ based on previous analyses of the Working Group to investigate the total potential yield from a mixed demersal fishery in Subarea 48.3.

7.194 The mean ratios of *C. aceratus*, *P. georgianus* and *N. gibberifrons* in bottom trawl catches in the years when the fishery targetted on *C. gunnari* were approximately 1:1:1:6 (see Appendix H), i.e. a catch of any one of the species *N. gibberifrons*, *P. georgianus*, *C. aceratus* would result in an equal proportion of the others and a six-fold proportion of *C. gunnari*. The Working Group noted that the ratios had changed from year to year.

7.195 Using estimates of age-at-recruitment, **K** and **M** contained in WG-FSA-91/15 and WG-FSA-90/6, values of λ (Table 2 of Beddington and Cooke, 1983) were interpolated and applied to estimates of total unexploited biomass (Appendix H). Values of λ give the estimated MSY as a proportion of total unexploited biomass. These are shown, together with current sustainable yields at $\mathbf{F_{0.1}}$ given in the previous sections (see paragraph 7.176 and 7.185), in Table 16.

Table 16: MSY and 1992 yield ($\mathbf{F_{0.1}}$) for demersal species in Subarea 48.3.

Species	λ	Potential MSY (tonnes)	Current Yield $\mathbf{Y_{(F_{0.1})}}$ (tonnes)
C. aceratus	0.118 - 0.127	2 124 - 2286	1 757
P. georgianus	0.18	7 920	4 756
N. gibberifrons	0.035	1 470	1 502 - 3 025

7.196 In any mixed bottom trawl fishery where catches are at $\mathbf{F_{0.1}}$ (the agreed policy of the Commission) or $\mathbf{F_{max}}$, the TAC of *N. gibberifrons* will be reached first if catches of the various species remain in similar proportions to those calculated from Polish catches (i.e. the TAC of *N. gibberifrons* is limiting). The sustainable yield of the target species *C. gunnari* from a bottom trawl fishery therefore cannot be higher than six times the TAC for *N. gibberifrons* (8 800 tonnes at $\mathbf{F_{max}}$). If that fishery is targetting *C. gunnari*, the MSY from the fishery including all species would be about 13 000 tonnes under the most favourable circumstances, and would likely be much less given the uncertainties surrounding these estimates and the adverse effects of bottom trawling on benthos which may affect fish communities in the medium or long-term, e.g. by habitat destruction (see WG-FSA-90/24).

7.197 Given the low current yield ($\mathbf{F_{0.1}}$) and potential yield (MSY) of a bottom trawl fishery in Subarea 48.3, the uncertainties surrounding the ratios of the species in catches of mixed fishery and in stock size estimates and the potentially adverse effects of habitat destruction, the Working Group recommended that the prohibition of bottom trawling should remain in force.

South Orkney Subarea (48.2)

7.198 Catches in Subarea 48.2 were only high in the 1977/78 season, when 140 000 tonnes were taken (almost exclusively *C. gunnari*). Catches reported for the subarea in subsequent years have been in the order of a few thousand tonnes, except in 1982/83 and in 1983/84, when 18 412 and 15 956 tonnes were caught. *C. gunnari* and *N. gibberifrons* have been so far the most abundant species in the catches. Catches reported as Pisces nei were composed of different species of channichthyids (mainly *C. aceratus*, *Chionodraco rastrospinosus* and *P. georgianus*) and *Notothenia kempi*, but may have also been *N. gibberifrons* (see WG-FSA-90/16).

7.199 A conservation measure prohibiting fishing activities for finfish in Subareas 48.1 and 48.2 for the 1990/91 season was implemented (Conservation Measure 27/IX). The only reported catches for the last season are those reported from the survey carried out by Spain (WG-FSA-91/33).

Table 17: Catch by species in Subarea 48.2.

Year	*C. gunnari*	*N. gibberifrons*	*N. rossii*	Osteichthyes nei	Total
1978	138 895	75	85	2 603	141 658
1979	21 439	2 598	237	3 250[1]	27 524
1980	5 231	1 398	1 722	6 217[2]	14 568
1981	1 861	196	72	3 274	5 403
1982	557	589		2 211	3 357
1983	5 948	1		12 463[3]	18 412
1984	4 499	9 160	714	1 583	15 956
1985	2 361	5 722	58	531	8672
1986	2 682	341		100	3 123
1987	29	3		3	35
1988	1 336	4 469			5 805
1989	532	601		1	1 134
1990	2 528	340			2 868
1991*	14	9		27[4]	50

* Catches from research activities
[1] Mainly *C. aceratus*
[2] *P. georgianus*,unidentified nototheniids and channichthyids
[3] Unknown species

7.200 The scarcity of historical and recent data from the commercial fishery has made any assessment of the fish stocks in the subarea difficult. Three attempts have been made so far to assess the stock of *N. gibberifrons* and *C. gunnari* using the VPA method (SC-CAMLR-VII, Annex 5; SC-CAMLR-VIII/18, WG-FSA-90/16). In addition, standing stock biomass estimates by the swept area method have been calculated from different surveys conducted in the subarea by the Federal Republic of Germany (1975/76, 1977/78, 1984/85) and Spain (1986/87, 1990/91).

Champsocephalus gunnari (Subarea 48.2)

7.201 New biomass estimates for this species in the Subarea 48.2 using the swept area method were available from the Spanish survey ‘ANTARTIDA 9101’ (WG-FSA-91/33).

7.202 The survey design was similar to those of previous years (Balguerías, 1989) with a series of randomly located bottom trawl samples down to a depth of 500 m. The same three depth strata: 50 to 150, 150 to 250 and 250 to 500 metres were used as in previous surveys. The number of stations within each of those strata were allocated in proportion to the area of seabed and expected fish densities within the stratum.

7.203 Biomass for the whole subarea down to 500 m depth was estimated to be around 43 000 tonnes associated with a high CV of 68%. This value was obtained by extrapolating mean abundance per square nautical mile to the whole shelf area assuming that the fish were more or less equally dispersed over the shelf (WG-FSA-91/33). It is in the same order of magnitude of the size of the stock in the 1977/78 season (40 000 tonnes) (Kock, 1986). However, the Working Group noted that most of the icefish caught during the cruise was concentrated in a small area around Inaccessible Islands and its abundance could have been overestimated.

7.204 The Working Group decided that a restratification was needed, both to calculate a more realistic value of abundance and to minimise the associated CV. In doing so, two regions were considered: region A comprises a restricted area around Inaccessible Islands (Subdivisions 75 and 79 in Table 4 of SC-CAMLR-VI/BG/31), region B comprises the remaining area down to 500 m depth. Two approaches were used in calculating the standing stock biomass per stratum in region A. In the first attempt (restratification 1) all catches were used in the calculations. In the second one (restratification 2), the exceptionally high catches obtained in hauls 3 (1 038 kg/30 min) and 124 (6 137 kg/30 min) were excluded in the calculations as proposed in WG-FSA-90/13.

7.205 Details of these calculations are given in Appendix I.

7.206 The biomass estimates for the two different approaches were 9 620 tonnes (CV = 34%) and 5 606 tonnes (CV = 22%).

7.207 These values and their associated CVs are both well below those obtained in WG-FSA-91/33 (43 000 tonnes, CV = 68 %) and are likely to be more realistic. However, taking into consideration the underestimation of the areas of seabed in region A due to a lack of accuracy in the limits of the 500 m isobath in the area of seabed estimates, the minimum biomass obtained after restratification (5 606 to 9 620 tonnes) should be considered as a lower limit of stock size.

7.208 Figure 15 shows the biomass estimates for *C. gunnari* in Subarea 48.2 obtained from VPA analysis (Kock and Köster, 1989) and from different surveys carried out since 1975 (Kock, 1981; Kock, 1986; Kock *et al.*, 1985; Balguerías, 1989).

7.209 From this figure it is suggested that the size of the stock has slightly increased since 1985 (3 669 tonnes), but it is still at a very low level related to its pristine biomass in the middle of the 1970s.

Notothenia gibberifrons (Subarea 48.2)

7.210 Trends of the estimated abundance of *N. gibberifrons* in Subarea 48.2 from VPA analysis (WG-FSA-90/16) and from different surveys (Kock, 1986; Kock *et al*.,1985; Balguerías, 1990) are given in Figure 16. Previous VPA analyses were run under two assumptions of **M** (**M** = 0.25 and **M** = 0.125) and allocating 75 % of the catch of 'Pisces nei' reported from 1979/80 to 1982/83 to *N. gibberifrons* (WG-FSA-90/16).

7.211 Both surveys and VPA estimates (Figure 16) suggest a continuous decline of the stock from its initial size in 1976 (68 430 tonnes) up to 1987 (7 109 tonnes) with minor peaks in 1980 and 1983. The biomass estimate from the 1990/91 survey suggest that biomass has increased since then. Conservation measures introduced in the fishery (minimum mesh size of 80 mm in 1985, prohibition of directed fishing in 1989, closure of the finfish fishery in 1990) may have been responsible for the increase of the stock size in 1991.

Other Species

7.212 The Working Group had the opportunity to assess changes in biomass of other species (*C. aceratus, P. georgianus, C. rastrospinosus,* and *N. kempi*) based on survey estimates conducted in different years (Kock *et al*., 1985; Kock, 1986; Balguerías, 1989; WG-FSA-91/33).

7.213 All the species considered seem to have experienced an important increase in terms of biomass after the middle of the 1980s (Figure 17). Some of them, such as *C. aceratus* and *C. rastrospinosus,* are even at a similar level to the pristine stocks, although these figures should be taken with caution because surveys may not be comparable due to different gear types, vessels etc., and also due to the variability associated with the estimates.

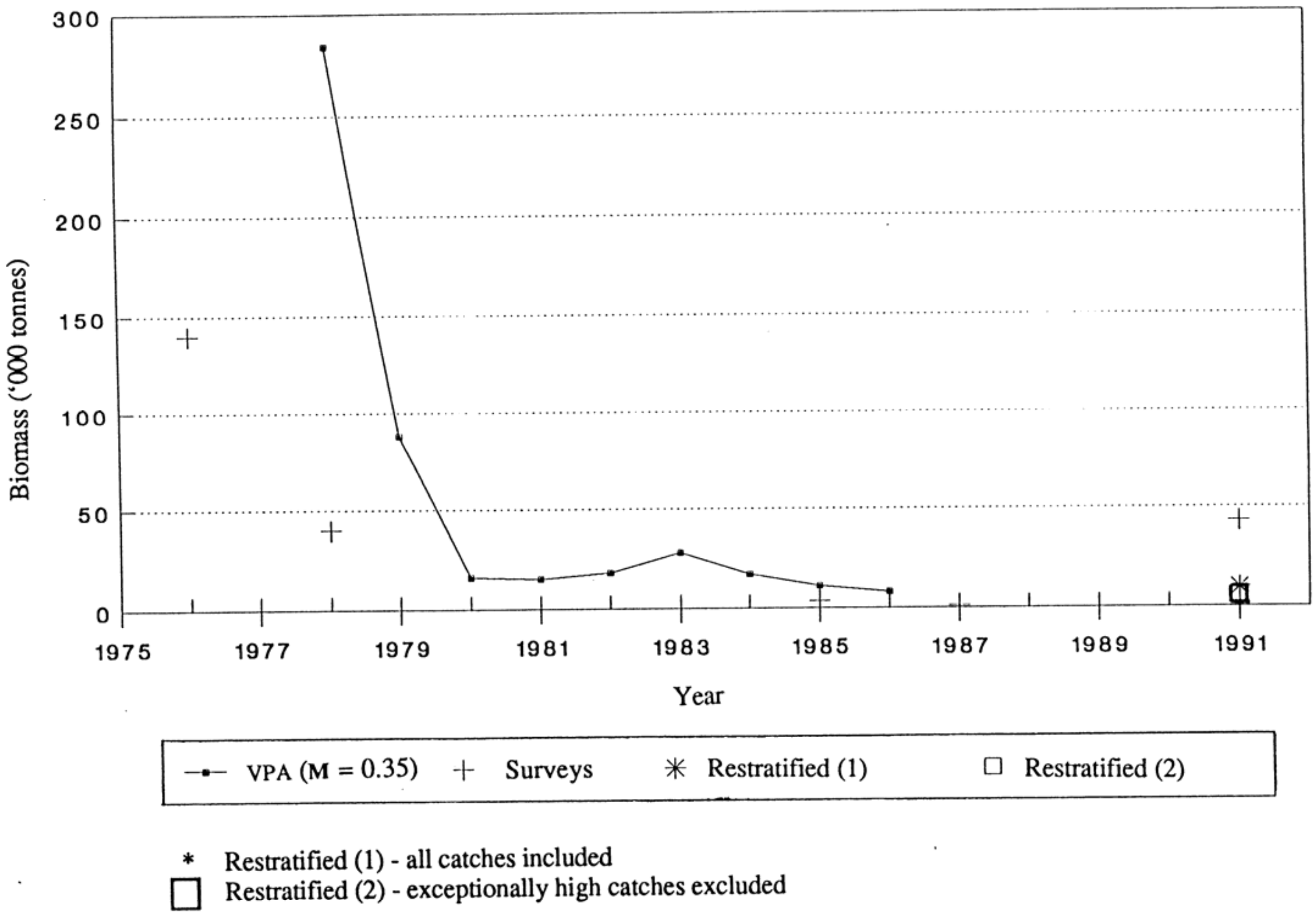

Figure 15: Biomass estimates for *C. gunnari* in Subarea 48.2.

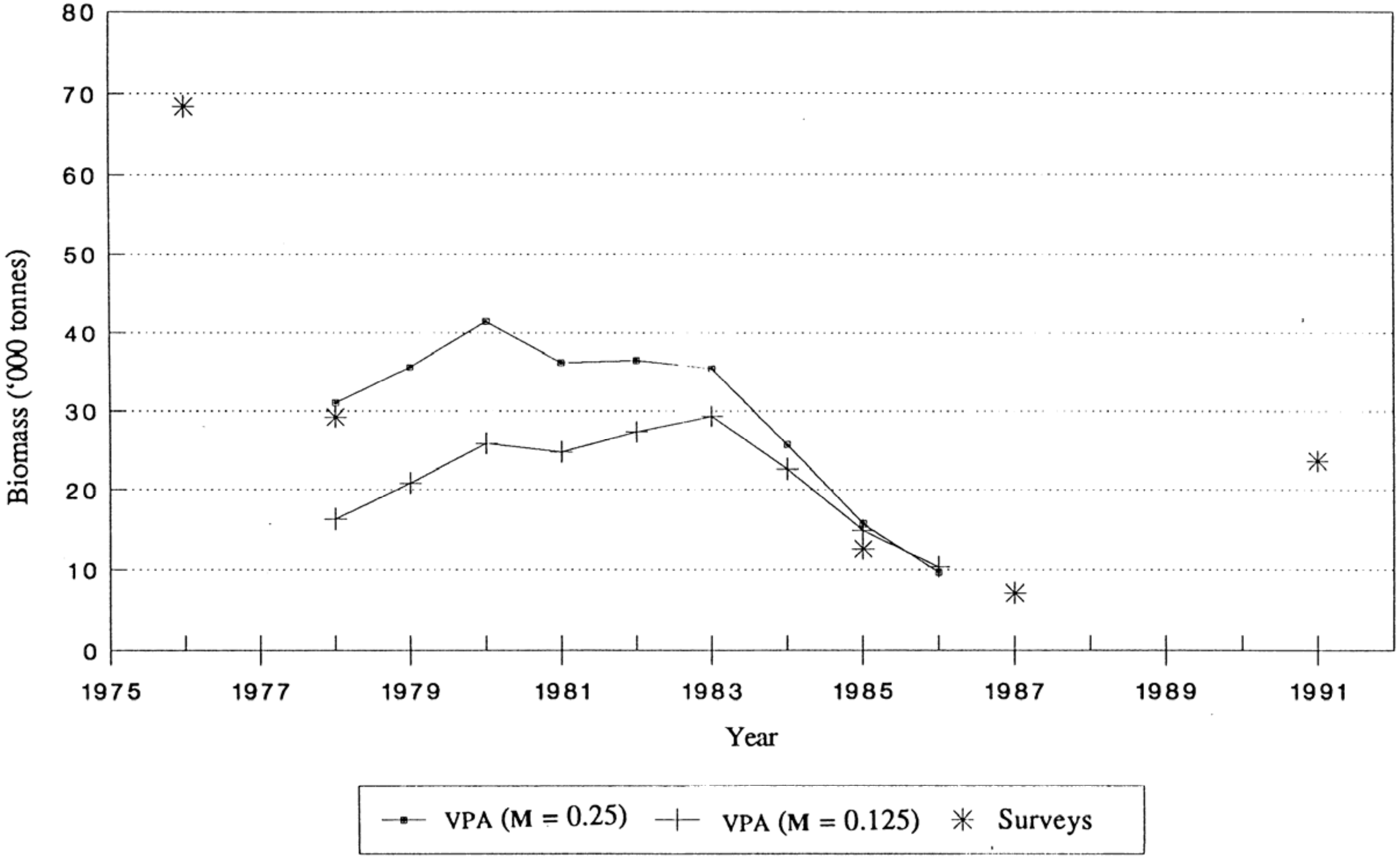

Figure 16: Biomass estimates for *N. gibberifrons* in Subarea 48.2

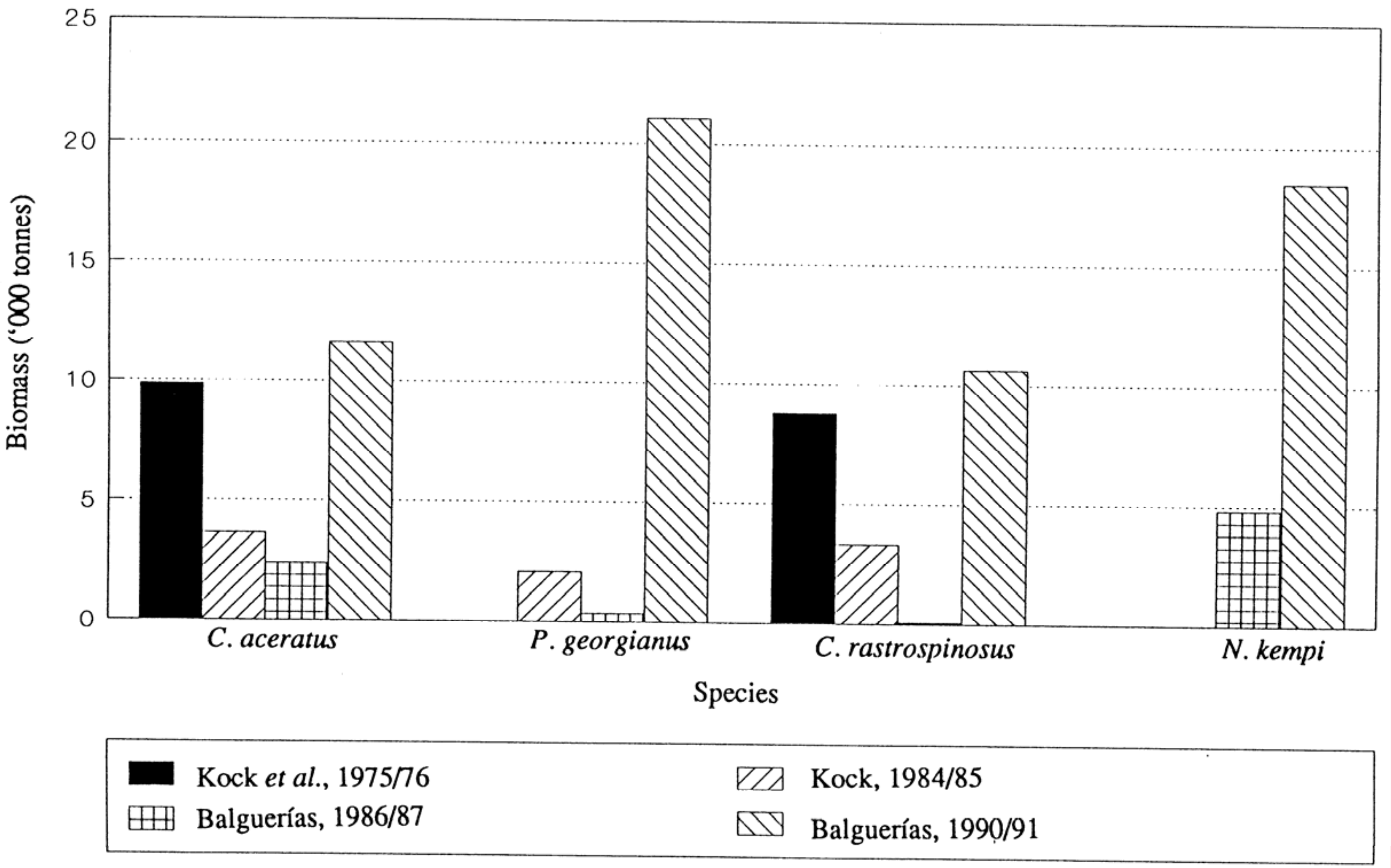

Figure 17: Survey biomass estimates for other species in Subarea 48.2.

Calculation of TAC

7.214 MSY for the six species composing 97% of the catches taken during the Spanish survey 'ANTARTIDA 9101' were calculated using the Beddington-Cooke (1983) equation.

7.215 Three biomass estimates for *C. gunnari* in 1991 (before restratification and after restratification 1 and restratification 2) were considered in the calculations. **M** values are the same as those used in other analyses by the Working Group. In the absence of an **M** for *N. kempi*, the value obtained for the closely related *N. squamifrons* in Kerguelen Islands has been used.

7.216 Minimum and maximum levels of MSY corresponded to *C. gunnari*: 392 tonnes for a biomass estimate of 5 606 tonnes, and 3 010 tonnes for a biomass estimate of 42 998 tonnes. These two values were fixed as minimum and maximum TACs for this species. Trying to follow a mixed-fishery approach, the TAC for all the other species were calculated in relation to the percentage of representation of each species in the total catch of the Spanish survey 'ANTARTIDA 9101'. That is, the expected catch of each species if any of the *C. gunnari* TACs would be attained using a bottom trawl.

7.217 The results are set out in Table 18.

Table 18: Biomass, MSY and maximum and minimum TACs for bottom trawl species in Subarea 48.2.

Species	Biomass 1991* (tonnes)	**M**	MSY Bedd.&Cook (tonnes)	% in Catch	Minimum TAC	Maximum TAC
	42 998		3 010			
C. gunnari	9 620	0.350	673	33	392	3 010
	5 606		392			
		0.250	1 181			
N. gibberifrons	23 627			22	261	2 007
		0.125	591			
P. georgianus	21 043	0.400	1 683	33	154	1 186
N. kempi	18 493	0.180	666	11	131	1 003
C. aceratus	11 603	0.300	696	11	131	1 003
C. rastrospinosus	10 645	0.380	809	7	83	638

* Biomass estimates from the Spanish survey 'ANTARTIDA 9101'

Management Advice

7.218 Since the Commission has implemented conservation measures in Subarea 48.2 (minimum mesh size of 80 mm in 1985, prohibition of directed fishing in 1989, closure of the finfish fishery in 1990) all assessed stocks in the subarea have exhibited an upward trend in their size. However, most of them appear still far from having recovered. A possible re-opening of the fishery and its implications have been considered in light of a mixed species bottom trawl fishery (Figure 18).

7.219 The allocation of a TAC for *C. gunnari* corresponding to the maximum MSY of 3 010 tonnes (Table 18) is likely to produce catches of *N. gibberifrons, N. kempi*, and *C. aceratus* of respectively 1.7, 1.4 and 1.4 times in excess of their maximum MSY.

7.220 In the case of allocating TACs according to the lower MSY of *C. gunnari* (392 tonnes) the expected catches of associated species would be under their respective MSYs.

7.221 In this more conservative scenario, the estimated potential yield of a bottom trawl fishery in Subarea 48.2 would be around 1 152 tonnes.

7.222 In the absence of information about the ratios of the species in the midwater catches, the Working Group was unable to evaluate what the implications of the re-opening of such a fishery may have been.

7.223 In light of the low sustainable yield which can be obtained from a bottom trawl fishery, the still low stock size of *C. gunnari* and the uncertainties associated with the by-catch in a midwater trawl fishery on *C. gunnari* most members of the Working Group recommended that conservation measures for the subarea should be retained (Conservation Measure 27/IX).

7.224 Dr Shust suggested that a limited fishery in accordance with the calculated MSY should be allowed.

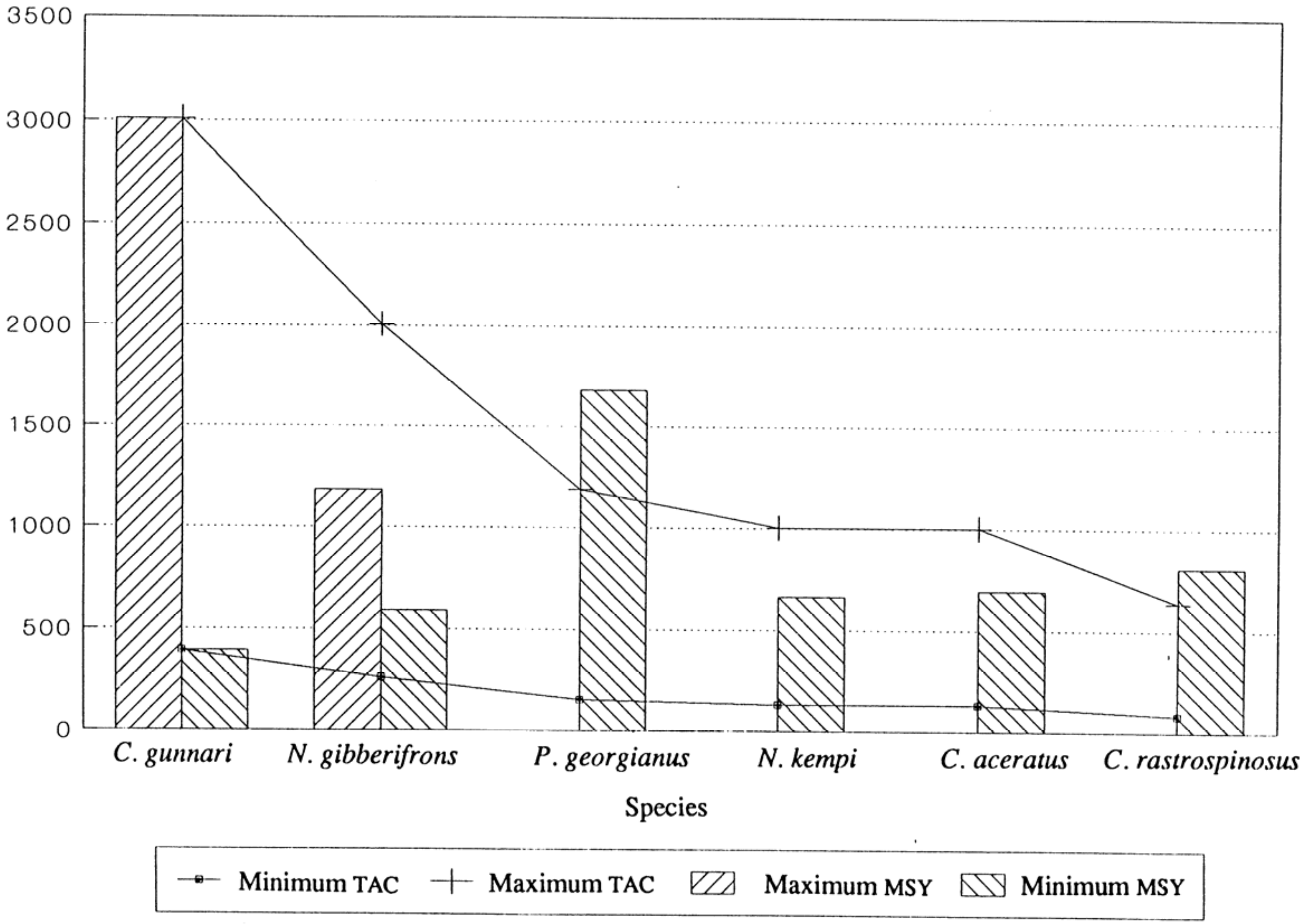

Figure 18: TAC estimates for Subarea 48.2.

Antarctic Peninsula (Subarea 48.1)

7.225 The only new information on the fish stock abundance in this area available to the Working Group was the results of pre-recruit surveys of *N. gibberifrons*, *N. rossii* and *Notothenia neglecta*, and the analysis of the size structure of the latter two at Potter Cove (South Shetland Islands) tabled in WG-FSA-91/13. Pre-recruit abundances of *N. gibberifrons* and *N. rossii*, relative to *N. neglecta*, are at low levels compared with those found in 1983.

7.226 The size structure of the *N. rossii* population shows that during 1983 to 1986 a single cohort (year class 1980) passed through the Cove, suggesting that low abundances are the consequence of poor recruitment to the Cove. The usefulness of such a time series was pointed out and the enlargement of the number of sampling sites was recommended.

Management Advice

7.227 In view of the very limited new information available to re-assess the state of the stocks in the Peninsula region, the Working Group recommended that the conservation measures in force for the 1990/91 season should be retained (Conservation Measure 27/IX).

Statistical Area 58

7.228 In 1990/91 fishing took place in Subarea 58.4 and Division 58.5.1. In addition, an exploratory longline fishing cruise took place in Division 58.5.1 in the deep sea zone (> 500 m) of the Kerguelen Islands shelf. There was also a joint French/Soviet scientific cruise in the same area to investigate the *N. rossii* stock.

7.229 A summary of the catches reported from Statistical Area 58 is given in Table 19. In Division 58.5.1, the major harvested species were *C. gunnari* (80.5% of total catch), and *D. eleginoides* (11.8% of total catch). No directed fishery occurred for *N. squamifrons* or *N. rossii.*

Table 19: Total catches by species and subarea in Statistical Area 58. Species are designated by abbreviations as follows: ANI (*Champsocephalus 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	ANI		LIC	WIC	TOP				NOR			NOS			ANS		MZZ			SRX
Year	58	58.5	58.5	58.4	58	58.4	58.5	58.6	58	58.4	58.5	58	58.4	58.5	58	58.4	58	58.4	58.5	58.5.1
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		50		364	7	
1983		25852				4	128	17			1829		95	1832		229		4	17	1
1984		7127				1	145	-		50	744		203	3794					611[1]	17
1985		8253		279		8	6677	-		34	1707		27	7394		966		11	7	4
1986		17137		757		8	459	-		-	801		61	2464		692				3
1987		2625		1099		34	3144	-		2	482		930	1641		28		22		
1988		159		1816		4	554	488		-	21		5302	41		66				
1989		23628		306		35	1630	21			245		3660	1825		47		23	24	
1990		226		339			1062				155		1450	1262					2	
1991		13283[2]					1944				287		575	98						

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.

NB: Before 1979/80 catches reported in Statistical Area 58 mainly concern Division 58.5.1 (Kerguelen Subarea)

Subarea 58.5

Division 58.5.1 (Kerguelen)

7.230 Data available as a basis for assessments are from the trawl fishery for *C. gunnari* and *D. eleginoides*, longline exploratory fishing for *D. eleginoides*, and a scientific survey of the pre-spawning aggregation of *N. rossii*.

7.231 Fishing was conducted by the Soviet Union and France. The Soviet fishery, under licence from France, targetted *C. gunnari* with bottom trawls (five vessels). Fishing effort was concentrated between January and April 1991. France conducted a trawl fishery on *D. eleginoides* with one vessel in October 1990 and May 1991.

Notothenia rossii (Division 58.5.1)

7.232 During fishing operations, *N. rossii* was taken only as a by-catch, and a total of 40 tonnes was reported. This is considerably less than the average for previous seasons, which was due to the *C. gunnari* fishery not occurring in the south and southeast sector, where *N. rossii* is most abundant.

7.233 The scientific cruise investigated the spawning area of this species in the south eastern part of the Kerguelen shelf during May and early June 1991. The total catch of 255 tonnes was analysed, but the data have not yet been completely assessed. These will be presented at next year's meeting of WG-FSA. The objectives of the study were not fully realised because the work was terminated before the spawning aggregation was fully formed.

7.234 Preliminary results indicate an increase in the mean length of the spawning stock compared to the last observations at a comparable time from the fishery (1984/85 season). The CPUE index of abundance from this survey indicates no significant increase in stock size since the end of the directed fishery for this species in 1984/85. In 1984/85 CPUE was 2.58 tonnes/hour, whereas in this survey it was 0.95 tonnes/hour. However, more detailed analysis of the latter figure is required because this value is derived from data acquired before the spawning aggregation was completely formed.

Management Advice

7.235 The existing regulations in force (no directed fishery) should continue in order to protect the adult stock. Trends in the abundance of the juveniles need to continue to be monitored. Research on prespawner and spawner biomass should be continued during the 1991/92 spawning season.

Notothenia squamifrons (Division 58.5.1)

7.236 In the 1990/91 season, no directed fishery occurred on the grounds where this species is usually exploited. Only 89 tonnes were caught during the season. CPUE on the few hauls conducted on the normal fishing grounds for this species was very low, with the maximum at 0.63 tonnes/hour in January 1991. No biological data are available, and no new assessment is possible for this stock.

Management Advice

7.237 Previous biomass estimates and VPA analyses of this stock reported to WG-FSA from 1988 to 1990 indicate that the stock size is very low. In the light of this, even a low level of catches could prevent recovery of the stocks of this species.

Champsocephalus gunnari (Division 58.5.1)

7.238 The three-year cycle of the appearance of a strong cohort continued in this fishery. In 1990/91 the strong cohort of the 1988 year class entered the fishery when it reached the legal size of 25 cm total length. Its mean length observed in February 1991 was 28.4 cm TL at age 2+. The fishable part of the stock was concentrated, as usual, on the north-eastern part of the shelf, where the fishery occurred from January to April 1991. The total catch was 12 660 tonnes.

7.239 The Soviet fishing fleet (five vessels) is very homogeneous with respect to vessel and gear type and general fishing methods, so CPUE for the entire fleet can be used as and index of abundance. Mean CPUE for the 1990/91 season was 4.09 tonnes/hour fished. There was no significant decline of CPUE through the season.

7.240 It is possible to compare CPUE index of abundance of the present cohort with those of the previous exploited cohorts of 1982 and 1979 because the fishing method, area of fishing and age at exploitation were comparable. These comparisons show (Figure 19) that the present cohort at age 2 seems significantly less abundant than the 1979 and 1982 cohorts at the same age. At age 3, there has been a steady decline in abundance from the 1979 to the 1985 cohort. For the 1988 cohort, the abundance at age 3 will follow the same trend because its abundance at age 2 is already less than the abundance of 3 year old fish in previous cohorts.

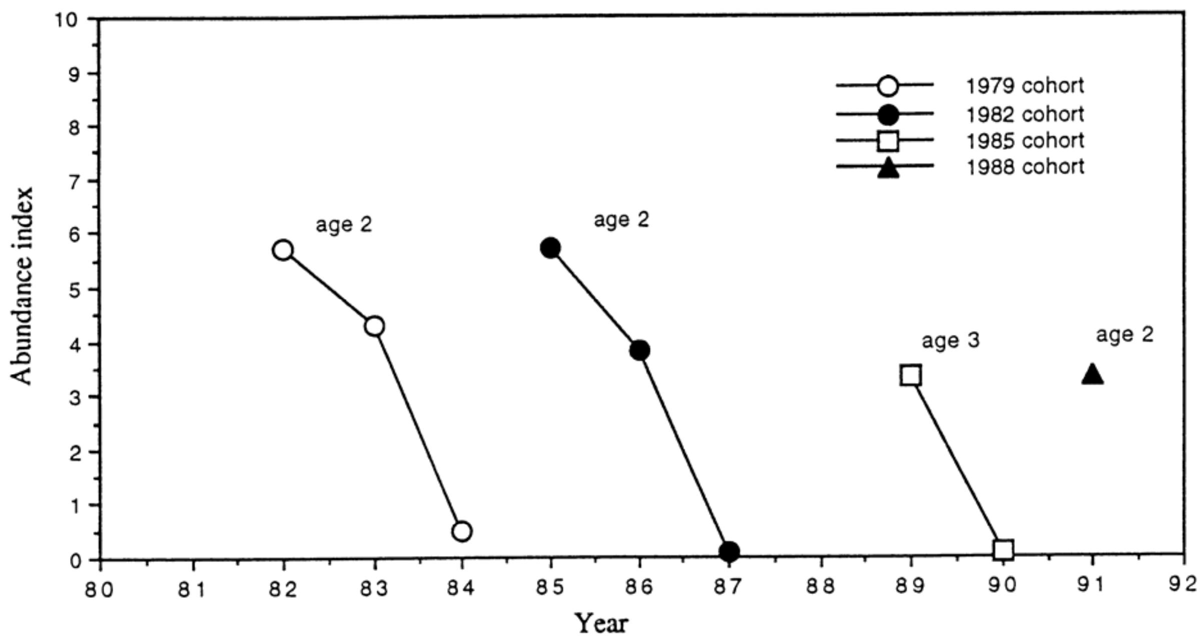

Figure 19: Abundance index of *C. gunnari* in Division 58.5.1.

7.241 The cohort analysis has been extended to include the number of fish caught in the 1990/91 season (100.64 x 10^6). The comparison with previous cohorts is shown in Figure 20, using the methods presented in WG-FSA-90/17. Two values of **F** were used to run the cohort analysis; those calculated for year class 2 of the 1979 and 1982 cohorts respectively. The value for the 1985 cohort was not used because the fishing effort was very low. The results using these **F** values (0.494 and 0.424) were very similar. The predicted stock size at age 3 is similar to the calculated stock sizes of the 1982 and 1985 cohorts, which produced catches of 17 055 and 23 048 tonnes at age 3 respectively.

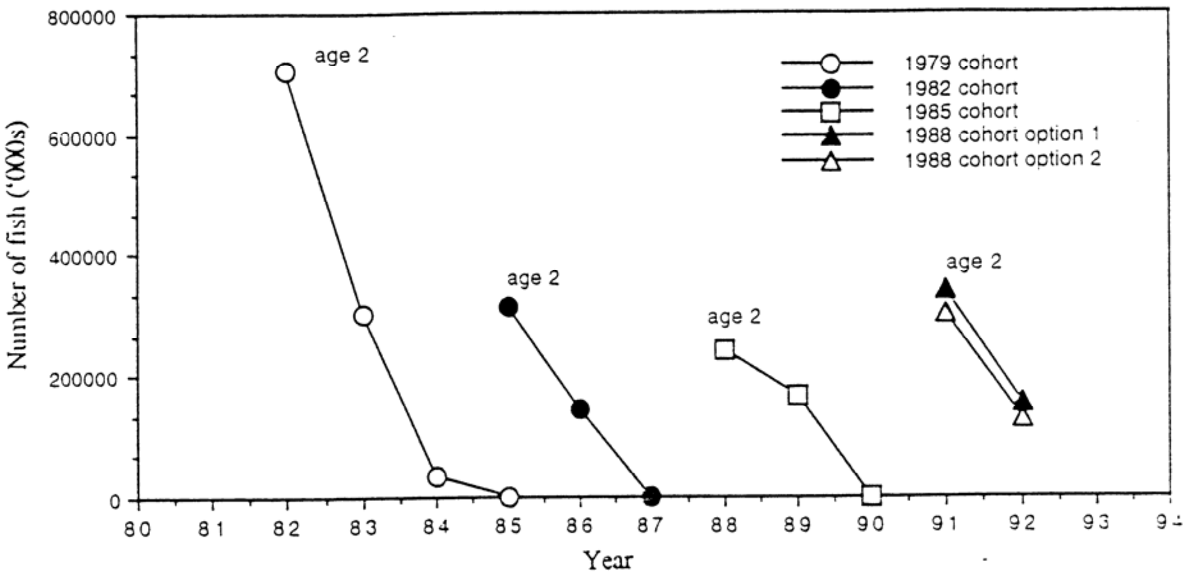

Figure 20: Population size of *C. gunnari* in Division 58.5.1.

7.242 There was no fishing on Skif Bank in the 1990/91 season. No new information can be provided on the separate stock of *C. gunnari* on this bank.

Management Advice

7.243 Given the steady decline in index of abundance at similar ages in successive cohorts, the catch in the 1991/92 season on 3 year old fish should be less than that on previous cohorts at the same age (i.e. less than 17 000 tonnes). The cohort analysis does not indicate a significant decrease in year class strength between cohorts. This analysis, however, makes assumptions about parameters such as **F** and **M**, and so is possibly a less reliable index than CPUE, which is a direct observation from a large body of data.

7.244 The cause of disappearance of age 3 fish still needs to be resolved during the 1991/92 season.

Dissostichus eleginoides (Division 58.5.1)

7.245 A total of 1 848 tonnes was caught by trawling in the 1990/91 season. This comprised 1 560 tonnes caught by France, and 288 tonnes by USSR vessels. In addition, 109 tonnes were caught in an experimental longline fishery (one Soviet longliner). The trawl fishery exploited stocks in the depth range 300 to 500 m, while the longliner fished in depths of 500 m and greater. *D. eleginoides* was the main target species for one French trawler, but a secondary target for the Soviet trawlers, which concentrated on *C. gunnari*. At a total of nearly 2 000 tonnes this season's catch is the third highest recorded, and the third successive season in which catches have exceeded 1 000 tonnes. WG-FSA-91/9 gives a comprehensive summary of the history and characteristics of the fishery in the Kerguelen area, as requested at the 1990 meeting of WG-FSA (SC-CAMLR-IX, Annex 5, paragraph 243).

Western Sector

7.246 Since the first year of significant catches in 1984/85, the fishery concentrated on the western part of the shelf, and exploited sub-adults. Analysis of length frequency distribution shows a clear correlation between mean length of fish and depth fished. It is important to take this into account in the analysis of index of abundance. Three seasons in which the fishery concentrated on more shallow depths have catches with comparable length frequency distributions:

Year	Mean Length of Catch (cm)	Index of Abundance (tonnes/hour)
A. Lesser depth range		
1984/85	66.3	2.5
1986/87	69.8	1.81
1988/89	65.8	1.65

7.247 These results show a clear decline in the index of abundance. It appears that the smaller sub-adult part of the stock in the shallower part of the species' range has been affected by the fishery. During other years the fishing effort was directed to the older part of the stock in deeper water as shown by the mean length of fish caught.

Year	Mean Length of Catch (cm)	Index of Abundance (tonnes/hour)
B. Greater depth range		
1987/88	73.6	0.81
1989/90	81.6	1.26
1990/91	87.4	1.38

7.248 The index of abundance is consistently lower than in the shallower fishery, indicating a lower abundance of the larger fish, but there is no clear trend in the index as the fishery develops.

7.249 The exploratory longline fishery was also conducted in the western sector, but at greater depths than the trawl fishery. However, the length frequency distribution of the longline catch was very similar to that of the trawl fishery in the deeper waters as described above. This indicates that the longline and the deeper trawls are exploiting the same part of the stock. At this stage little more can be done to compare the two fishing methods and their relative impact on the stock.

New Fishing Ground

7.250 The French trawl fishery exploited a new trawling ground for *D. eleginoides* during this season, which explains the relatively high total catch (1 356 tonnes in the new fishery compared to 311 tonnes for the western sector). CPUE index of abundance was 3.4 tonnes/hour which is very similar to the value obtained in the western sector in the first year of exploitation (1984/85). The length frequency distributions in the two fisheries during their first year of exploitation were also comparable.

Management Advice

7.251 In view of the steadily declining CPUE in the western sector, the management advice in paragraph 166 of the Report of the 1989 Meeting of WG-FSA (SC-CAMLR-VIII, Annex 6) that the catch should not exceed 1 100 tonnes should be continued. If the new fishing grounds are further exploited, care must be taken that catches in these areas do not produce a decline in abundance similar to that seen in the western sector. When the new areas are further studied, the limit of 1 100 tonnes per annum may have to be revised. Considering the probably increasing importance of this species in the Kerguelen fishery, further information on age and growth and other parameters is needed for stock assessment in the future.

Other Species (Division 58.5.1)

7.252 A substantial by-catch in the *C. gunnari* fishery of 826 tonnes was mostly *Bathyraja spp*. A similar by catch was also observed in 1983/84 in the same area, but not in other years. No information is available for assessment of this catch.

Division 58.5.2 (Heard Island)

7.253 No fishery occurred in this area, and no other new data are available. No advice can be provided.

Subarea 58.4

Division 58.4.4 (Ob and Lena Banks)

7.254 The 1990 meeting of WG-FSA performed a VPA on the *N. squamifrons* stocks on these two banks, although the validity of this assessment was reduced due to the poor quality of the data. TACs of 267 tonnes for Ob Bank and 305 tonnes for Lena Bank were set on the basis of this assessment to allow the stocks to recover from their depleted state. A combined catch of 575 tonnes for both banks was reported by USSR for the 1990/91 season, which is 100.5% of the TAC. New data were provided to the meeting too late to be analysed. These new catch data perpetuate the problem encountered at the 1990 meeting of WG-FSA, of large discrepancies between STATLANT and data submitted in assessments, and this must be resolved in good time for next year's meeting. For example, the total catch for both banks in the period 1980/81 to 1989/90 was 31 442 tonnes in the new data submitted, 33 684 tonnes in WG-FSA-90/27 and 15 439 tonnes in the Statistical Bulletin. The TACs of 267 tonnes for Ob Bank and 305 tonnes for Lena Bank were set on the basis of VPAs using the data in WG-FSA-90/37. As these data now appear to be incorrect, and the total catches were apparently 2 500 tonnes (7%) greater over a 10-year period than assumed, it follows that the VPAs, and hence the TACs, are inaccurate.

Management Advice

7.255 Last year's recommendation that catches should be reduced below $\mathbf{F_{0.1}}$ for a few years to allow the stocks to rebuild is now even more valid. A re-evaluation of the fishery on these two stocks based on definitive datasets is urgently needed. Until this is satisfactorily completed, the fishery should be closed, to avoid the danger of allowing over-fishing on the basis of inadequate information. As the present TAC is only 572 tonnes, and is probably too high, this is a real danger.

7.256 If the fishery is not closed, it is necessary that a five-day catch reporting system be instituted, as with other fisheries with TACs. Fine-scale catch and effort data should also be submitted.

Division 58.4.2 (Coast of the Antarctic Continent)

7.257 Fine-scale catch and effort data and age/length information for *P. antarcticum* have been submitted by the USSR for the period 1978 to 1989. An analysis of these data proposed in paragraph 4.70 of the Report of the 1990 Meeting of WG-CEMP (Annex 7) was not available to the meeting, so no assessment has been made.

7.258 WG-FSA-91/4 examines the effect of oceanographic conditions on the abundance of *P. antarcticum* and *Chaenodraco wilsoni*. No other data have been provided, and so no management advice is possible.

Other Subareas and Divisions in Statistical Area 58

7.259 No fishing was reported for Subarea 58.7 (Prince Edward and Marion Islands), Subarea 58.6 (Crozet Islands) and Divisions 58.4.3 and 58.4.1 (Coastal Areas of the Antarctic Continent).

FUTURE WORK

Data Requirements

8.1 Data requirements associated with specific stocks were identified by the Working Group. Appendix E lists these and other requirements identified by the Working Group.

8.2 It was noted that data requirements had been repeatedly requested by the Working Group each year. Such a list was prepared last year and once again adequate data had not been submitted and some survey reports were still being submitted in an incomplete form.

Dissostichus eleginoides, Subarea 48.3

8.3 Data required by Conservation Measure 26/IX had not been reported as specified under the Conservation Measure. In particular:

- haul-by-haul data had not been reported; and

- length frequencies from the fishery had been reported for only 5 out of the 10 months of the fishery.

The requirement for reporting these data from the fishery every month should be maintained in future conservation measures.

8.4 In addition, the requirement for reporting data by five-day period should be expanded to include:

- the number of vessels;
- the coordinates of fishing activity;
- the number of hooks per set;
- the number of sets;
- the number of vessel days in the period; and
- the total number of hooks used in that period.

The latter two should be reported as a summary in the same manner as on the STATLANT B forms, and not as ranges of boats and hooks as was reported in 1990/91.

8.5 The length and age composition data used in WG-FSA-90/34 and WG-FSA-91/24 should be submitted in standard format to the Secretariat.

8.6 The Commission received an invitation in 1990 from the USSR for observers on vessels engaged in the *D. eleginoides* longline fishery. The Working Group acknowledged the advantage of having observers on these vessels for data collection, and noted that whilst no observers had been able to take up the invitation during the 1990/91 season the extension of this invitation to the 1991/92 season would be welcome.

Electrona carlsbergi, Statistical Area 48

8.7 At its Ninth Meeting the Commission agreed that the following information be submitted to the Secretariat (CCAMLR-IX, paragraph 4.27):

(i) full details of the proposed fishing operation including method of fishing, mesh sizes in use, proposed target region and any indication of the minimum catch levels required to develop a viable fishery for *E. carlsbergi*;

(ii) details of the species' stock size, abundance and demography (e.g. growth parameters and size/age at annual maturity); and

(iii) details of the predator dependent on this resource and their requirements.

8.8 The Working Group noted that no information had been submitted in answer to requirement (i), no information additional to that submitted in 1990 (which particularly addressed stock size and demography) was available in answer to requirement (ii), and that a review paper had been prepared by the Secretariat in response to requirement (iii) (SC-CAMLR-X/BG/6). The requirements of paragraph 4.27 have therefore not been fulfilled, even though the fishery has increased by about 300%.

8.9 The following are required for *E. carlsbergi*:

- full reporting of existing biological and survey data;

- further data on the distribution, biomass, demography and age structure of *E. carlsbergi* populations both within and north of the Convention Area;

- a description of the derivation of the acoustic target strength used for surveys of *E. carlsbergi*, and the techniques used to distinguish between myctophids and krill in acoustic surveys;

- details of the by-catch in the *E. carlsbergi* fishery;

- studies on the stock identity and migration of *E. carlsbergi*, including stocks north of the South Polar Front; and

- further surveys, extending around South Georgia.

Champsocephalus gunnari, Subarea 48.3

8.10 The following data are required for the *C. gunnari* fishery in Subarea 48.3:

- biological data from the commercial fishery, including representative length and age samples especially since the current 80 mm mesh will change to 90 mm mesh in the 1991/92 season (Conservation Measure 19/IX);

- quantitative information on the by-catch in the commercial midwater trawl fishery for *C. gunnari*; no additional information is available to that described in paragraph 3.42 of SC-CAMLR-IX and WG-FSA-90/15, that between 138 and 638 kg of *N. gibberifrons* and about 4 tonnes of *C. gunnari* would be caught for each haul directed at *C. gunnari*, a by-catch rate of about 3 to 15%; information on the by-catch in the demersal trawl fishery is presented in paragraphs 7.189 to 7.194 and Appendix H;

- more information is required in the reports of surveys: the position of hauls, description of cruise tracks, data on haul-by-haul catches and descriptions of methodologies used to calculate survey biomass should be given in reports of the survey in accordance with the guidelines set down in Appendix F of the Report of the 1990 Meeting of WG-FSA (SC-CAMLR-IX, Annex 5), and research data should be submitted to the Secretariat; and

- in order to resolve the discrepancies between surveys by the UK and USSR, joint cruises should be considered.

South Orkneys (Subarea 48.2)

8.11 Whilst the fishery in Subarea 48.2 remains closed research surveys are required every few years to investigate the status of the stocks of demersal species. Upon resumption of a commercial fishery, the collection and submission of biological data from the catch would be required.

Antarctic Peninsula (Subarea 48.1)

8.12 Very little biological data is available on the stocks in Subarea 48.1. A research survey is urgently required to enable assessments to be conducted.

Indian Ocean (Subarea 58.4)

8.13 The following are required for the Kerguelen fisheries (Division 58.4.1):

- investigations of the mortality of *C. gunnari* at age 3 to 4;

- length frequency data and age/length keys for *D. eleginoides* from both trawl and longline fisheries; and

- the abundance of *N. rossii* and *N. squamifrons* should continue to be monitored.

8.14 Fine-scale and biological data should be submitted from fisheries in Division 58.4.2 should they recommence.

8.15 The following are required from the fishery on Ob and Lena Banks (Division 58.4.4):

- correct catch data should be submitted to the Secretariat for these fisheries, given the discrepancies between data identified in paragraph 245 of last year's report (SC-CAMLR-IX, Annex 5 and paragraph 7.254 of this report);

- fine-scale data for Division 58.4.4 should be submitted to the Secretariat (paragraph 7.256); and

- age/length keys and other biological data for Subarea 58.4 should be submitted to the Secretariat.

Research Requirements

8.16 The Working Group identified studies of age determination of *D. eleginoides* and a description of the process of longline fishing (including details of types of hooks and their deployment) as information that would significantly increase the ability of the Working Group to perform assessments of this species.

8.17 Specific information is required on the behaviour and mortality of seabirds and marine mammals in the longline and trawl fisheries and evaluations of the effectiveness of techniques for reducing this mortality should be undertaken.

8.18 One of the most important questions affecting assessments of *D. eleginoides* is whether the stock at Shag Rocks and South Georgia is effectively separate from the stocks whose distribution extends up the western coast and round the southern tip of South America (WG-FSA-91/10). Studies investigating stock identification and migration of this species are strongly encouraged, and could utilise genetic, tagging, morphometric and parasite-marker techniques.

8.19 It was pointed out that whilst tagging of adult or juvenile fish may involve a degree of increased mortality due to the tagging process, the technique may yield preliminary qualitative information about migration routes. An investigation of this type may be expensive, as in the order of 5 000 to 10 000 fish may need to be tagged. Tagging fish caught as adults or juveniles in Subarea 48.3 or off South America would be equally valuable.

8.20 Although the ability to distinguish between stocks using genetic techniques is reduced by only very little migrational exchange, these techniques are simpler to apply and could be used in an initial attempt to answer the question of stock identification in *D. eleginoides*.

8.21 An additional area of necessary research is the investigation of the existence of and patterns of migration of fish species, including *C. gunnari*, between the South Orkneys and other areas of the Scotia arc including South Georgia (see paragraphs 7.28 and 7.32).

8.22 The distribution of stocks of *E. carlsbergi* in Subarea 48.3 may be influenced by current movements on a macro-scale. Such a flux of myctophids between areas within

Subarea 48.3 and between Statistical Area 48 and areas north of the Polar Front, would have important implications for assessments and management advice. However, before considering the effects that these fluxes would have on management advice it is essential to demonstrate that they exist with respect to the *E. carlsbergi* stocks.

8.23 It is apparent that for some stocks in some areas (such as *C. gunnari* in Subarea 48.3 and Division 58.5.1) there are periodically large fluctuations in biomass and recruitment. These may be intrinsically biological in origin, or they could be related to environmental fluctuations. Studies that investigate relationships between environmental parameters and stock characteristics, such as that described in WG-FSA-91/30 which attempted to relate sea surface temperature to survey biomass, should be encouraged.

8.24 It was emphasised that whilst the functional relationships between environment and biological parameters may never be understood to a degree that enables their predictive use in management, an awareness of the qualitative relationships between these parameters may allow the Working Group to interpret assessments and stock predictions with regard to these relationships. Where advice is formulated as a range of options and probabilities, appropriate probabilities could be adjusted in the light of environmental information.

8.25 Dr Shust informed the Working Group that the USSR had many years of environmental data obtained from research cruises. He suggested that these data could be presented to the Working Group in a preliminary review by the USSR at a future meeting.

8.26 It was noted that there was no way of determining the relative reliability of the various assessment methods used in the calculation of catch levels for *D. eleginoides* (Table 8). Simulation studies investigating the robustness of the various methods that might help the Working Group to decide on their appropriateness as assessment techniques for *D. eleginoides*, would be welcome.

Analyses and Software to be Prepared for the Next Meeting of the Working Group

8.27 The VPA program most commonly used by the Working Group was that written by the UK Ministry of Agriculture, Fisheries and Food, Fisheries Research Laboratory. A problem encountered with this program was the inability to incorporate both CPUE and survey biomass indices with a different weighting factor for each index in the same run, and the relatively restricted methodologies used to apply residual functions in the tuning process. The necessity of inputting weighting values by hand was also a restriction.

8.28 The Secretariat was asked to investigate updated versions of this program, and the possibility of changing the tuning modules to combine several different abundance estimates, each series of which may be incomplete. In addition, the incorporation of objective functions using maximum likelihood techniques for tuning should be considered.

8.29 Dr B. Sjöstrand (Sweden) suggested that the ADAPT program (originally written by S. Gavaris, 1988), written in APL by Dr R. Mohn (Canada), provided increased flexibility in the functions fitting VPA to tuning data and should be considered as an alternative assessment program by the Secretariat.

8.30 There are considerable uncertainties about the effects of different management strategies for *E. carlsbergi*. Strategies based on $\mathbf{F_{0.1}}$ were considered to be inappropriate by the Working Group (paragraph 7.144). The species is short-lived and recruits to the fishery before becoming sexually mature. It was suggested that a series of simulations should be performed to investigate the sensitivity of different management strategies to variability in recruitment and uncertainties about natural mortality, maturity and catchability.

OTHER BUSINESS

Closure of Fisheries Subject to a TAC

9.1 SC-CAMLR-X/BG/9 described an investigation of various methods for determining the date of closure of fisheries subject to a TAC. Two types of fisheries were investigated (constant and fluctuating catches), at different levels of catch rate, and the probability of the closure decision resulting in catches greater or less than the TAC was determined. The results indicated that the system currently in force in Conservation Measure 25/IX was the least successful method investigated, and resulted in a high probability of TAC overshoot. The most successful method operated by predicting future catch rates from the trend over a number of preceding reporting periods. The decision to close the fishery would be made when the predicted date of completion of the TAC falls within one reporting period of the date that the information on the latest catches was received by the Secretariat.

9.2 The implications of these results were that Conservation Measure 25/IX should be changed to incorporate the proposed method, and that because the overshoot probabilities have a skewed distribution, the TAC would be more likely to be exceeded than undershot. This is primarily because of the lag time between catches being taken, their reporting to the Secretariat and the Secretariat informing Members of a closure decision, which was in the order of two to three reporting periods in the 1990/91 season.

9.3 It was suggested that to accommodate the latter point, the 'effective TAC' used for the calculations should be 95 to 98% of the agreed TAC. It was also suggested that the Secretariat be given some freedom within the conservation measure to choose the most appropriate method of determining a closure date, because SC-CAMLR-X/BG/9 showed that this often depended on the type of fishery and its catch rates.

Review of Working Group

9.4 The Secretariat had produced WG-FSA-91/12 in response to paragraph 311 of SC-CAMLR-IX, Annex 5. This was a useful first attempt at a review of Working Group performance, and whilst it was appreciated that such a study was very difficult, it was felt that:

- the summary of assessment results disguised many of the caveats and discussions that took place in the Working Group meetings; and

- the summary of advice from WG-FSA and action by the Commission only considered specific advice concerning management options, and did not address the many comments about data requirements and general management advice that the Working Group had provided in the past.

9.5 Despite these reservations, the review had been useful in helping the Working Group develop an overview of its work, and especially to focus attention on the ways in which assessments should be improved. It was felt that a more comprehensive internal review, periodically performed by the Convener and several other members of the group, would be most helpful in the future.

Workshop on Survey Design and the Analysis of Research Vessel Surveys

9.6 Considerable problems associated with survey design and the application of the 'swept area' method to survey data on species that are patchily distributed were again in evidence in this year's assessments, for example those of *C. gunnari* in Subarea 48.3 (paragraphs 7.24) and Subarea 48.2 (paragraphs 7.204). The Working Group at its last meeting, drew attention to the need for investigation of these problems as a matter of priority (SC-CAMLR-IX, Annex 5, paragraph 91). Because of the specialised and detailed examination required, this work cannot be done during a regular meeting of WG-FSA. The Working Group therefore recommended that a workshop be held in the intersessional period to address the problem. Dr Kock offered to host such a workshop in Hamburg, Germany. He agreed to put a proposal forward to the Scientific Committee setting down the terms of reference of such a workshop and the costs involved.

ADOPTION OF THE REPORT

10.1 The Report of the 1991 Meeting of the CCAMLR Working Group on Fish Stock Assessment was adopted.

CLOSE OF THE MEETING

11.1 In closing the meeting, Dr Kock expressed his gratitude to the Members of the Working Group for their cooperation and support during the meeting and during the five years that he had been Convener. He said it was gratifying to note the improvement in the detail and the conduct of the work of WG-FSA over the period. He also thanked the Secretariat and commended its members for their dedication and efficiency.

11.2 Dr W. de la Mare (Australia), on behalf of the Working Group, thanked Dr Kock for his guidance and leadership.

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GLOSSARY

CPUE	Catch-per-unit-effort
CV	Coefficient of variation
F	Fishing mortality
$\bar{F}_p$	Mean fishing mortality
M	Natural mortality
MSY	Maximum sustainable yield
TAC	Total allowable catch
SD	Standard Deviation
VPA	Virtual population analysis
Y/R	Yield-per-recruit

APPENDIX A

LIST OF PARTICIPANTS

Working Group on Fish Stock Assessment
(Hobart, Australia, 8 to 17 October 1991)

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SECRETARIAT:

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APPENDIX B

AGENDA

Working Group on Fish Stock Assessment
(Hobart, Australia, 8 to 17 October 1991)

1. Opening of the Meeting

2. Organization of the Meeting and Appointment of Rapporteurs

3. Adoption of the Agenda

4. The CCAMLR Scheme of International Scientific Observation

5. Approaches to Conservation
   - 5.1 New and Developing Fisheries
   - 5.2 Interaction of Other Components of the Ecosystem (e.g. birds, mammals) with Fisheries
   - 5.3 By-catch of Young and Larval Fish in the Krill Fishery

6. Review of Material for the Meeting
   - 6.1 Data Requirements Endorsed by the Commission in 1990
   - 6.2 Catch and Effort Statistics
   - 6.3 Size and Age Composition Data
   - 6.4 Other Available Biological Information
   - 6.5 Mesh/Hook Selectivity and Related Experiments Affecting Catchability
   - 6.6 Assessments Prepared by Member Countries
   - 6.7 Other Relevant Documents

7. Assessment Work and Management Advice
   - 7.1 Organization of Assessment Work
   - 7.2 Discussion of Assessments Carried Out During the Meeting and by Member Countries, and Management Advice

7.2.1 South Georgia (Subarea 48.3)

Notothenia rossii

Champsocephalus gunnari

Patagonotothen guntheri

Dissostichus eleginoides

Electrona carlsbergi

Notothenia gibberifrons

Chaenocephalus aceratus

Pseudochaenichthys georgianus

Notothenia squamifrons

7.2.2 South Orkney Islands (Subarea 48.2)

Champsocephalus gunnari

Notothenia gibberifrons

Other species

7.2.3 Antarctic Peninsula (Subarea 48.1)

Champsocephalus gunnari

Notothenia gibberifrons

Other species

7.2.4 Kerguelen Islands (Division 58.5.1)

Notothenia rossii

Notothenia squamifrons

Champsocephalus gunnari

Dissostichus eleginoides

7.2.5 Ob and Lena Banks (Division 58.4.4)

Notothenia squamifrons

Other species

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

Pleuragramma antarcticum

Chaenodraco wilsoni

Other species

7.2.7 Pacific Ocean Sector

8. Future Work

   8.1 Data Requirements
   8.2 Software to be Prepared or Developed Prior to the Next Meeting and Data Analyses Required
   8.3 Proposal for New Convener of the Working Group on Fish Stock Assessment

9. Other Business

10. Adoption of the Report

11. Close of the Meeting.

APPENDIX C

LIST OF DOCUMENTS

WORKING GROUP ON FISH STOCK ASSESSMENT
(HOBART, AUSTRALIA, 8 TO 17 OCTOBER 1991)

WG-FSA-91/1	AGENDA FOR THE 1991 MEETING OF THE WORKING GROUP ON FISH STOCK ASSESSMENT (WG-FSA)
WG-FSA-91/2	LIST OF PARTICIPANTS
WG-FSA-91/3	LIST OF DOCUMENTS
WG-FSA-91/4	STATE OF WATER STRUCTURE AS A FACTOR DETERMINING FISH BEHAVIOUR (AT THE EXAMPLE OF KOSMONAVTOV AND SODRUZHESTVA SEAS) B.G. TROTSENKO *et al.* (USSR)
WG-FSA-91/5	ANALYSES CARRIED OUT DURING THE 1990 MEETING OF THE WORKING GROUP ON FISH STOCK ASSESSMENT Secretariat
WG-FSA-91/6	ON THE PROBLEM OF ICEFISH (*CHAMPSOCEPHALUS GUNNARI*) VERTICAL MIGRATION ON THE SOUTH GEORGIA SHELF J.A. FROLKINA AND V.I. SHLIBANOV (USSR)
WG-FSA-91/7	REPRODUCTION IN THE MACKEREL ICEFISH (*CHAMPSOCEPHALUS GUNNARI*) AT SOUTH GEORGIA I. EVERSON *et al.*
WG-FSA-91/8	FEEDING OF NINE ANTARCTIC FISH SPECIES AND THEIR DAILY RATION EVALUATIONS Ye. A. Pakhomov and V. B. Tseitlin (USSR)
WG-FSA-91/9	BIOLOGY AND HARVESTING OF *DISSOSTICHUS ELEGINOIDES* AROUND KERGUELEN ISLAND (DIVISION 58.5.1) G. Duhamel (France)
WG-FSA-91/10	REGIONAL CATCH ANALYSIS OF THE LONGLINE FISHERY OF *DISSOSTICHUS ELEGINOIDES* (PISCES: NOTOTHENIIDAE) IN CHILE Christian Lemaitre *et al.* (Chile)

WG-FSA-91/11 HOOK SELECTIVITY IN THE LONGLINE FISHERY OF *DISSOSTICHUS ELEGINOIDES* (NOTOTHENIIDAE) OFF THE CHILEAN COAST
Carlos A. Moreno (Chile)

WG-FSA-91/12 WORKING GROUP PERFORMANCE
Secretariat

WG-FSA-91/13 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 Marschoff and Esteban Barrera-Oro (Argentina)

WG-FSA-91/14 FISH STOCK ASSESSMENT SURVEY IN SUBAREA 48.3
I. Everson *et al.*

WG-FSA-91/15 STOCK ASSESSMENT OF THE MACKEREL ICEFISH, *CHAMPSOCEPHALUS GUNNARI* (LÖNNBERG, 1906) IN SUBAREA 48.3 FOR THE 1991/91 SEASON, USING VIRTUAL POPULATION ANALYSIS
G. Parkes (UK)

WG-FSA-91/16 THE UK FISH STOCK ASSESSMENT SURVEY BOTTOM TRAWL FOR SOUTH GEORGIA
G. Parkes (UK)

WG-FSA-91/17 AGE/LENGTH KEY FOR *CHAMPSOCEPHALUS GUNNARI* 1990/91 FALKLANDS PROTECTOR SURVEY JANUARY/FEBRUARY 1991
UK/Poland/Germany

WG-FSA-91/18 AGE/LENGTH KEY FOR *CHAMPSOCEPHALUS GUNNARI* FROM SOUTH GEORGIA; HILL COVE SURVEY, JANUARY 1990
G. Parkes (UK)

WG-FSA-91/19 REPRESENTATIVE LENGTH AND AGE DISTRIBUTIONS FROM RANDOM STRATIFIED DEMERSAL FISH SURVEYS
G. Parkes (UK)

WG-FSA-91/20 STOCK ASSESSMENT OF THE PATAGONIAN TOOTHFISH (*DISSOSTICHUS ELEGINOIDES*) AT SOUTH GEORGIA
I. Everson (UK)

WG-FSA-91/21 A SHORT TECHNICAL CHARACTERISTIC OF BOTTOM TRAWLS USED IN SURVEYS IN THE SOUTH GEORGIA AND SHAG ROCKS AREAS IN THE 1988/89, 1989/90 AND 1990/91 SEASONS
W. Moderhak and Z. Cielniaszek (Poland)

WG-FSA-91/22 GENETIC POPULATION STRUCTURE OF THE MACKEREL ICEFISH, *CHAMPSOCEPHALUS GUNNARI*, IN ANTARCTIC WATERS
G.R. Carvalho and M. Warren (UK)

WG-FSA-91/23 ASSESSMENT OF THE STOCKS OF ABUNDANT FISH SPECIES IN THE SOUTH GEORGIA SUBAREA (48.3) MADE ON THE BASIS OF DATA OBTAINED FROM THE RV *ATLANTIDA* TRAWL SURVEY OF APRIL/MAY 1991
V.I. Shiblanov *et al.* (USSR)

WG-FSA-91/23 Rev. 1 ASSESSMENT OF THE STOCKS OF ABUNDANT FISH SPECIES IN THE SOUTH GEORGIA SUBAREA (48.3) MADE ON THE BASIS OF DATA OBTAINED FROM THE RV *ATLANTIDA* TRAWL SURVEY OF APRIL/MAY 1991
V.I. Shiblanov *et al.* (USSR)

WG-FSA-91/24 ASSESSMENT OF THE *DISSOSTICHUS ELEGINOIDES* STOCK IN SUBAREA 48.3 FOR THE 1990/91 SEASON AND CALCULATION OF TAC FOR THE 1991/92 SEASON
P.S. Gasiukov *et al.* (USSR)

WG-FSA-91/25 A SIMULATION STUDY OF THE METHOD OF REFINING THE NATURAL MORTALITY COEFFICIENT WITH *CHAMPSOCEPHALUS GUNNARI* IN SUBAREA 48.3 USED AS AN EXAMPLE
P.S. Gasiukov and R.S. Dorovskikh (USSR)

WG-FSA-91/26 ON ASSESSING THE SIZE OF THE HUMPED ROCKCOD STOCK (*NOTOTHENIA GIBBERIFRONS*) IN SUBAREA 48.3
P.S. Gasiukov (USSR)

WG-FSA-91/27 ASSESSMENT OF THE STATUS OF THE *CHAMPSOCEPHALUS GUNNARI* STOCK IN THE SOUTH GEORGIA AREA FOR THE 1990/91 SEASON AND TAC CALCULATIONS FOR THE 1991/92 SEASON
P.S. Gasiukov (USSR)

WG-FSA-91/28 WITHDRAWN - SEE DOCUMENT SC-CAMLR-X/10

WG-FSA-91/29 FOOD AND FEEDING OF THE MACKEREL ICEFISH (*CHAMPSOCEPHALUS GUNNARI*) AROUND SOUTH GEORGIA IN JANUARY/FEBRUARY 1991
K.-H. Kock *et al.*

WG-FSA-91/30 TEMPERATURE AS A CAUSE OF VARIATION IN STANDING STOCK ESTIMATES OF FISH AROUND SOUTH GEORGIA
I. Everson and S. Campbell (UK)

WG-FSA-91/31	NEW AND DEVELOPING FISHERIES - COMMENTS BY WG-KRILL AND WG-CEMP Secretariat
WG-FSA-91/32	CCAMLR OBSERVATION SCHEME - COMMENTS BY WG-KRILL AND WG-CEMP Secretariat
WG-FSA-91/33	INFORME DE LA CAMPAÑA ESPAÑOLA DE EVALUACION DE LOS STOCKS DE PECES DE ORCADAS DEL SUR ('ANTARTIDA 9101') E. Balguerías (España)
WG-FSA-91/34	A BRIEF DESCRIPTION OF THE 1991 *DISSOSTICHUS ELEGINOIDES* FISHERY D.J. Agnew and M. Perchard (Secretariat)
WG-FSA-91/35	POTENTIAL NURSERY AREAS FOR FISH IN THE PRYDZ BAY REGION R. Williams (Australia)
WG-FSA-91/36	REPORT ON THE POLISH CATCHES AND BIOLOGICAL INVESTIGATIONS OF *CHAMPSOCEPHALUS GUNNARI* FROM COMMERCIAL CRUISE OF FV *LEPUS* IN SOUTH GEORGIA AND SHAG ROCKS AREAS DURING 1990/91 SEASON R. Zaporowski and I. Wojcik (Poland)
WG-FSA-91/37	ICHTHYOLOGICAL INVESTIGATION BY FIXED GEARS IN TERRA NOVA BAY (ROSS SEA) - SPECIES LIST AND FIRST RESULTS M. Vacchi *et al.* (Italy)

OTHER DOCUMENTS:

CCAMLR-X/6	NEW AND DEVELOPING FISHERIES Executive Secretary
CCAMLR-X/7	CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION Executive Secretary
CCAMLR-X/BG/9	CHOICE OF A PROCEDURE FOR DECIDING CLOSURE OF CCAMLR FISHERIES: A SIMULATION MODEL Secretariat

SC-CAMLR-X/8	A PROPOSAL FOR THE FORMATS FOR OBSERVATIONS BY OBSERVERS ON COMMERCIAL FISHING VESSELS IN THE CCAMLR AREA Secretariat
SC-CAMLR-X/BG/2	CCAMLR DATABASES AND DATA AVAILABILITY Secretariat
SC-CAMLR-X/BG/4	INCIDENTAL CATCH OF SEABIRDS IN TRAWL FISHERIES Delegation of New Zealand
SC-CAMLR-X/BG/8	REPRODUCTIVE PERFORMANCE, RECRUITMENT AND SURVIVAL OF WANDERING ALBATROSSES *DIOMEDEA EXULANS* AT BIRD ISLAND, SOUTH GEORGIA Delegation of UK
SC-CAMLR-X/BG/12	REPRODUCTION IN ANTARCTIC NOTOTHENIOID FISH - A REVIEW Delegation of Germany
SC-CAMLR-X/BG/13	THE STATE OF EXPLOITED FISH STOCKS IN THE SOUTHERN OCEAN - A REVIEW Delegation of Germany
SC-CAMLR-X/BG/14	INCIDENTAL MORTALITY ARISING FROM FISHERIES ACTIVITIES AROUND KERGUELEN ISLAND (DIVISION 58.5.1) Delegation of France
WG-CEMP-91/16	INTERACTIONS OF ANTARCTIC MARINE MAMMALS AND BIRDS WITH FISHERIES K.-H. Kock (Germany)
WG-KRILL-91/25	BY-CATCH OF FISH IN THE KRILL FISHERY Inigo Everson (UK), Alexei Neyelov and Yuri Permitin (USSR)

APPENDIX D

DRAFT FORMS FOR DATA SUBMISSION

OBSERVER SUMMARY INFORMATION

OBSERVATION NUMBER: __________

OBSERVER DETAILS:

Name: ____________________________________

Nationality: ______ Flag State: ______________

Sponsoring Organisation: __________________

Dates of Observation: from ___ to __________

Location of Boarding: _____________________

Location of Debarkation: ___________________

VESSEL DETAILS:

Name of Vessel: __________________________________

Port of Registration: ______________________________

Call Sign: ____________ Cruise Number: _________

Vessel Type: _________ Fitted Gear: _____________

Size (GRT): __________ Length (LOA): __________

Area, Subarea(s) Covered: _________________________

On Board Acoustic Equipment: ____________________

Haul No. or Set No.* (HN)	Sample No.** (SN)	Date and Time of Start	Coordinates	Water Temp.	Weather	Fishing Gear	Mesh Size (if applic.)	Target Species	Bottom Depth	Fishing Depth Min-Max (m)	Duration of Fishing	Duration of Searching	Total catch (kgs)	Catch of various species (kgs)

* A sample is not necessary for each haul or set

** Haul number for trawl and set number for longline

FORMAT 1

KRILL SAMPLE SUMMARY INFORMATION

OBSERVATION NUMBER: ____________

Name of Vessel: ________________________ Cruise Number: ______________ Area, Subarea: _______________

Target Species: _________________________

Sample No. (SN)	Date	Coordinates	Fishing Gear	Trawl No. (HN)	Total Catch (kgs)	Catch of Target Species (kgs)	Duration of Fishing	Trawl Depth Max-Min (m)

(continued)

Total Size (mm)						Number of Specimens	Mean Length (mm)	Total Sample Weight (grams)	Mean Weight (grams)	Notes
25	26	27	...	61	62					

FORMAT 2

KRILL SIZE, WEIGHT, FEEDING INTENSITY AND MATURITY

OBSERVATION NUMBER: __________
HAUL NUMBER: ____________
SAMPLE NUMBER: __________

Area: ________________________ Catch Location: ______________________________
Date: ________________________ Station Number: ______________________________
Fishing Gear Used: ____________ Start Fishing: _________ End Fishing: __________
Trawling Depth (m): ___________ Total Catch and Catch-per-hour Trawling: _________
Water Temperature: ___________ Wind: ___________ Swell: _______________
Sample No.: _______________

(a) Krill Number and Weight

Sample No. ....

	Length								Total
	21	22	23	24	...	...	63	64	
Juveniles (no. of specimens)									
Juveniles (weight in grams)									
Males (number)									
Males (weight in grams)									
Females (number)									
Females (weight in grams)									
Total									

(b) Krill Colouration

Sample No.: ....

Group	I-Y			II-LG			III-G			IV-DG			V-D		
Subgroup	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Juvenile (no.)															
Males (no.)															
Females (no.)															
Total															
%															

Note: (a) Liver colour - Y=yellow; LG=light green; G=green; DG=dark green; D=dark.
(b) Krill colour - A=red; B=pink; C=yellow or colourless.

(c) Krill Feeding Intensity

Sample No.: ....

Mean Krill Length (mm)	Sex	Section of Gastro-intestinal Tract	Degree of Stomach/Intestine Fullness (Number of krill in each category)					Mean Degree of Fullness
		Stomach	0	1	2	3	4	
		K1						
		K2						
		K3						
		K4						

(d) Individual Krill Maturity Stage Determination

Sample No.: ....

Males				
Measurement No.	Length (mm)	Maturity of Petasma	Presence of Spermatophore	General Stage of Maturity

Females					
Length (mm)	Maturity Telichum	Shape of Stern Plate	Shape of Pre-anal Spine	Thorax Condition	Presence of Spermatophore

(continued) Females

Presence of Sperm Sac	Spawn Maturity	Ovary Maturity	General Stage of Maturity	Notes

FORMAT 3

SUMMARY OF KRILL MATURITY BY SIZE

OBSERVATION NUMBER: __________
HAUL NUMBER: __________
SAMPLE NUMBER: __________

Area, Subarea: ______________ Coordinates: ______________ Vessel: ____________________ Station: ________________
Year: _______________________ Month: ____________________ Day of the Month: _________
Duration of Trawling: _______ Trawl Depth: ______________ Catch: _____________________

		Number of Krill by Size												
Sex	Stage of Maturity	25-26 (mm)	27-28 (mm)	29-30 (mm)						61-62 (mm)	63-64 (mm)	Total	%	Mean Length (mm)

FORMAT 4

OBSERVATIONS OF BIRDS, MAMMALS AND BY-CATCH SPECIES

OBSERVATION NUMBER: ________

							Species				Observations		
Date	Time	Haul No. or Set No. if Fishing	Depth of Water	Surface Water Temp.	Coordinates	Trawling/ Steaming	Bird Species	Mammal Species	Incidental Mortality Birds and Mammals (species and no. caught)	By-catch Fish Species	Quantity Observed	Direction of Movement	Notes

FORMAT 5

LENGTH AND MATURITY OF FINFISH

OBSERVATION NUMBER: __________

HAUL NUMBER: __________

SAMPLE NUMBER: __________ SPECIES: __________

Length				Total
Male		Female		
Length	No.	Length	No.	
20				
...				
...				
65				

Maturity				Total
Male		Female		
Maturity	No.	Maturity	No.	
1				
...				
...				
6				

FORMAT 6

AGE/LENGTH KEY AND AGE-BASED DATA FOR FINFISH

OBSERVATION NUMBER: ___________

HAUL NUMBER: ___________

SAMPLE NO.: ___________ SPECIES: ___________

Age	Maturity Stage - Males						Maturity Stage - Females						Total	Mean Weight	
	1	2	3	4	5	6	1	2	3	4	5	6		Males	Females

Length	Age							Total	Mean Weight
	1	2	....	....	....	15	16+		
20									
21									
...									
...									
60									

FORMAT 7

ADDITIONAL EFFORT DETAILS FOR LONGLINE OPERATION

OBSERVATION NUMBER: ___________

Set No.: __________ No. of Hooks: _____________ Type of Line: _________________ Length of Line: _______________

Size of Hooks: ____ Spacing of Hooks (cm): _____ Type of Bait: _________________

Set Times: from (h/m) ____ /____ to ____ /____ (h/m) ____ /____ Hauled Times: from (h/m) ____ /____ to (30) (h/m) ____ /____

Height above Bottom (m): __________________

APPENDIX E

DATA REQUIREMENTS FOR THE WORKING GROUP

I Data Required by WG-FSA-90	II Data Received by WG-FSA	III Data Required by WG-FSA-91
1. *D. eleginoides* Subarea 48.3 commercial data required (length and biological) Fine-scale data required	Length data: Oct, Nov, Jan, Apr, May. No ALK 1990 Research data only Fine-scale data not reported	Length and age data from *D. eleginoides* in Subarea 48.3. Continued requirement from historical fishery
2. Data on size selectivity of longline fishery for *D. eleginoides* in Subarea 48.3	No information	Data on size selectivity of longline fishery for *D. eleginoides* in Subarea 48.3
3.		*D. eleginoides,* Subarea 48.3: • length and age data in WG-FSA-90/34 and 91/24 should be submitted (paragraph 8.4) • changes to 5-day reporting to include vessel days and number of hooks (paragraph 8.3)
4. Report *E. carlsbergi* as *E. carlsbergi* rather than Osteichthyes nei Fine-scale data from Convention Area and areas north of convergence requested	No information on areas north of the convergence	Report *E. carlsbergi* catches from north of convergence (paragraph 8.9)
5. Biological data from historical catches of *E. carlsbergi* requested Fine-scale data requested	Fine-scale data not available 1989	Biological data from commercial catches (paragraph 8.9)
6.		*E. carlsbergi,* Subarea 48.3: • description of operations (CCAMLR-IX, paragraph 4.27) • details of by-catch (paragraph 8.9) • full reporting of existing biological and survey data (paragraph 8.9)
7. Representative length-frequency from the commercial catch of *C. gunnari* in Subarea 48.3 should be reported for recent years	No information	Representative length-frequency from the commercial catch of *C. gunnari* in Subarea 48.3 should be reported for recent years (paragraph 8.9)
8.		*C. gunnari* Subarea 48.3: • quantitative information on by-catch in midwater and demersal fisheries (paragraph 8.10) • reports from past surveys should be submitted in detail • research data should be submitted to Secretariat (paragraph 8.10)
9. Biological information on incidental catch of *N. rossii* in Subarea 48.3	No information	Biological information on incidental catch of *N. rossii* in Subarea 48.3
10. Length and age, *N. squamifrons*, Subarea 48.3 - commercial data	Research data only	Length and age, *N. squamifrons*, Subarea 48.3 - commercial data for past years (paragraph 7.17)

I	II	III
11. Commercial age and length data for *N. gibberifrons* Subarea 48.3	No data	Commercial age and length data for *N. gibberifrons*
12. *C. gunnari* and *N. gibberifrons* length and age data, Subarea 48.2 Research survey data	USSR research data on *N. gibberifrons* and *C. gunnari* length frequencies, 1989	-
13. Fine-scale catches of *P. antarcticum*, Subarea 58.4	Yes 1978 to 1989	-
14. Catches reported as *C. gunnari* from Division 58.4.2 should be *C. wilsoni*	Fine-scale data submitted and STATLANT adjusted by Secretariat	-
15. STATLANT catches of *N. squamifrons* reported from Division 58.4.4 should be corrected to agree with those in WG-FSA-90/37 Catches should be reported for Ob and Lena Banks	No information	*N. squamifrons*, Division 58.4.4 • statlant catches should be corrected to agree with those in WG-FSA-90/37 • catches should be reported for Ob and Lena Banks in fine-scale format (paragraph 8.15). • commercial age and length data should be submitted to Secretariat
16. Age/length data from catches of *C. gunnari* in Division 58.5.1 prior to 1980	No data	Age/length data from catches of *C. gunnari* in Division 58.5.1 prior to 1980
17.		Commercial length and age data for the *D. eleginoides* trawl and longline fisheries in Division 58.5.1 (paragraph 8.13)
18. Various data from *N. squamifrons* in Division 58.5.1: • length and ALK data • catch data separated for Division 58.5.1 • data consistency	No data	*N. squamifrons*, Division 58.5.1 • length and ALK data • catch data separated for Division 58.5.1 • data consistency
19. Reports requested from *Slavgorod*, *Borispol*, *Passat 2* fishing in October 1989 (SC-CAMLR-VIII, paragraph 3.7)	No information	Reports requested from *Slavgorod*, *Borispol*, *Passat 2* fishing in October 1989 (SC-CAMLR-VIII, paragraph 3.7)
20. Want haul-by-haul information from research vessel surveys and experimental fisheries	Haul-by-haul data reported by Spain, UK, not by USSR	Want haul-by-haul information from research vessel surveys and experimental fisheries
21. An increase in availability of biological data from commercial catches (general)	Very few data from commercial catches	-
22. Information on levels of discarding and conversion rates from fish products to nominal weight are required	No information	Information on levels of discarding and conversion rates from fish products to nominal weight are required

INPUT DATA FOR THE VPA OF *CHAMPSOCEPHALUS GUNNARI*, TUNED USING THE METHOD OF LAUREC-SHEPHERD TO SURVEY AND CPUE INDICES

Run 1:

M = 0.48
Ages 1 to 6+
Years 1976/77 to 1990/91
Catch-at-age as in WG-FSA-91/15 with 1990/91 adjusted to account for a catch of 92 tonnes (Table 3)
Mean weights in Table 4
Maturity ogive in Table 5
Tuned to abundance indices in Table 6
Regression weighted according to inverse CV

Run 2:

M = 0.48
Ages 1 to 6+
Years 1976/77 to 1989/90
Catch-at-age as in WG-FSA-91/15 with 1990/91 adjusted to account for a catch of 92 tonnes (Table 3)
Mean weights in Table 4
Maturity ogive in Table 5
Tuned to CPUE indices in table 7
Regression weighted according to inverse CV

Table 1: Commercial catch-at-age, *C. gunnari*, South Georgia 1976/77 to 1990/91. Numbers of fish x 10^3 (WG-FSA-91/15).

Year	Age					
	1	2	3	4	5	6
1977	1	350	173 132	201 466	32 269	3 844
1978	2 899	59 909	4 866	3 528	1 082	593
1979	88	5 258	614	232	49	33
1980	1	39 008	14 350	4 930	903	573
1981	2 200	261 434	30 901	5 197	1 248	831
1982	12 716	264 956	53 952	33 271	7 766	5 666
1983	43 877	743 217	191 146	72 835	18 850	13 378
1984	9 853	702 144	881 88	23 282	1 176	155
1985	1 335	89 878	31 631	4 280	185	271
1986	3 849	83 462	12 127	6 738	712	115
1987	6 920	207 120	276 940	19 310	4 210	700
1988	8 600	12 420	70 060	35 510	25 160	6 850
1989	10 250	128 890	14 470	9 180	11 490	2 310
1990	240	6 195	31 920	1 967	96	1
1991	2	215	242	86	4	2

Table 2: Mean weight-at-age (kg) for the stock and in the catch for all years, 1976/77 to 1990/91 (Anon., 1990a).

Age:	1	2	3	4	5	6
Mean weight (kg)	0.029	0.083	0.169	0.284	0.421	0.575

Table 3: Maturity ogive for all years 1976/77 to 1990/91 (Anon., 1990a).

Age:	1	2	3	4	5	6
Proportion mature	0	0.5	0.65	0.75	0.75	0.75

Table 4: Standardised survey abundance indices, number of fish x 10^3, 1986/87 to 1990/91 for **M** = 0.48.

Year*	Effort	Age					
		1	2	3	4	5	6+
1987	100	21 325	382 233	255 150	21 466	2 796	410
1988	100	32 083	39 700	115 735	30 436	17 586	4 862
1989	100	474 160	213 813	53 045	29 936	15 235	3 355
1990	100	114 350	880 914	200 336	12 681	928	2 061
1991	100	241 636	68 550	53 919	22 595	1 324	437

* References:

1986/87	SC-CAMLR-VI/BG/12 Rev. 1
1987/88	SC-CAMLR-VII/BG/23
1988/89	WG-FSA-89/6
1989/90	WG-FSA-90/11 Rev. 1
1990/91	WG-FSA-91/14

Table 5: Standardised effort indices and catch at age for *C. gunnari* in Subarea 48.3 (effort from WG-FSA-90/27).

		Age					
Year	Effort	1	2	3	4	5	6+
1981	14 142	2 200	261 434	30 901	5 197	1 248	31
1982	7 182	12 716	264 956	53 952	33 271	7 766	5 666
1983	20 420	43 877	743 217	191 146	72 835	18 850	13 378
1984	15 798	9 853	702 144	88 188	23 282	1 176	155
1985	2 984	1 335	89 878	31 631	4 280	185	271
1986	4 483	3 849	83 462	12 127	6 738	712	115
1987	20 035	6 920	207 120	27 6940	19 310	4 210	700
1988	15 941	8 600	124 20	70 060	35 510	25 160	6 850
1989	7 972	10 250	128 890	14 470	9 180	11 490	2 310
1990	1 497	217	5 610	28 902	1 781	87	1

APPENDIX G

DELURY METHOD OF CALCULATING INITIAL STOCK SIZE OF *DISSOSTICHUS ELEGINOIDES* FROM A CPUE SERIES

The Chapman formulation of the deLury analysis was applied to *D. eleginoides* in Subarea 48.3 by considering population growth by month and assuming that initially the population existed under conditions of replacement recruitment.

Replacement recruitment $R = N_1(1-e^{-m})$

where $\mathbf{N_1}$ = initial population size
$\mathbf{m}$ = monthly natural mortality = M/12

Numbers at month 1,2,3...t are

N1

$N_2 = N_1e^{-m}+R-C_1$
$= N_1e^{-m}+N_1(1-e^{-m})-C_1$
$N_3 = N_2e^{-m}+N_1(1-e^{-m})-C_2$
$= [N_1e^{-m}+N_1(1-e^{-m})-C_1]e^{-m}+N_1(1-e^{-m})-C_2$
$= N_1[e^{-2m}+(1-e^{-m})e^{-m}+(1-e^{-m})]-C_1e^{-m}-C_2$
$= N_1-Ce^{-m}-C_2$

If **D** is defined such that
$D_{t+1} = D_te^{-m}+C_t$ then
$N_t = N_1-D_t$ (1)
Now Catch = N.q.Effort and therefore C/E = CPUE = N.q
Multiplying (1) by q
$qN_t = CPUE_t = qN_1-qD_t$ (2)

therefore a regression of **D** against CPUE will have intercept $\mathbf{qN_1}$, and slope **q**, enabling initial population size to be calculated by

N_1 = intercept/slope

These calculations were performed for populations starting in July 1989 and July 1990, yielding the results in Table 7 of this report.

APPENDIX H

CALCULATIONS FOR ASSESSMENT OF TOTAL DEMERSAL CATCH, SUBAREA 48.3 (AGNEW AND KOCK)

1. Catch from Subarea 48.3 by Poland by bottom trawl:

	Total	SSI	SGI	NOG	NOS	ANI	TOP	SRX
1980	11 692	1 084	665	7 274		753	255	218
1981	17 656	1 272	1 661	4 949		9 166	71	74
1982	8 324	676	956	970		4 446		1
1985	5 709	1 042	1 097	1 583		389	88	16
1986	3 926	504	156	463		2 506	29	16
1987	1 952	221	72	211	26	1 397		
1988	1 630	198	319	202	112	784	15	
1989	8				4			

Calculated ratios of: SSI/SGI/NOG/ANI

1980	1/0.613/6.7/0.695
1981	1/1.31/3.89/7.21
1982	1/1.41/1.44/6.57
1985	1/1.05/1.52/0.373
1986	1/0.31/0.92/4.97
1987	1/0.33/0.96/6.32
1988	1/1.61/1.02/3.96

For NOG, 1980 and 1981 were years of high but declining stock size. For ANI, 1980 and 1985 were abnormally low ratios. These years have been left out of the following calculations.

Mean ratios taken over 1980 to 1988 for SSI, SGI; 1982 to 1988 for NOG; 1981, 1982 and 1986 to 1988 for ANI.

1/0.947/1.17/5.8

2. Calculations of MSY using Table 2 of Beddington and Cooke (1983):

	NOG	SSI	SGI
TOTAL UNEXPLOITED BIomass	42 000[1]	18 000[1]	44 000[2]
Age of recruitment	4[1]	6[1]	3[2]
K	0.15[3]	0.20 - 0.30[2]	0.527[2]
M	0.125[1]	0.3[2]	0.4[2]
λ^4	0.035	0.118 - 0.127	0.18
MSY (biomass x λ)	1 470	2 124 - 2 286	7 920

Values from WG-FSA-91/5, 90/6, Kock *et al.* 1985

1 WG-FSA-91/5
2 WG-FSA-90/6
3 Kock *et al.*, 1985
4 Table 2 of Beddington and Cooke, 1983

SSI	*C. aceratus*	ANI	*C. GUNNARI*
SGI	*P. GEORGIANUS*	TOP	*D. eleginoides*
NOG	*N. gibberifrons*	SRX	Rajiformes spp.
NOS	*N. squamifrons*		

APPENDIX I

DETAILS OF CALCULATIONS OF BIOMASS ESTIMATES FROM THE RESEARCH CRUISE 'ANTARTIDA 9101' IN SUBAREA 48.2

Depth (m)	Subarea 48.2	*Champsocephalus gunnari*				
		Region A[1]		Region B[2]	Total	
		All Catches	High Catches Excluded		All Catches	High Catches Excluded
50-150	Nº hauls	9		12	21	21
	X (kg/0.021 nm²)	1.864		3.107	2.493	2.493
	SD	1.270		1.635	1.038	1.038
	CV (%)	68		53	42	42
	DM (t/nm²)	0.089		0.148	0.119	0.119
	BME (t)	38		65	104	104
	Extension (nm²)	431		441	872	872
150-250	Nº hauls	17	16	24	41	40
	X (kg/0.021 nm²)	118.119	60.605	2.248	52.696	27.655
	SD	61.323	22.649	0.482	26.700	9.865
	CV (%)	52	37	21	51	36
	DM (t/nm²)	5.625	2.886	0.107	2.509	1.317
	BME (t)	2672	1371	66	2738	1437
	Extension (nm²)	475	475	616	1091	1091
250-500	Nº hauls	14	13	52	66	65
	X (kg/0.021 nm²)	566.420	137.996	10.392	21.627	12.970
	SD	432.669	65.316	3.405	9.358	3.588
	CV (%)	76	47	33	43	28
	DM (t/nm²)	26.972	6.571	0.495	1.030	0.618
	BME (t)	3587	874	3191	6799	4065
	Extension (nm²)	133	133	6494	6582	6582
Total (50-500)	Nº hauls	40	38	88	128	126
	X (kg/0.021 nm²)	127.280	46.145	9.296	23.642	13.776
	SD	62.078	13.319	2.927	7.974	3.039
	CV (%)	49	29	31	34	22
	DM (t/nm²)	6.061	2.197	0.443	1.126	0.656
	BME (t)	6297	2283	3323	9620	5606
	Extension (nm²)	1039	1039	7506	8545	8545

1 60°20'S - 61°00'S (see figure in this appendix)
46°00'W - 47°00'W
2 Remaining area (see figure in this appendix)
X Mean biomass in 0.021 nm ^{2} (corresponding to a 30 minute haul)
SD Standard deviation of the mean
CV Coefficient of variation
DM Mean density
BME Mean trawlable biomass

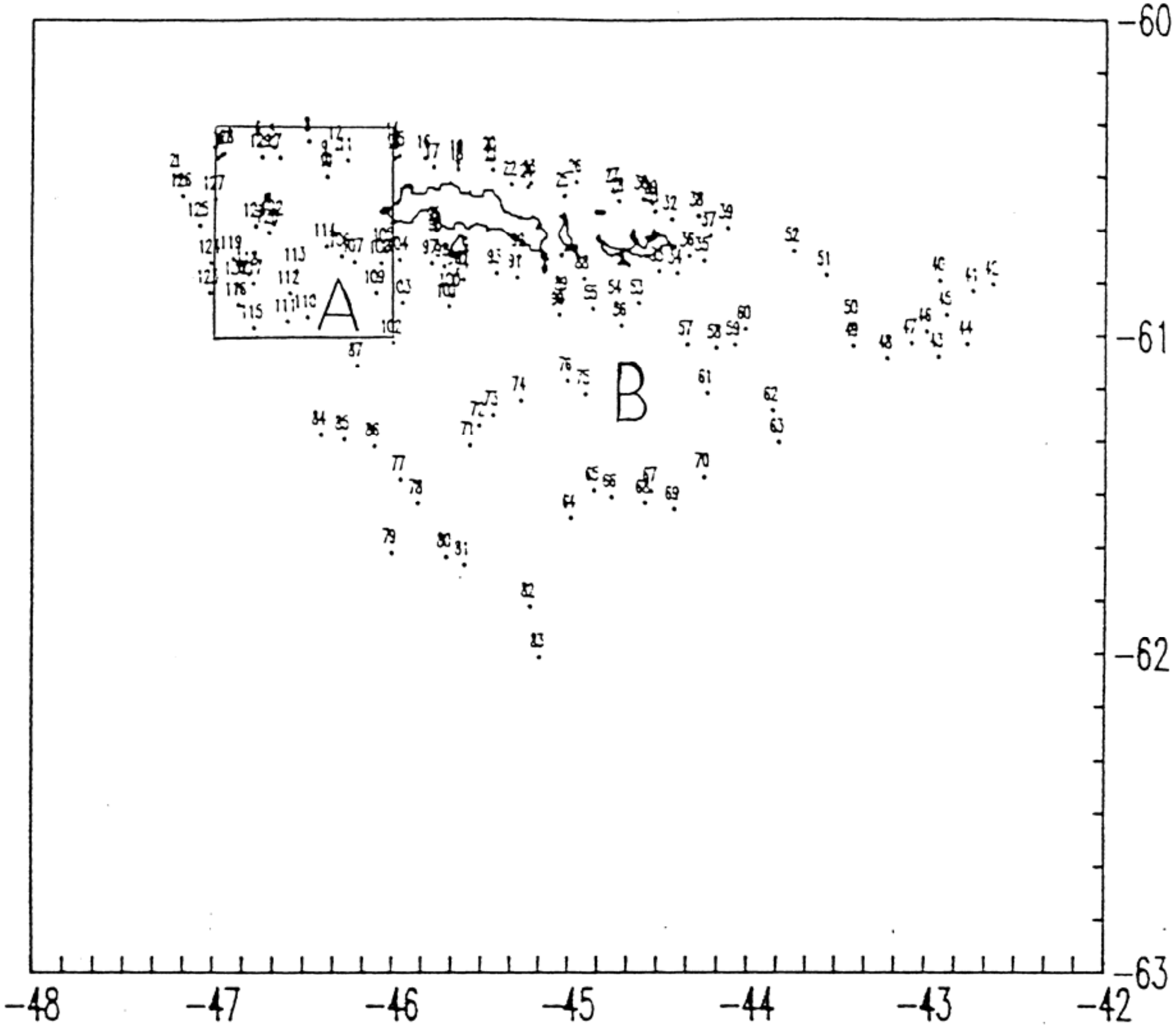

Figure I.1: Location of hauls - 'ANTARTIDA 9101'.

APPENDIX J

1991 ASSESSMENT SUMMARIES

Assessment Summary: *Notothenia rossii*, Subarea 48.3

Source of Information: This Report

Year	1986	1987	1988	1989	1990	1991	Max[2]	Min[2]
Recommended TAC					0			
Agreed TAC					300	300		
Landings	70	216	197	152	2	1	24897	1
Survey Biomass		11471[a] 1634[b]	1699	2439	1481[a] 3915[b] 3900[b]	4295[c] 10022[d]		
Surveyed by		Spain[a] USA/POL[b]	USA/POL	UK/POL	UK/POL[a] USSR[b]	UK[c] USSR[d]		
Sp. Stock Biomass[3]			No information					
Recruitment (age...)			available					
Mean **F** (.....)[1]			since 1985/86					

Weights in tonnes, recruits in ....

1 ···weighted mean over ages (...)
2 Over period 1981 to 1991
3 From VPA using (..........)

Conservation Measures in Force: 2/III, 3/IV, 20/IX

Catches:

Data and Assessment:

Fishing Mortality:

Recruitment:

State of Stock: Although survey biomass estimates indicate slightly higher stock than previous years, the stock is still at a very low level.

Forecast for 1991/92:

Option Basis	1991 **F**	1991 SSB	1991 Catch	1992 **F**	1992 SSB	1992 Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Champsocephalus gunnari*, Subarea 48.3

Source of Information: This Report

Year	1986	1987	1988	1989	1990	1991	Max[2]	Min[2]
Recommended TAC			31500	10200	12000			
Agreed TAC			35000	- [4]	8000	26000		
Landings	11107	71151	34619	21359	8027	92	128194[6]	7592
Survey Biomass		159283	15716	22328[5]	149598[a]	26204[a]		
					442168[b]	192144[b]		
Surveyed by		Spain	USA/POL	UK/POL	UK/POL[a]	UK[a]		
					USSR[b]	USSR[b]		
Sp. Stock Biomass[3]								
Recruitment (age...)								
Mean **F** (.....)[1]								

Weights in tonnes

1 ... weighted mean over ages (...)
2 Over period 1981 to 1991
3 From VPA using (..........)
4 Prohibition from 4 November 1988
5 Standard estimate from Appendix D
6 Maximum catch in 1983

Conservation Measures in Force: 19/IX, 20/IX, 21/IX, 25/IX

Catches: Poland 41 tonnes (commercial)
UK 3 tonnes (research)
USSR 49 tonnes (research)

Data and Assessment: Commercial length data in WG-FSA-91/36. VPA assessments tuned to commercial effort and survey abundance indices in WG-FSA-91/27 and WG-FSA-91/15.

Fishing Mortality: Very low **F** in 1990/91.

Recruitment: Uncertainty regarding current strength of 1987/88 year class. Survey reported in WG-FSA-91/14 shows high proportion of 1 year olds. Subject to significant uncertainty, indications of a large decline since 1989/90.

State of Stock:

Forecast for 1991/92:

Option Basis	1991			1992			Implications/ Consequences
	F	Stock	Catch	**F**	Stock	Catch	
CPUE tuned $\mathbf{F_{0.1}}$ **M** = 0.48				0.39	236779	61870	Could lead to serious over-exploitation if stock status is accurately assessed by survey tuned VPA
Survey tuned $\mathbf{F_{0.1}}$ **M** = 0.48				0.39	41834	9672	

Weights in ‘000 tonnes

Assessment Summary: *Patagonotothen guntheri*, Subarea 48.3

Source of Information: This Report

Year	1986	1987	1988	1989	1990	1991	Max[2]	Min[2]
Recommended TAC				-	-	20-36000		
Agreed TAC				13000	12000	0		
Landings	16002	8810	13424	13016	145	0	36788[4]	5029
Survey Biomass		81000				584[a] 16365[b]		
Surveyed by		Spain				UK[a] 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 1981 to 1991

3 From VPA using (..........)

4 Maximum catch in 1989

Conservation Measures in Force: 23/IX

Catches:

Data and Assessment:

Fishing Mortality:

Recruitment:

State of Stock: Unknown

Forecast for 1991/92:

Option Basis	1991 **F**	1991 SSB	1991 Catch	1992 **F**	1992 SSB	1992 Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Dissostichus eleginoides*, Subarea 48.3

Source of Information: This Report

Year	1986	1987	1988	1989	1990	1991	Max[2]	Min[2]
Recommended TAC					-			
Agreed TAC					-	2500[5]		
Landings	564	1199	1809	4138	8311	3843	8311	109
Survey Biomass		1208	674	326	9631*[a] 335+[a] 1693*[b] 3020+[b]			
Surveyed by		USA/POL[4]	USA/POL[4]	UK/POL[4]	POL/UK[a] USSR[b]			
Stock Biomass[3]					20745 - 435817			
Recruitment (age...)					na			
Mean **F** (.....)[1]					na			

Weights in tonnes

1 ... weighted mean over ages (...)
2 Over period 1981 to 1991
3 Estimated from cohort projections
4 Survey excluding Shag Rocks
5 TAC from 1 November 1990 to 2 November 1991
* Shag Rocks
\+ South Georgia

Conservation Measures in Force: 24/IX, 26/IX

Catches: Before TAC 1 440 and under TAC 2 394 = 3 834 tonnes.

Data and Assessment: Two assessments presented by members (WG-FSA-91/20 and 24). Both methods subject to criticism. No haul-by-haul data. STATLANT B data and some length frequency data.

Fishing Mortality: Insufficient information.

Recruitment: WG-FSA-91/20 suggest large number of 2 year olds in 1989/90 but very low number of 3 year olds in 1990/91 (bottom trawl survey).

State of Stock: Very uncertain (range about 14 000 - 609 000). CPUE suggests stock is NOT increasing.

Forecast for 1991/92: Suggested catch levels range 400 to 11 000 tonnes.

Option Basis	1991 **F**	1991 SSB	1991 Catch	1992 **F**	1992 SSB	1992 Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Notothenia gibberifrons*, Subarea 48.3

Source of Information: This Report

Year	1986	1987	1988	1989	1990	1991	Max[2]	Min[2]
Recommended TAC								
Agreed TAC								
LANDINGS	1678	2844	5222	838	11	3	11758	0
SURVEY BIOMASS	0	1400	7800	8500	17000	25000		
SURVEYED BY		USA	USA	UK	UK USSR	UK USSR		
Sp. Stock Biomass[3]	4200	4700	4300	3300	4300	6200	18800	3300
Recruitment (age 2)	25000	24000	24000	21000	27000	25000	27000	13000
Mean **F** (.....)[1]	0.19	0.36	0.86	0.54	0.014	0.0002	0.95	0.0

Weights in tonnes
1 Weighted mean over ages 2 to 16
2 Over period 1975/76 to 1990/91
3 From VPA using survey q = 1 model

Conservation Measures in Force: 22/IX

Catches: Low in recent years due to low fishing effort.

Data and Assessment: VPA analysis tuned to survey biomass estimates treated as measures of absolute biomass.

Fishing Mortality: Low in recent years due to low fishing effort.

Recruitment: Stable.

State of Stock: Increasing. Current biomass roughly one half of virgin level.

Forecast for 1991/92:

Option Basis	1992			1993			Implications/ Consequences
	F	SSB	Catch	F	SSB	Catch	
$\mathbf{F_{0.1}}$, survey q = 1 model	$\mathbf{F_{0.1}}$ = 0.0935	7700	1400	$\mathbf{F_{0.1}}$ = 0.0935	9300	1600	conservative option
$\mathbf{F_{0.1}}$, survey q □ 1 model	$\mathbf{F_{0.1}}$ = 0.0935	9000	5000	$\mathbf{F_{0.1}}$ = 0.0935	20000	8000	riskier option

Weights in tonnes

Assessment Summary: *Chaenocephalus aceratus*, Subarea 48.3

Source of Information: This Report

Year	1986	1987	1988	1989	1990	1991	Max[2]	Min[2]
Recommended TAC				1100	0	300		
Agreed TAC				0	300	300		
Landings	504	339	313	1	2	2	1272	1
Survey Biomass		8621	6209	5770	14226[a] 14424[b] 17800[b]	13474[c] 18022[d]		
Surveyed by		USA/POL	USA/POL	UK/POL	UK/POL[a] USSR[b]	UK[c] USSR[d]		
Sp. Stock Biomass[3]	3006	4179	4156	4404	5098[4]			
Recruitment (age 2)	6573	5375	8648	6717	4047[4]			
Mean **F** (.....)[1]	0.19	0.17	0.13	0.002				

Weights in tonnes, recruits in '000s

1 ... weighted mean over ages 3 to 11

2 Over period 1981 to 1991

3 From VPA using revised VPA from WG-FSA-90/6

4 Predicted

Conservation Measures in Force: 20/IX, 22/IX

Catches: The only catches in 1990 and 1991 were research catches since the fishery was closed by Conservation Measure 22/IX.

Data and Assessment:

Fishing Mortality:

Recruitment:

State of Stock: Current stock size is increasing slowly and has recovered to 80 to 90% of its initial level.

Forecast for 1991/92:

Option Basis	1991			1992			Implications/ Consequences
	F	Biomass	Catch	**F**	SSB	Catch	
$\mathbf{F_{0.1}}$					1300-1800	1757[1]	

Weights in tonnes

1 Adjusting the value calculated by WG-FSA-90 by a factor of 1.1 as a consequence of the difference in biomass estimates.

Assessment Summary: *Pseudochaenichthys georgianus*, Subarea 48.3

Source of Information: This Report

Year	1986	1987	1988	1989	1990	1991	Max[2]	Min[2]
Recommended TAC				1800	0	300		
Agreed TAC					300	300		
LANDINGS	156	120	401	1	1	2	1661	1
SURVEY BIOMASS		5520	9461	8278	5761[A] 12200[B] 10500[B]	13948[C] 9959[D]		
SURVEYED BY		USA/POL	USA/POL	UK/POL	UK/POL[A] USSR[b]	UK[C] USSR[d]		
Sp. Stock Biomass[3]	3758	5498	8090	8889[4]				
Recruitment (age 1)	1819 7	4337	1372					
Mean **F** (.....)[1]	0.08	0.09	0.15					

Weights in tonnes, recruits in '000s

1 ... weighted mean over ages 3 to 6

2 Over period 1981 to 1991

3 From VPA described in WG-FSA-90/6

4 Predicted

Conservation Measures in Force: 20/IX, 22/IX

Catches: The only catches since 1989 have been research catches.

Data and Assessment:

Fishing Mortality:

Recruitment:

State of Stock: The stock has increased slowly over the last few years and is now about 30% of its initial level.

Forecast for 1991/92:

Option Basis	1992 **F**	 SSB	 Catch[1]	Implications/ Consequences
$\mathbf{F} = \mathbf{F_{0.1}}$		10000-14000	4756	
$\mathbf{F}$ = 50% $\mathbf{F_{0.1}}$		10000-14000	2717	

Weights in tonnes

1 Adjusting the value calculated by WG-FSA-90 by a factor of 1.33 as a consequence of the difference in biomass estimate.

Assessment Summary: *Notothenia squamifrons*, Subarea 48.3

Source of Information:

Year	1986	1987	1988	1989	1990	1991	Max[2]	Min[2]	Mean[2]
Recommended TAC					0	300			
Agreed TAC					300	300			
Landings	41	190	1553	927	0	0	1553	0	563
Survey Biomass		13950	409	131	1359[a] 534[b]				
Surveyed by		USA/POL	USA/POL	UK/POL	UK/POL[a] USSR[b]				
Sp. Stock Biomass[3]									
Recruitment (age...)									
Mean **F** (.....)[1]									

Weights in tonnes, recruits in ....

1 ... weighted mean over ages (...)

2 Over period 1981 to 1991

3 From VPA using (..........)

Conservation Measures in Force: 20/IX, 22/IX

Catches:

Data and Assessment:

Fishing Mortality:

Recruitment:

State of Stock: No new information on this stock is available.

Forecast for 1991/92:

Option Basis	1991 **F**	1991 SSB	1991 Catch	1992 **F**	1992 SSB	1992 Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Electrona carlsbergi*, Subarea 48.3

Source of Information:

Year	1986	1987	1988	1989	1990	1991	Max[2]	M-in[2]	Mean[2]
Recommended TAC	-	-	-	-	-	-	-	-	-
Agreed TAC	-	-	-	-	-	-	-	-	-
Landings	1187	1102	14868	29673	23623	78488			
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 1981 to 1991

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: Nil (But see CCAMLR-IX, paragraph 4.27).

Catches: Threefold increase in catch from 1989/90 to 1990/91. Fishery takes mostly juvenile fish (2 year olds).

Data and Assessment: WG-FSA-90/21 and 23 for biomass yield-per-recruit analysis.

Fishing Mortality: 0.64 (to give around 50% escapement to spawning stock).

Recruitment: Unknown.

State of Stock: Total biomass large compared with cumulative catch.

Forecast for 1991/92:

Option Basis	1991 **F**	1991 Exploitable Biomass	1991 Catch	1992 **F**	1992 Exploitable Biomass	1992 Catch	Implications/ Consequences
50 percentile	0.64	1200[1]	398	0.64	1200	398	Preliminary
5 percentile	0.64		245			245	
50 percentile	0.64	160	53.0	0.64	160	53.0	TACs
5 percentile	0.64		32.7			32.7	

Weights in '000 tonnes

1 Assume that 1987/88 survey estimates the exploitable stock in the current years. Exploitable stock assumed to be 100% of 2 year olds and 20% of 3 year olds.

Assessment Summary: *Notothenia rossii*, Division 58.5.1

Source of Information: This Report

Year	1986	1987	1988	1989	1990	1991	Max[2]	Min[2]	Mean[2]
Recommended TAC									
Agreed TAC									
Landings	801	482	21	245	155	287	9812	21	2531
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 1981 to 1991

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:

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1991/92:

Option Basis	1991 **F**	1991 SSB	1991 Catch	1992 **F**	1992 SSB	1992 Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Notothenia squamifrons*, Division 58.5.1

Source of Information: This Report

Year	1986	1987	1988	1989	1990	1991	Max[2]	Min[2]	Mean[2]
Recommended TAC									
Agreed TAC		5000	2000	2000[4]					
Landings	2464	1641	41	1825	1262	89	11308	41	4057
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 1981 to 1991

3 From VPA using (..........)

Conservation Measures in Force: Catch limits set since 1987 (French/Soviet agreement). Conservation Measures 2/III; Arrêté 20 and 32.

Catches:

Data and Assessment:

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1991/92: CPUE very low - maximum = 0.63 tonnes per hour.

Option Basis	1991			1992			Implications/ Consequences
	F	SSB	Catch	**F**	SSB	Catch	

Weights in tonnes

Assessment Summary: *Champsocephalus gunnari*, Division 58.5.1

Source of Information: This Report

Year	1986	1987	1988	1989	1990	1991	Max[2]	Min[2]	Mean[2]
Recommended TAC									
Agreed TAC									
Landings (Skif Bank)	0	2625	2	0			2625	0	578
Landings (Kerguelen)	17137	0	157	23628		12644	25848	0	9784
Landings (Combined)					226				
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 1981 to 1991

3 From VPA using (..........)

Conservation Measures in Force: Conservation Measure 2/III; Arrêté 20; Conservation Measure as for *N. rossii* TACs set under French-Soviet Agreement.

Catches: Mainly in north-eastern part of shelf (normal fishing grounds).

Data and Assessment:

Fishing Mortality: Assumed between 0.42 and 0.49 (from cohort analysis of previous cohorts).

Recruitment: A strong cohort was recruited in the 1990/91 season.

State of Stock: The strong cohort should remain into the 1991/92 season, and catches should remain high. However there appears to have been a steady decrease in the strength of successive cohorts.

Forecast for 1991/92:

Option Basis	1991			1992			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	1986	1987	1988	1989	1990	1991	Max[2]	Min[2]	Mean[2]
Recommended TAC									
Agreed TAC									
Landings	459	3144	554	1630	1062	1848	6677	40	1304
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 1981 to 1991

3 From VPA using (..........)

Conservation Measures in Force: None

Catches: 288 tonnes caught by Soviet trawlers on usual grounds
1 560 tonnes caught by French trawler on new grounds
109 tonnes caught by Soviet longliner

Data and Assessment:

Fishing Mortality:

Recruitment:

State of Stock: Uncertain. New grounds may or may not be exploiting the same stock as the usual grounds. Longlining appears to exploit the same stock as the trawl fishery. CPUE appears to have declined steadily since 1985.

Forecast for 1991/92:

Option Basis	1991 **F**	1991 SSB	1991 Catch	1992 **F**	1992 SSB	1992 Catch	Implications/ Consequences

Weights in tonnes
Total catches should be limited to 1 100 tonnes until more is known.

Assessment Summary: *Notothenia squamifrons*, Division 58.4.4

Source of Information: This Report

Year	1986	1987	1988	1989	1990	1991	Max[2]	Min[2]
Recommended TAC (Lena Bank)								
Agreed TAC								
Landings (Ob Bank[a])*	9531	1601	1971	913				
Landings (Lena Bank[a])*	1977	441	2399	3003				
Landings (Combined[b])	61	930	5302	3360	1450	575	5302	27
Survey Biomass (Ob Bank)				12700				
Survey Biomass (Lena Bank)								
Surveyed by				USSR				
Sp. Stock Biomass[3]					na			
Recruitment (age...)					na			
Mean **F** (.....)[1]								

Weights in tonnes, recruits in ....

1 ... weighted mean over ages (...)

2 Over period 1985 to 1991

3 From VPA using (..........)

* Calendar Year data

a From WG-FSA-90/37

b From SC-CAMLR-IX/BG/2 Part 2 (Statistical Bulletin)

Conservation Measures in Force: 2/III, 4/V, 28/IX.

Catches: Catches were nearly identical to the TACs. A third set of historical catch data were inconsistent with the previous two reported.

Data and Assessment: Data are unreliable but latest catch figures are 7% greater than those used for VPA and TAC calculation at WG-FSA-90. Therefore TAC was probably overestimated.

Fishing Mortality:

Recruitment:

State of Stock: Almost certainly depleted.

Forecast for 1991/92:

Option Basis	1991 **F**	1991 SSB	1991 Catch	1992 **F**	1992 Biomass	1992 Catch	Implications/ Consequences
$\mathbf{F_{0.1}}$ Ob Bank	0.17			0.13	2949	267	
$\mathbf{F_{0.1}}$ Lena Bank	0.47			0.13	3454	305	

Weights in tonnes

A low or zero catch should be taken.

REPORT OF THE WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM

(Santa Cruz de Tenerife, Spain, 5 to 13 August 1991)

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INTRODUCTION

1.1 The Sixth Meeting of the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP) was held at the Instituto Español de Oceanografía, Santa Cruz de Tenerife, Spain from 5 to 13 August 1991. The meeting was chaired by the Convener, Dr J.L. Bengtson (USA).

1.2 The Convener, on behalf of the Working Group, expressed thanks to the Government of Spain for inviting the Working Group to hold its meeting in Santa Cruz de Tenerife and appreciation to the hosts at the Instituto Español de Oceanografía for arranging such a pleasant and efficient meeting venue.

1.3 The Convener opened the meeting and welcomed participants. Scientists from 10 Member countries attended the meeting and a special word of welcome was extended to Dr S. Focardi (Italy) since he was the first scientist from Italy to attend a WG-CEMP meeting.

1.4 It was noted with regret that several Members, namely Argentina, Brazil and Chile, actively engaged in monitoring approved CEMP parameters had not sent scientists to the meeting. It was also noted that scientists from France, Germany, New Zealand and South Africa, all of whom have programs of research highly relevant to CEMP, including studies of monitored parameters, were not present.

ADOPTION OF THE AGENDA

2.1 The Provisional Agenda was introduced and discussed. A revised Agenda was adopted with the addition of three items: 7.5 ‘CCAMLR Scheme of International Scientific Observation’, 7.6 ’New and Developing Fisheries’ and 9. ‘Summary of Recommendations and Advice to the Scientific Committee’.

2.2 The Agenda is attached as Appendix A, a List of Participants is given in Appendix B and documents submitted for consideration at the meeting are listed in Appendix C.

2.3 Rapporteurs were Drs D. Agnew (Secretariat), P. Boveng (USA), I. Everson (UK), K. Kerry (Australia) and J. Croxall (UK).

REVIEW OF MEMBERS' ACTIVITIES

3.1 The Convener called attention to the substantial amount of monitoring and directed research being conducted by Members in support of CEMP. Summaries of these activities are given in Tables 1, 2 and 3.

3.2 Information in Table 2 (directed research on the assessment of potential predator parameters) has been accumulating for several years. The Working Group felt that the format and content of Table 2 no longer provided a convenient summary of work undertaken or a useful guide to the likely availability of data on or advice concerning these additional parameters.

3.3 The Secretariat was asked to prepare a new version of Table 2 which would summarize the data on each parameter collected and analyzed by each Member in each year and allow the inclusion of references to publications describing results of the analyses. The Secretariat would circulate intersessionally a draft version of this new Table 2 soliciting comments and especially references to the sources of the published information and circulate the updated table in advance of the Working Group meetings.

3.4 Scientists present at the meeting provided brief reports on recent and prospective activities as part of CEMP. Written reports also were received from German and New Zealand scientists. These reports are attached at Appendix D.

MONITORING PROCEDURES

Predator Monitoring

Sites and Species

4.1 The Working Group considered a draft management plan for the protection of the CEMP site at the Seal Islands, South Shetland Islands (WG-CEMP-91/7). This plan was submitted under the Commission's formal guidelines (Conservation Measure 18/IX). The Working Group reviewed those aspects which related specifically to monitoring and agreed that with the inclusion of minor revisions the proposal adequately provided the information specified by the Commission. The Working Group noted however that there were aspects with legal implications, such as permits, disposal of waste and the restriction of activities, which would be more appropriately addressed by the Scientific Committee and the Commission.

4.2 The Working Group recommended that the revised proposal be reviewed by the Scientific Committee at its 1991 meeting.

Proposals for New Procedures

4.3 At its 1990 meeting the Working Group accepted a proposal to include the gentoo penguin (*Pygoscelis papua*) in the list of species designated for monitoring. Dr Croxall had been requested to provide descriptions of changes to the Standard Methods that would be necessary for monitoring gentoos. The proposed changes were presented to the Working Group as WG-CEMP-91/6.

4.4 The Working Group accepted the changes proposed in WG-CEMP-91/6. It was agreed that additional comments on these methods, especially details relating to gentoo studies at South Georgia and the Antarctic Peninsula, should be collated by Dr Croxall and passed to the Secretariat. In the interim WG-CEMP suggests modifying Method A9 to include a subsample of nests from several colonies to quantify the well documented, asynchronous breeding chronology of gentoo penguins.

4.5 It was noted that the Standard Methods document was expensive to publish and that it might be most efficient to issue occasional addenda between less frequent editions of the full document. The Secretariat agreed to complete an analysis of the costs of alternative formats for addenda and to report to the Working Group.

4.6 It was recommended that the comments and any relevant interim advice on existing monitoring sites, species, parameters and procedures should be circulated by the Secretariat (together with appropriate supporting documents), separately from the Scientific Committee report, to all Members and specifically to the investigators undertaking the CEMP studies.

Standard Methods for Penguins

4.7 The Working Group reviewed the methods for monitoring predator parameters set out in Standard Methods for Monitoring Studies (CEMP, 1991). No changes were made to the Methods A3, A6 and A7. Comments on and changes to other parameters are set out below.

Standard Method A1:
Adult Weight on Arrival at Breeding Colony

4.8 This method requires that the sex of birds be determined at the time of weighing and that a discriminant analysis of morphometric parameters (e.g. bill length and depth) be used to determine sex. Studies reported in WG-CEMP-91/5 show, however, that determination of the sex of Adélie penguins at the time of arrival remains a problem because discriminant analysis of morphometric parameters could not be used realistically to determine sex in Adélie penguins if a better than 90% success rate is required (at Béchervaise Island, 89% of birds could be correctly sexed by comparing the discriminant score: D = 0.582 (bill length) + 1.12 (bill depth) + 0.219 (flipper width), with a mean discriminant score (MDS) of 55.39). The paper recommended that a correct MDS be determined separately for each site by a single operator.

4.9 The probability of correctly identifying the sex of birds can be increased by avoiding those with a discriminant score close to the mean. However, to be >90% certain of sex using this method, 80% of the total measured sample would have to be discarded. The Working Group agreed that such discarding would introduce an unacceptable bias into the results of monitoring.

4.10 The Working Group agreed that the only practical method to positively identify the sex of Adélie and chinstrap penguins at first arrival was by cloacal examination. It was noted, however, that considerable practice is required to achieve a level of competence in this technique.

4.11 Members were encouraged to investigate whether Method A1 would retain sufficient power to detect changes if the sexes were pooled for this parameter.

4.12 Alternative methods for sexing Adélie penguins are provided in paragraphs 4.22 to 4.24.

Standard Method A2: Duration of First Incubation Shift

4.13 Preliminary evidence from several sources suggests that for Adélie penguins, the duration of the first incubation shift may not be strongly related to prey availability (e.g. results of Dr L. Davis's (New Zealand) research). Dr W. Trivelpiece (USA) indicated that for Adélie penguins annual variations in this parameter may be related to variations in distance to the pack-ice edge.

Standard Method A4:
Age-Specific Annual Survival and Recruitment

4.14 Dr Croxall presented evidence of substantial variation in mate and nest-site fidelity of gentoo and macaroni penguins at South Georgia (WG-CEMP-91/20). Low return rates were caused by extensive non-breeding as well as mortality. Those results imply that several years of resighting effort may be required before concluding that a banded bird has died.

Standard Method A5: Duration of Foraging Trips

4.15 The Working Group considered a study by US investigators of the effects of radio-telemetry transmitters on foraging behaviour and reproductive success of chinstrap penguins (WG-CEMP-91/33). No significant effects of the transmitters on parameters such as foraging trip and visit durations were found, in contrast to a previous study (WG-CEMP-90/21) that used larger transmitters. There were, however, significant differences in reproductive success that may have been caused by transmitters and/or handling during attachment.

4.16 The question of whether one or both adults per nest should be instrumented was discussed. Because of the possibility that attaching instruments to both members of a pair may increase the probability of nest failure (WG-CEMP-91/33), and the likelihood that the foraging patterns of paired birds during the guard stages are not independent, the Working Group advised that pending further studies of this issue, only one member of each pair should be instrumented with a radio transmitter for this parameter.

4.17 It was noted that there may be chronic effects on birds carrying instruments for long periods. Members were encouraged to continue efforts to detect and minimize deleterious effects of procedures used for CEMP research. Those efforts could include investigation of new technologies such as the implanted passive inductance transmitters now being tested by Australian investigators.

Standard Method A8: Chick Diet

4.18 The Working Group noted that data submitted to CEMP for this method should be based on a consistent sample size at least as large as that suggested in the Standard Methods.

Standard Method A9: Breeding Chronology

4.19 It was noted that WG-CEMP-91/29 presents analytical techniques for sampling distribution over time and that such techniques might reduce the work involved in characterizing the breeding chronology and choosing critical dates for calculation of indices. Members were encouraged to consider during the intersession period whether the procedures described in WG-CEMP-91/29 might be applicable to CEMP studies.

Standard Methods B1 to B3: Flying Birds

4.20 Dr Croxall hoped that a paper on black-browed albatross demography would be available at the next meeting of the Working Group. The analytical methods for this species are very similar to those presented previously for wandering albatross.

Standard Methods for Seals

4.21 A study by UK scientists of Antarctic fur seal foraging/attendance cycles in relation to pup growth (WG-CEMP-91/24) found that despite significant differences between years in the duration of both foraging trips and periods ashore, neither proportion of time spent at sea nor pup growth rates showed significant differences between years (and the latter did not relate significantly to foraging trip duration). In neither year did maternal age or size influence foraging cycles or pup growth. These results indicate the potential importance of assessing aspects of foraging performance in addition to quantifying trip duration.

Determining the Sex of Penguins

4.22 The Working Group agreed that the only way to positively identify the sex of Adélie penguins was from behaviour during copulation or by cloacal examination during the first half of the breeding cycle (i.e. until hatching). At later times cloacal sexing becomes increasingly difficult. The methods for cloacal sexing are referenced in WG-CEMP-91/5.

4.23 Dr Trivelpiece pointed out that weighing each member of the pair after the laying of the first egg can also be used to determine sex as the male is always heavier. Additionally, within pairs, males have larger culmens than females; however, neither weight nor bill measurements can be used to distinguish sex of birds in the colony as a whole.

4.24 Dr Kerry noted in WG-CEMP-91/31 that at Béchervaise Island a period could be identified when in excess of 97% of birds at nest sites are males and another period when a similar percentage of females are present. Thus observation at these times will identify the male or female bird. Since the breeding cycle of Adélie penguins is highly synchronous it is probable that the dates at which the incubating birds will be one sex or the other will be consistent from year to year for a specific site. This, however, needs to be tested.

Future Proposals for Potential Sites, Species and Parameters

4.25 The Working Group agreed that any future proposals for inclusion of new species, parameters or sites in CEMP should be submitted in writing to the Secretariat by 30 June each year. Such proposals should contain reasons and supporting evidence for their inclusion.

4.26 The results of UK investigations of aspects of foraging performance (during trips to sea in the breeding season) of gentoo penguins and fur seals were presented (WG-CEMP-91/18, 19 and 23). Both WG-CEMP-91/18 and 23, in addition to data on dive depth and duration, review several variables connected with foraging and diving. Estimates of proportion of trip spent diving, and dive rate are given for different categories of dive and within and without objectively defined bouts of intense diving activity. In addition, for fur seals, transit time (including time submerged) can be estimated allowing potential foraging time to be calculated. Many of these variables may have significance as potential indices of foraging performance in the context of CEMP studies. This work will be especially relevant to the proposed workshop evaluating such parameters.

Processing/Analysis Methods

4.27 At its 1990 meeting the Working Group agreed that in order to facilitate its annual evaluation of status and trends of predator parameters, indices of monitored parameters would have to be calculated from the data available at the CCAMLR Data Centre. Analyses based on these indices would then be considered for the formulation of advice to the Scientific Committee.

4.28 The Secretariat had prepared WG-CEMP-91/8 which suggested a rationale and methodology for the calculation of indices. There was broad support for this approach in the Working Group.

4.29 A subgroup composed of Drs Agnew (Convener), Bengtson, Boveng, Croxall, Kerry, Naganobu, Penhale and Trivelpiece was formed to review the methods of calculating these indices and the presentation of the results to the Working Group. The subgroup reviewed document WG-CEMP-91/8 with particular reference to technical comments from Dr P. Rothery (UK) given in WG-CEMP-91/36.

4.30 To reduce the number of individual indices presented to the Working Group, it was recommended that data be combined to calculate summaries by site. If any further divisions of the data are required, these should proceed following consideration of special features of the data especially as noted by the originators of the data.

4.31 Several problems were noted concerning the indices suggested for Parameter A6 ‘breeding success’. Although it was recognized that any single summarising index will lose information if it ignores separated data on the numbers of pairs rearing 0, 1 and 2 chicks, the *ad hoc* approach suggested by WG-CEMP-91/8 or WG-CEMP-91/36 should be followed until further investigation of analytical techniques is performed.

4.32 The subgroup noted that in WG-CEMP-91/8 Method 1(a) combines samples with the same underlying distribution. Dr Agnew explained that the weighting in Method 1(b) is necessary to accompany the weighting of means in CEMP Methods A1 and A7. It was agreed that these methods were adequate for the time being.

4.33 The arcsin transformation of the proportions of crustaceans in the chick diet parameter (A8) is a commonly used transformation for these sorts of data. Comparisons should be made using the transformed indices, and the back-transformed numbers should be used only as a reference.

4.34 Based on the recommendations of the subgroup, the Working Group agreed that:

(i) indices should be calculated by the Secretariat using the methods described by WG-CEMP-91/8;

(ii) a document describing the methods of calculation of indices, with worked examples of calculations, should be prepared by the Secretariat for review at the next meeting of WG-CEMP. The source code (e.g. in FORTRAN) used by the Secretariat to compile indices should also be distributed for testing and corroboration by the CCAMLR community;

(iii) a summary of the calculated indices and trends in indices should be presented by the Secretariat to the Working Group each year, starting at the next meeting of the Working Group, utilising all data held at the CCAMLR Data Centre (following the annual reporting deadline of 30 June). These data should be presented in two forms:

(a) a concise summary of all data including a description of what data have been submitted by Members and calculation of the specified indices; and

(b) a summary of changes and trends in parameters between years, and between colonies, sites and species as appropriate.

(iv) Members are encouraged to perform analyses of their own data, and those held by CCAMLR, with a view to refining the methods of calculating indices so that they better fit the criteria described on page 3 of WG-CEMP-91/8 and the requirements of the Working Group.

Reporting Formats and Requirements

4.35 The importance of reporting CEMP predator data on the latest version of reporting forms was emphasized. Representatives of the Scientific Committee were requested to ensure that scientists from their countries use the correct data submission form.

4.36 The CEMP data submissions received from Members have generally been easy to understand. The most common problems were with the 'split-year' entry on all forms (the second year in a split-year should be used as the designator) and with the five-day period definitions (the standard periods described in Appendix 2 of the Standard Methods should be used).

4.37 The Data Manager noted that for Method A5 (Duration of Foraging Trip), the information requested in Category C of the present data sheet is not ideally suited to the calculation of indices (WG-CEMP-91/8) which use only data from Category B. Members were encouraged to propose improved analytical procedures concerning indices for Method A5.

4.38 It was agreed that the Secretariat has the authority to make minor changes to data submission formats as appropriate.

4.39 The purpose of the Standard Methods is to obtain data and incorporate them into indices that can be easily compared between sites, but it was recognized that on occasion it may not be possible to follow the methods exactly. There was some discussion concerning whether Members should submit data that had been collected in a way that did not follow precisely the Standard Methods. It was noted that initially it is up to investigators to judge whether their data have been collected by methods that do not deviate substantially from the Standard Methods.

4.40 For example, sample sizes specified in the Standard Methods should be viewed as guidelines (usually minimum); if they are not achieved, it may reduce the power of the data to detect change, but the data can still be compared with other years or sites. In contrast, there is less flexibility in most other technical aspects of the methods. Using different techniques or collecting different types of data other than those specified will reduce the comparability of results with other CEMP data.

4.41 The degree to which the Standard Methods are followed by individual investigators will become increasingly important now that indices are being calculated and compared among sites and years. Given that the data will be scrutinized closely to detect potential methodological inconsistencies, investigators should be prepared to provide an acceptable explanation of any deviations that were necessary from the procedures described in the Standard Methods. Data considered by the Working Group to have been collected using procedures inconsistent with the Standard Methods will be excluded from the calculations of indices.

Field Research Procedures

4.42 Dr Kerry indicated that efforts by Australia to develop and refine automated monitoring of Adélie penguins which include the use of implanted transmitters (WG-CEMP-90/24) are continuing to yield promising results. These studies will facilitate estimating rates of loss for standard flipper bands.

4.43 Dr Trivelpiece informed the Working Group of his investigations of the impact of research activities on penguins. A report on his results should be available in about one year.

4.44 It was noted that several participants have begun to document field research procedures on video, in response to last year's discussion of a need to standardize and compare procedural details that are difficult to portray in the Standard Methods (SC-CAMLR-IX, Annex 6, paragraph 85). A video prepared by Dr Kerry was made available for viewing during the meeting. It was agreed that this topic will remain open and participants should continue collecting documentation for a possible future workshop.

4.45 At its 1990 meeting, WG-CEMP noted that a Standard Method for activity budgets of birds and seals at-sea might be proposed in the future. It was agreed that it might be useful to hold a workshop to standardize sampling protocols, set-up of instruments used in these studies and subsequent data analysis (e.g. time-depth recorders (TDRs) and satellite transmitters) (SC-CAMLR-IX, Annex 6, paragraphs 88 and 89).

4.46 In response to a request from the Working Group, Dr Bengtson had written during the intersessional period to scientists active in this field to solicit their views on the utility of holding such a workshop. Scientists and manufacturers indicated broad support for holding such a workshop, and a summary of their responses was provided in WG-CEMP-91/27.

4.47 The Working Group agreed that the primary focus of such a workshop should be on new methods and technology rather than a symposium-style presentation of scientific results. Because of the importance of participation by scientists outside the working group (including scientists working in the Northern Hemisphere), it was agreed that there should be a general workshop (approximately three days) followed by a session focussing on the specific needs of CEMP (approximately two days).

4.48 The Working Group agreed that the general workshop would have the following terms of reference:

(i) to review the current state of the art regarding the design and deployment techniques;

(ii) to review the available information on the potential instrument effects on animals;

(iii) to review the existing data collection, processing, and analytical methods and the compatibility of these within and between various devices and species;

(iv) to identify appropriate procedures for analysing the data sets of at-sea behaviour produced by TDRs and satellite-linked instruments; and

(v) to assess whether indices of at-sea activity, suitably standardized for use in routine monitoring operations (e.g. as part of CEMP), can be derived from the data currently being collected on behaviour of seals and seabirds.

4.49 It was agreed that the general workshop should seek to produce a report of workshop discussions, including summaries of various technical reviews of data collection, definitions of dive record components, analytical approaches, and hardware.

4.50 The Working Group agreed that the two-day session focussing on the specific needs of CEMP should have the following terms of reference:

(i) to advise on the most suitable indices for monitoring the at-sea behaviour of pinnipeds and penguins; and

(ii) to propose draft standard methods for collecting, processing, analysing and submitting summaries of such data to CCAMLR.

4.51 The Working Group feels that holding a workshop on methods to monitor the at-sea behaviour of penguins and pinnipeds is worthwhile and should be scheduled for the earliest feasible opportunity. However, it noted that scheduling the workshop in the near future is complicated because:

(i) the calendar for the remainder of 1991 and most of 1992 (aside from the field season) is filled with meetings already scheduled;

(ii) although an at-sea behaviour workshop is important, the Working Group agreed that the proposed workshop to estimate the prey requirements of predators should be given higher priority; and

(iii) given the scheduling realities described above, it would be difficult to hold an at-sea behaviour workshop before late 1993 or early 1994.

4.52 To prepare for a workshop in the future, the Convener was asked to undertake the following tasks with the assistance of other participants:

(i) to advise appropriate scientists of the responses received to the initial circular (i.e. WG-CEMP-91/27) and the decisions taken by WG-CEMP at this meeting;

(ii) to prepare an agenda within the terms of reference above;

(iii) to identify necessary preparatory tasks to accomplish the goals of the workshop;

(iv) to investigate sources of support to supplement CCAMLR funding that may be available for the conduct of the workshop and for the participation of selected key experts;

(v) to investigate potential venues and optimal scheduling for the proposed workshop;

(vi) to coordinate logistics for the workshop as the meeting date draws nearer; and

(vii) to report to WG-CEMP and to appropriate scientists regarding progress in preparing the workshop.

Prey Monitoring

Review of WG-Krill and Subgroup on Survey Design Reports

4.53 Dr Everson introduced the Report of the Working Group on Krill (WG-Krill) (Annex 5); that report also contained, as Appendix D, the Report of the Subgroup on Survey Design (SGSD). He outlined the main conclusion in both reports and then highlighted the topics of particular relevance to CEMP.

4.54 The total krill catch for the 1990/91 season was expected to be similar to that in previous years. However, WG-Krill, when considering the locations of fishing activities, had noted that a significant proportion of the krill catch in Subarea 48.1 had been taken from waters in the vicinity of penguin and fur seal colonies.

4.55 WG-Krill and SGSD had considered monitoring krill in support of CEMP predator studies and had provided outline survey designs at different scales, (Survey Designs 1 to 4 in Attachment 4 of Appendix D, Annex 5).

4.56 A specific design aimed at determining the availability of krill within the foraging range of penguins in the Antarctic Peninsula Integrated Study Region of CEMP to take into account predator parameter A5 (Foraging Trip Duration) was discussed. The design provides for a totally different layout of transects to that adopted as an interim approach last year (SC-CAMLR-IX, Annex 4, paragraph 100). However, other features such as time of day for sampling, and net tows to supplement acoustic data remain the same.

4.57 The design involved a series of regularly spaced parallel transects running offshore and perpendicular to the predominant currents. It was noted that the design assumed a reasonably straight coastline; different transect layouts would be required for other localities.

4.58 There was some discussion on the relative merits of a regular, as opposed to a random, spacing of transects. WG-CEMP agreed with conclusions provided by WG-Krill that regularly spaced transects offer advantages in analysing the data to obtain information on krill distribution. It was agreed that, on balance, this advantage outweighed the alternative advantage of statistical rigour of biomass estimates derived from randomly spaced transects.

4.59 In many cases, areas particularly close inshore are not well charted. It was recognized that this would pose problems for survey vessels and would almost certainly result in underestimates of the total krill available. It was noted that these inshore areas are not generally used for foraging by chinstrap and Adélie penguins, the species under consideration for the proposed design.

4.60 WG-CEMP agreed that, although aimed at predator parameter A5, the design outlined in Survey Design 1 could be used, with slight modification, for investigating krill distribution directly related to parameters A6, A7, A8, C1 and C2 because they integrate information over approximately the same spatial and temporal scales. Sufficient information was provided in the report to enable further surveys to be designed to cater for different situations. These modifications could be undertaken by those groups planning the field work.

4.61 WG-CEMP discussed the general principles outlined in Survey Design 3 to be used in designing surveys on a larger meso-scale. It was felt that for the present time, sufficient information had been provided from which designs for such surveys could be developed in association with CEMP prey monitoring.

4.62 Meso-scale surveys are also required around those restricted areas identified as having direct relevance to parameters A5 to A8, C1 and C2. WG-CEMP felt that surveys of this scale should be undertaken to provide information on the distribution, abundance and flux of krill. It was noted that this information was essentially on the same spatial and temporal scales as that required by WG-Krill to assess krill biomass.

4.63 The primary aim of meso-scale studies, for the time being, should be biomass estimation. It was recognized that in the future, attention will need to be paid to the distribution of krill within these meso-scale areas and that WG-CEMP would try to determine those aspects of greatest significance to support predator monitoring.

4.64 At the macro-scale, much would depend on the ability to understand the distribution of krill with respect to major environmental features such as sea-ice, oceanographic and atmospheric circulation. This topic was of particular interest to WG-CEMP in helping it interpret results from monitoring studies on predator parameters A1 to A4. On the macro-scale it was noted that there was much commonality between the spatial and temporal scales of interest to WG-CEMP and WG-Krill.

4.65 Because interpretation of predator indices will be facilitated by information on aggregation parameters as well as biomass, all the methods of acoustic data presentation outlined in SC-CAMLR-IX, Annex 4, paragraph 102 and Annex 5 of this report, paragraph 4.14 are of potential interest. However, it was accepted that a summary form of ping-by-ping data would be desirable.

4.66 WG-CEMP felt that the outline Survey Designs 2, 3 and 4 were all of value for designing surveys for prey monitoring in support of CEMP.

4.67 Several anomalies were noted in the summary of temporal and spatial scales for monitoring CEMP predator parameters (WG-CEMP-91/4). The Working Group provided corrections to this information; the revised tables are given in Appendix E.

4.68 WG-CEMP thanked WG-Krill and its Subgroup on Survey Design for the information provided in their reports. Responses to the questions posed by WG-Krill in paragraph 5.9 of its report are included in paragraphs 4.56 to 4.66 of this report.

Other Species

4.69 At its 1990 meeting, the Scientific Committee reiterated the requirement for the submission of fine-scale data for catches of *Pleuragramma antarcticum* in Subarea 58.4 (and especially in the Prydz Bay Integrated Study Region) (SC-CAMLR-IX, paragraph 5.20).

4.70 Dr K. Shust (USSR) informed the Working Group that Soviet scientists are presently completing papers concerning *P. antarcticum* catch rates, distribution, and demography from fine-scale surveys conducted from 1978 to 1989 in the Indian Ocean sector. It is anticipated that these reports will be made available to the 1991 meeting of the Working Group on Fish Stock Assessment (WG-FSA). It was noted that the fine-scale catch data requested by the Scientific Committee (SC-CAMLR-IX, paragraph 3.101) have been submitted to the Secretariat.

4.71 Dr Trivelpiece reported on studies near Palmer Station which indicated that the status of the south polar skua (*Catharacta maccormicki*) was closely linked to the availability of *P. antarcticum*, one of its principal prey items. There are plans to conduct annually a series of larval tows to assess the status of the *P. antarcticum* population as part of the Long-Term Ecological Research (LTER) program at Palmer Station. Since this work is of direct interest to CEMP, Dr Trivelpiece agreed to arrange for information on the LTER to be made available to WG-CEMP.

Environmental Monitoring

4.72 The Working Group reviewed the Standard Methods F1 (sea-ice as viewed from the colony), F3 (local weather) and F4 (snow cover in the colony) for monitoring environmental parameters which have a direct effect on predators. They were considered adequate. No additional requirements were proposed. It was noted that Members are required to archive their own data and that there is no requirement to submit data to the Secretariat at present.

4.73 It was noted that weather conditions prevailing at a monitoring site may in some instances be quite different from those at a nearby meteorological station. Members were encouraged to determine the degree of similarity of data collected locally and at nearby stations.

4.74 Detailed discussions were held over the provision of data required under Method F2 'Sea-Ice Within the Integrated Study Region'. Method F2 aims to determine the amount and characteristics of sea-ice within the Integrated Study Regions, and suggests for data collection:

(i) information on the regional distribution of sea-ice can only feasibly be obtained using remote sensing techniques. Sea-ice imagery is available from a number of satellites that pass over the Integrated Study Regions;

(ii) sea-ice data should be collected at least for the period beginning two to three weeks prior to the arrival of adult birds or seals, and should continue until counts indicate that most breeding adults have arrived. In addition, it may be desirable to consider sea-ice data obtained via satellite throughout the year; and

(iii) as feasible, it would be desirable to obtain data on sea-ice cover, extent, and type.

4.75 Dr Shust informed the Working Group that his institute was preparing detailed maps which show changes occurring in the macro-scale distribution of ice for the past five years over the whole of the Antarctic.

4.76 Dr R. Holt (USA) reported progress (see SC-CAMLR-IX, Annex 6, paragraph 112) on the analysis of satellite data from the Antarctic Peninsula Integrated Study Region. Of the approximately 500 images available over the past two years, some 300 had been examined for temperature, chlorophyll, cloud-cover and sea-ice conditions. Data will be presented at the next Working Group meeting.

4.77 At its meeting in 1990, WG-CEMP asked the Secretariat to investigate procedures for acquiring and archiving summary data on sea-ice distribution (Method F2) available from organisations which process and supply satellite imagery (SC-CAMLR-IX, Annex 6, paragraph 118).

4.78 The Secretariat in response prepared a paper (WG-CEMP-91/9) on the information and analytical techniques available for these data that would be of use in the routine monitoring of sea-ice distribution for CEMP. Dr Agnew presented the paper setting out details of satellite imagery available and presented options for acquisition of and presentation to the Working Group.

4.79 The Working Group agreed that the data requirements set out in Method F2 were still appropriate and that there were two scales over which the monitoring of sea-ice should be considered:

(i) CCAMLR subarea monitoring, which has particular relevance to parameters A1 to A4;

- spatial scale: over 100 km, including the whole area or subarea;
- spatial resolution: 1 to 50 km;
- temporal scale: several months or the whole year;
- temporal resolution: half-monthly to quarterly;

(ii) local monitoring, i.e. within the foraging range of land-breeding animals and relevant to parameters A5 to A8, C1 and C2;

- spatial scale: 25 to 150 km;
- spatial resolution: 50 m to 1 km;
- temporal scale: several months (e.g. November to March);
- temporal resolution: 5 to 30 days.

4.80 The most readily accessible satellite data that could be used to investigate ice distribution over the first scale (i), are the US Navy/NOAA Joint Ice Centre (JIC) weekly charts of circum-Antarctic ice extent, concentration, and type of ice in different parts of the Southern Ocean.

4.81 The Working Group noted that many sources of satellite imagery with a resolution of the second scale (ii) or better were available and include the NOAA Polar Orbiter, Landsat Multispectral Scanner (MSS), Landsat Thematic Mapper (TM), SPOT Multispectral Imager, Synthetic Aperture Radar (SAR) mounted on the European Research Satellite-1 (ERS1), Soyuzkarta Panchromatic Imager and the Soyuzkarta Multispectral Imager. The three satellites that have the highest temporal and spatial resolution are the NOAA Polar Orbiter, SPOT and ERS1. Whilst many of these satellites offer extremely high resolution (20 to 30 m) this is at the expense of temporal resolution because of the narrow swath widths that must be adopted by the satellite. High temporal resolution is especially important in the Antarctic where cloud-cover may obscure a given area for much of the time.

4.82 Furthermore, high resolution data (e.g. from MSS, SPOT or ERS1) are expensive and the purchasing agreements of the distribution companies mean that CCAMLR would have to purchase images directly from the company. The cost of images from MSS, TM, SPOT and ERS1 is US$200 or more per photographic image. Data from the NOAA Polar Orbiter, in particular from AVHRR (Advanced Very High Resolution Radiometry) are cheaper and available from organisations with a receiving or processing agreement with NOAA at a cost of around US$90 per image.

4.83 The Working Group therefore agreed that the most suitable and cost effective data would be those obtained from AVHRR. This type of imaging which has a spatial resolution of 1.1 km and repeat time of approximately 0.25 days, is the most commonly processed by several organisations, and is the most readily available.

4.84 For higher spatial resolution close to monitoring sites it was suggested that the use of aerial surveys, possibly conducted by aircraft performing regular fly-overs *en route* to re-supply Antarctic bases, would provide very high resolution photographs.

4.85 Several receiving stations for AVHRR data operate in the Antarctic Peninsula area, the principal being at Palmer Station on Anvers Island. This receiving station covers an area from approximately 30°W to 80°W. A receiving station will be installed soon at Casey Station which will access data from a 'window' covering some of the Prydz Bay area.

4.86 The Working Group therefore recommends:

(i) JIC weekly ice charts be used for monitoring of sea-ice conditions at large spatial scales (over 100 km, relevant to predator parameters A1 to A4 and larger considerations of prey distribution);

(ii) AVHRR data on sea-ice distribution, in fully processed image form be used for monitoring sea-ice conditions on smaller scales (25 to 150 km, with a frequency of five to ten days, relevant to predator parameters A5 and to prey monitoring surveys); and that

(iii) when available and needed, aerial photography rather than satellite imagery be used for monitoring of sea-ice conditions on much smaller scales (less than 50 m).

4.87 The Working Group discussed the classification of sea-ice data, and agreed that both first and second order interpretations as set out in the following table would be required.

	Type (i) Submissions JIC Antarctic Ice Extent Maps	Type (ii) Submissions AVHRR (or other) Imagery
Raw data storage	Hard copy of maps	Hard copy of images. Bit mapped images (pixels).
First order interpretation	Digitized sea-ice extent by subarea -outlines and extent of different ice types. Presentation to Working Groups as maps.	Digitized sea-ice extent boundaries and extent of different ice types. Presentation to Working Groups as maps.
Second order interpretation	Data on ice distribution parameters by subarea. Presentation to Working Groups as indices.	Data on ice distribution parameters by CEMP site. Presentation to Working Groups as indices.

4.88 Regarding the types of indices to be calculated, Dr Trivelpiece suggested that data collected should contain as a minimum the following elements: (i) maximum extent of ice cover; (ii) duration of ice cover; (iii) rate of retreat and advance past a given monitoring site; and (iv) distance from the site to the ice edge. Dr Croxall suggested that in the case of island sites this should include distance to the nearest ice edge when the island had open water all round.

4.89 The Working Group agreed that these parameters and those set out on page 8 of WG-CEMP-91/9 should be evaluated further, as appropriate, as part of a pilot study.

4.90 It was agreed that the only practical method of data acquisition would be for the Secretariat to obtain it by direct agreement with distributing organisations. This would remove the burden from Member organisations, eliminate the problem of copyright and ensure a regular supply of data. This approach has the added advantage that CCAMLR will own copies of the raw data which will enable many different analyses to be performed should these be required in the future.

4.91 It is understood that the acquisition of AVHRR images could be met by direct purchase of these images by the Secretariat from a number of organisations, including CSIRO, Australian Bureau of Meteorology, Scott Polar Research Institute or NOAA itself.

4.92 The Working Group agreed that it would be highly desirable to have the Secretariat obtain the necessary hardware and then on a trial basis obtain AVHRR images and process them for future examination by the Working Group. It is therefore recommended that a pilot study be conducted for two CEMP sites during a two-month period for which images would be obtained and processed every five days. The Working Group asked the Secretariat to prepare a detailed estimate of the expected costs for consideration by the Scientific Committee.

4.93 Pending evaluation of the pilot study, consideration should be given to expanding the number of sites and the period covered so that sea-ice data would be available for all relevant CEMP sites during the appropriate time of the year. Future costs associated with data acquisition would relate to the purchase of images only.

ECOSYSTEM ASSESSMENT

5.1 The Convener noted that WG-CEMP and the issues that it addresses have moved into a new phase. Over the past several years excellent progress has been made in identifying CEMP priorities, developing methodological protocols, and specifying data submission formats. Now that the Secretariat is receiving and archiving Members' CEMP data, the emphasis of the Working Group is shifting away from solely program development toward data evaluation and the formulation of advice to the Scientific Committee.

Predator Data

5.2 The Working Group emphasized that although methods for calculating indices had been established, insufficient data had been submitted to the CCAMLR Data Centre prior to the meeting to allow meaningful comparisons of calculated indices between years to be undertaken at the present meeting. However, it is anticipated that sufficient data will be available at the next meeting of WG-CEMP to allow consideration of predator indices and formulation of advice to the Scientific Committee.

5.3 To enable relevant data to be incorporated into annual summaries of CEMP predator data for calculating indices and for presenting results for the Working Group's consideration, Members were strongly encouraged to submit their data prior to the annual deadline of 30 June.

5.4 If they have not already done so, Members were encouraged to submit data that were previously reported as 'being prepared' (see Table 1 in SC-CAMLR-IX, Annex 6) and to submit other data collected in previous seasons as soon as possible. A list of CEMP monitoring data submitted prior to 30 June 1991 was presented in Appendix 2 of WG-CEMP-91/8. Data collected during the forthcoming 1991/92 field season are to be submitted to the Secretariat by 30 June 1992.

Prey and Environmental Data

5.5 Although standard sampling protocols for prey monitoring have not been adopted, and CEMP environmental monitoring methods do not provide detailed protocols, relevant data are available from directed research and surveys conducted under interim guidelines (SC-CAMLR-IX, Annex 4, paragraphs 90 to 100). Tabled documents presenting data pertaining to prey and environmental features included WG-CEMP-91/11, 17, 26, WG-Krill-91/7, 9, 11, 14, 15, 22, 23, 27, 30, 34, 37 and 39. These papers provided useful examples of the types of data that will be available for the Working Group's future assessments.

5.6 It was agreed that in order to perform its annual assessments and to formulate advice based on integrated perspectives of predator, prey, and environmental data, the following prey and environmental information should be assembled prior to each future meeting of WG-CEMP:

(i) summaries of fine-scale krill catch data (e.g. WG-Krill-91/9) and an analysis of the distribution of catches relative to predator colonies (e.g. WG-CEMP-91/25). The Secretariat is requested to provide these summaries;

(ii) the most recent estimates of krill biomass (or relative biomass) in each of the Integrated Study Regions (and other subareas or meso-scale survey areas as estimates become available). WG-Krill is requested to provide these estimates;

(iii) results of specific fine-scale surveys near CEMP sites (e.g. Annex 5, Appendix 4, Attachment 4, Survey Design 1) or surveys to determine aspects of distribution, movements, or behaviour, as they become available (e.g. WG-Krill-91/7 and 14). Members are requested to undertake these surveys and report the results; and

(iv) summaries of sea-ice conditions derived from satellite imagery (see paragraphs 4.79 to 4.87 and 4.93) and other key environmental data as these become available. The Secretariat is requested to provide these summaries.

Interactions Among Predators, Prey, and Environmental Features

5.7 The Working Group considered various methods to collectively evaluate predator, prey, and environmental data and to develop mechanisms to facilitate such an evaluation. At the present meeting, discussion focussed on identifying relevant data sets and methods for effective presentation of the data. It is anticipated that at WG-CEMP's next meeting, the Working Group will initiate comparisons of predator, prey, and environmental data and later advise the Scientific Committee on the outcome of these discussions.

5.8 The Working Group agreed that two papers that had been tabled (WG-CEMP-91/13 and 28) provided helpful examples of analyses of the relationships among predators, their prey, and the environment. Both studies identified features of predator populations that appear to fluctuate in response to cyclic environmental phenomena. Although such results suggest that identifying and evaluating the specific impacts of fisheries will be complicated, this approach may be helpful for determining periods when predator populations are particularly vulnerable.

5.9 Dr Trivelpiece noted that WG-CEMP-91/28 suggests that penguin population parameters indicate that the year in which FIBEX krill data were collected (1980/81) may have been a year of particularly high prey abundance. He stated that if this is the case, the FIBEX krill biomass estimates (which formed the basis of WG-Krill's recent calculations on a precautionary catch limit) should be used cautiously for formulating management advice.

5.10 Most participants agreed with this interpretation of the data sets presented in WG-CEMP-91/28. They noted that the most likely interpretation of the correlations between fluctuations in penguin parameters and changes in ice cover was that they were mediated by changes in krill availability. They also agreed that if this interpretation is correct, then the precautionary catch limits calculated by WG-Krill may be based on data for a year of relatively high krill availability to predators.

5.11 One participant noted that the conclusions concerning krill abundance in the FIBEX year in Statistical Area 48 did not necessarily follow from the results presented in WG-CEMP-91/28.

Other Relevant Matters

Potential Impacts of Localized Krill Catches

5.12 The Working Group found the two papers tabled by the Secretariat concerning analysis of fine-scale krill catch data (WG-CEMP-91/9 and 25) to be extremely useful in reviewing the proximity of krill catches to colonies of penguins and fur seals. There are clearly extensive temporal and spatial overlaps between krill harvesting and feeding by land-based predators in Subarea 48.1 during the predators' breeding season.

5.13 This overlap demonstrates the potential for competition between the fishery and krill-dependent predators, and raises questions concerning the degree to which fisheries may or may not be adversely affecting seabird and pinniped populations.

5.14 The Working Group reviewed the discussions of WG-Krill concerning approaches to defining precautionary limits on krill harvests in Statistical Area 48 and noted WG-Krill's intention to refine these estimates on a subarea basis (Annex 5, paragraph 7.4).

5.15 The Working Group noted that WG-CEMP-91/25 showed that within Subarea 48.1 at the South Shetland Islands more than 50% of the krill harvest had been taken consistently from within the foraging ranges of land-breeding predators. Additionally, preliminary estimates of krill consumption by land-breeding predators showed that the catch in some years was almost half the requirement of these predators at this time.

5.16 The Working Group noted that the concentration of the harvest in this region and its apparent stability/similarity year-to-year, indicated that Subarea 48.1 was the area where the fishery may have greatest potential impact on predators in the short-term. WG-CEMP identified several important implications arising from this situation.

5.17 First, information is required on krill biomass, production and fluxes in Subarea 48.1 generally and the area of the current fishery in particular, to interpret the magnitude and significance of interactions between krill harvest levels and predator requirements. This reinforces the urgency of conducting appropriate acoustic surveys and related directed research. It also indicates the high priority of revising and refining estimates of predator requirements in the area (paragraphs 6.1 to 6.24).

5.18 Second, undertaking CEMP activities in Subarea 48.1 is of increased importance because of the spatial and temporal overlap between the fisheries and the foraging of breeding birds and seals.

5.19 Third, although precautionary limits may be a potentially useful management procedure, restrictions on the timing and location of fisheries might be considered for providing land-breeding predators (particularly during their breeding seasons) with appropriate protection.

5.20 The Working Group therefore recommended that the Scientific Committee take steps to initiate a dialogue, especially with Members conducting fishing in the Convention Area, to explore the consequences of various types of potential conservation measures associated with a precautionary approach to management.

5.21 Studies of the geographical proximity of fisheries to foraging predators could be refined by considering haul-by-haul catch data such as those presented in WG-Krill-91/39. It was noted that at its 1990 meeting the Scientific Committee recommended that, if possible, haul-by-haul data should be collected and reported for krill catches within 100 km of land-based predator colonies. This recommendation was in turn endorsed by the Commission.

5.22 It was noted that in its previous recommendation on this topic, the intent of the Scientific Committee was to obtain haul-by-haul data for catches within 100 km (SC-CAMLR-IX, Annex 4, paragraph 113), rather than 10 km (SC-CAMLR-IX, paragraph 2.63; CCAMLR-IX, paragraph 4.41), of predator colonies. This typographical error (10 km is incorrect) should be brought to the attention of Members.

Myctophids

5.23 The recently developed fishery for *Electrona carlsbergi* in Subarea 48.3 and the lack of data on the role of myctophids in the Antarctic ecosystem were discussed by WG-FSA

(SC-CAMLR-IX, Annex 5, paragraphs 172 to 181) and the Scientific Committee (SC-CAMLR-IX, paragraph 5.20) at their 1990 meetings.

5.24 In response to the Scientific Committee's request (SC-CAMLR-IX, paragraph 5.21) that information be submitted to WG-CEMP on the significance of myctophids, especially *E. carlsbergi*, as prey for predators in the Convention Area, the Secretariat prepared and submitted WG-CEMP-91/17.

5.25 The Working Group welcomed the Secretariat's contribution, and noted that WG-CEMP-91/17 was a useful first step toward assessing the importance of myctophids in predator diets. The paper clearly identified that myctophids formed the prey of a wide range of vertebrate predators. *E. carlsbergi* and *E. antarctica* were identified as being particularly important. The paper emphasized the need to obtain quantitative data on *E. carlsbergi* as well as on other myctophids such as *E. antarctica*, which is an important prey species especially for predators in high latitudes.

5.26 It was noted that there is a body of unpublished data on this topic that was not available for inclusion in WG-CEMP-91/17. The Secretariat was requested to contact scientists having access to these data with the aim of including the data in the revision of the work. In the interim, the Working Group requested that the paper WG-CEMP-91/17 be updated with available data for presentation to the Scientific Committee as a background document.

PREY REQUIREMENTS FOR KRILL PREDATORS

6.1 This topic is currently being addressed by WG-CEMP with the following aims:

(i) assessing the significance (in terms of ecological and management implications) of geographical and temporal overlap between the commercial krill fishery and krill-dependent predators, especially at times of the year when the latter's foraging range is restricted by the need to feed dependent offspring regularly ;

(ii) contributing to management objectives under Article II of the Convention, in particular relating to:

(a) assessment of what level of krill escapement would be sufficient to meet the reasonable needs of krill predators (SC-CAMLR-IX, Annex 4, paragraph 61(iv));

(b) ensuring that any reduction of food to predators which may arise because of krill harvesting is not such that land-breeding predators with restricted foraging ranges are disproportionately affected in comparison with predators present in pelagic habitats (SC-CAMLR-IX, Annex 4, paragraph 61(iii));

(iii) contributing to estimates of potential yield of krill (Annex 5, paragraph 5.10).

Progress During the Past Year

6.2 The Commission (CCAMLR-VIII, paragraph 59) and Scientific Committee (SC-CAMLR-VIII, paragraphs 5.26 and 5.27) had already asked Members to synthesize data on breeding population size, diet and energy budgets of predators in order to provide estimates of krill requirements of predators in Integrated Study Regions (ISRs). They had also supported (CCAMLR-IX, paragraph 4.36; SC-CAMLR-IX, paragraphs 5.26 and 5.27) the development of detailed proposals for a workshop on this topic. Dr Croxall had agreed to coordinate intersessional correspondence in order to:

(i) formulate a more detailed outline of the precise models and data sets to be investigated during a workshop along the lines of that indicated in paragraph 128 of Annex 6 of SC-CAMLR-IX;

(ii) determine the necessary preparatory work required in advance of such a workshop; and

(iii) identify suitable places and times for a workshop.

6.3 Dr Croxall had circulated a letter (WG-CEMP-91/37) outlining his ideas on how best to proceed. Members discussed these suggestions, taking into account:

(i) additional relevant information presented at the meeting (e.g. WG-CEMP-91/25 and 35); and

(ii) the comments offered by WG-Krill (Annex 5, paragraphs 5.10 to 5.15).

6.4 The additional tabled information included: comparison of estimates of krill consumption by predators and commercial krill catches within parts of the Antarctic Peninsula ISR (WG-CEMP-91/25); notification of the development by a US research group of a synthesis of data on Adélie penguin for input to a model of energy and food requirements (WG-CEMP-91/35).

6.5 These initiatives were welcomed. WG-CEMP-91/25 provided an example of some of the products that the full-scale investigation of this topic is intended to provide. WG-CEMP-91/35 made a direct contribution to the synthesis of relevant data and promised to provide an additional model to use when these WG-CEMP initiatives reach the analytical stage.

6.6 In response to the suggestions by WG-Krill that pelagic predators such as whales and ice-breeding seals be included in the WG-CEMP deliberations (Annex 5, paragraph 5.11), WG-CEMP noted that these pelagic predators had always been included in discussions but that the paucity of some data important for present purposes inevitably limited what analyses could be undertaken in respect to such species. Similar problems were posed when considering incorporating data on seabirds other than penguins and on non-breeding populations of penguins and fur seals.

6.7 Additional considerations bearing on the best procedures to follow include:

(i) the increasing interest in this topic within Scientific Committee working groups; and

(ii) existing commitments of WG-CEMP participants which preclude holding a workshop before June 1993.

Future Work

6.8 The Working Group proposed that four approaches to future work be initiated/undertaken concurrently.

6.9 First, immediate attention should be given to synthesis and evaluation of relevant data on penguins and fur seals for each ISR. For the Antarctic Peninsula ISR consideration should be focused on best-studied parts of the region in addition to the whole ISR.

6.10 The initial tasks involving coordination of data synthesis and evaluation within ISRs were allocated as follows:

South Georgia:	UK
Antarctic Peninsula:	USA
Prydz Bay:	Australia.

6.11 The data required are those on breeding population size, duration and timing of breeding events, body weight, diet (% krill by weight) and energy content of that food. The data should be compiled in as much detail as possible, particularly with respect to seasonal variation in e.g. diet, body weight, and include minimum and maximum, as well as mean values for population size and other parameters as appropriate. Initially they should be assembled to conform with the inputs of data specified in WG-CEMP-90/31.

6.12 The task of compiling data on activity-specific energy budgets and foraging ranges for penguins in the ISRs would be coordinated by USA. It would be based on the approach initiated in WG-CEMP-90/30 Rev. 1, incorporating information assembled in the project described in WG-CEMP-91/35 and additional recent published data. Members aware of sources of published, and particularly unpublished, relevant data were urged to contact Dr D. Croll, National Marine Fisheries Service (NMFS) (USA).

6.13 Similar data on fur seals would be collated by the UK. The contact scientist there is Dr I. Boyd, British Antarctic Survey (BAS) (UK).

6.14 Second, the feasibility of undertaking a similar task to that outlined in paragraphs 6.9 to 6.13 in respect of crabeater (and possibly leopard) seals for appropriate ISRs should be investigated.

6.15 Drs Bengtson and T. Härkönen (Sweden) agreed to investigate and assess data relating to abundance, distribution and residence time of crabeater seals in ISRs. They also agreed to investigate the suitability of models of energy budgets of northern hemisphere phocid seals for application to data available on crabeater seals. They will report back to the Working Group on the feasibility of proceeding with the kinds of assessments and analyses envisaged for the penguin and fur seal data.

6.16 Third, discussions with the International Whaling Commission (initially by means of a letter from the Convener of WG-CEMP to the Chairman of the Scientific Committee of IWC) requesting advice on the sources of the best available data for estimating the krill requirements of baleen whales within ISRs should be started.

6.17 The minimum requirements would be quantitative data on numbers, biomass, diet (% krill) and daily energy requirements for each baleen whale species from October to March inclusive in each ISR. Any quantitative data on changes in any of these parameters within this period or on finer-scale distribution and density would be most valuable.

6.18 Fourth, the process of acquisition and collation of relevant data on seabirds other than penguins should continue. Members were encouraged to continue with this work and in particular to undertake surveys of areas and colonies for which recent data are unavailable.

6.19 Dr Croxall agreed to continue to coordinate this work. Progress on these initiatives would be reviewed by correspondence in May 1992 in order to assess what might be achieved before the next meeting of WG-CEMP.

6.20 Dr Croxall stressed that the success of the initial undertaking critically depended on the quality of the information on population size and energy requirements. Agreement on species- and activity-specific energy consumption coefficients might be impossible to achieve by correspondence (see paragraph 6.17) and a dialogue between appropriate experts might be essential. Several of these experts are likely to attend the same international meetings scheduled for June to September 1992. It was recommended that contingency funds be requested to enable two to three scientists to meet for a day in conjunction with one of these meetings to undertake final evaluations. The review of progress in May 1992 would indicate whether such a meeting would be required or not.

6.21 WG-CEMP hoped that it might be possible at least to provide the Scientific Committee in 1992 with significant interim results, in the form of a brief report, using the data on fur seals and penguins as inputs to existing models (e.g. WG-CEMP-90/30 Rev. 1, 31 and WG-CEMP-91/35).

6.22 Depending on the outcome of the evaluation of crabeater seal data it might be feasible to include some preliminary assessments in this report but it is most unlikely that any assessments will be available for baleen whales and seabirds generally.

6.23 WG-CEMP noted that an interim report to the Scientific Committee is being advocated because of the high level of current interest within CCAMLR on this topic. It emphasized, however, that an interim partial assessment on its own is no substitute for a full-scale critical evaluation, which would require an interactive workshop with multidisciplinary participation.

6.24 Such a workshop would not only have available more comprehensive and more rigorously assessed data sets but would also be in a position to investigate *inter alia*:

(i) sensitivity of models to changes in predator population size, energy consumption coefficient and foraging ranges; and

(ii) interactions between the distribution of krill catches and foraging activities of krill predators for a variety of assumptions concerning predator foraging ranges and locations and krill abundance, availability (to predators and fishery), distribution, density and movements.

Other Matters

6.25 During discussions on precautionary limits on krill catches WG-Krill had considered approaches including assessments of natural mortality (paragraph 6.57) and had referred (paragraph 5.10) to the importance of calculating required levels of krill escapement from the fishery (to meet the needs of dependent species).

6.26 WG-CEMP noted that the approach used in Annex 5, paragraph 6.57 is based solely on theoretical precepts. However, empirical determination of natural mortality and escapement levels requires estimates of krill consumption by all natural predators (e.g. whales, seals, birds, fish and squid). Prospects of realistic estimates of some of these (e.g. fish and squid) at appropriate temporal and spatial scales are remote.

GENERAL MATTERS

Integrated Analyses of Predator/Prey/Environmental Interactions

7.1 At its 1990 meeting, the Working Group discussed the potential use of geographical information systems (GIS) in assisting its efforts to undertake integrated analyses of predator, prey and environmental data.

7.2 Dr Holt presented a paper (WG-Krill-91/38) which describe such systems in more detail. GIS and Visualisation Software (VS) systems provide methods for storing data described by geographical position and investigating the relationships between different sets of similarly geo-referenced data. GIS operates two-dimensionally and has very powerful data handling and data analysis facilities. It would be of particular use to CCAMLR in the integrated analysis of large-scale environmental, survey, predator and fisheries data. VS systems operate three-dimensionally but offer fewer facilities for data analysis. Despite this restriction they may be more useful for specific analysis of research data described by position and depth.

7.3 As an example, the paper had used VS to analyze a detailed acoustic survey of krill aggregations in a 1 nautical mile square north of Elephant Island. Additional uses could include the 3-dimensional representation of krill swarms in the survey area combined with predator distributional and diving data and environmental data from vertical profiling of the water column.

7.4 The Working Group agreed that the VS described in WG-Krill-91/38 had potential. It noted, however, that the interpolations involved in this analysis required a high sampling intensity that may not be practicable on larger scales. Interpretation of the results could be complicated by the types of algorithms used in the VS, as well as the unknown effects of ship disturbance and current speed.

7.5 The Working Group agreed that whilst GIS held promise for the integrated analysis of CCAMLR data, its detailed application, the types of data to be collected and the data collection protocols would have to be established before such a system could be installed and routinely used at the Secretariat.

7.6 Members were encouraged to undertake specific research tasks to evaluate further the potential of GIS and VS, and their applicability to CEMP. Specific topics include:

(i) the relationship between krill and predator distribution established by research surveys (VS);

(ii) the effects of krill patch movement, avoidance behaviour and water current on the results of surveys involving planned fine-scale transects (VS); and

(iii) the investigation of krill patch density and the behaviour of the fishing fleet, using haul-by-haul and other appropriate data (GIS).

7.7 Drs Holt and Naganobu suggested that a cooperative research project may be initiated, involving the use of krill patch data and GIS and VS systems. Furthermore, Dr Holt indicated that the US was interested in cooperative studies with fishing nations involving analysis of haul-by-haul krill data using these systems.

Collaborative Work and Awareness of CEMP

7.8 The publication in 1991 of a brochure by CCAMLR describing the aims of CEMP was seen as an important step in publicising the Program. The poster to be presented by the Secretariat at the Antarctic Science Conference in Bremen, Germany (23 to 28 September 1991) will further promote awareness of CEMP. More detailed background on the development and current status of implementation of the program is provided in WG-CEMP-91/10.

7.9 A large number of CEMP related studies is currently under way as shown in Tables 1, 2 and 3. The Working Group noted, however, that scientists in research centres in several Member countries especially Germany, France, New Zealand and South Africa were known to be conducting research on subjects of direct interest to CEMP, but they did not participate regularly in WG-CEMP meetings or contribute data or analyses to CEMP.

7.10 The Working Group regretted that Chile, Argentina and Brazil were not represented at the present meeting, although these Members are actively involved in CEMP and have contributed significantly to past meetings of the Working Group.

7.11 The Working Group emphasized the importance of having all Members participate in CEMP, studying as many parameters at different sites as feasible and commented that the Working Group’s analytical efforts will be strengthened by having increased data available for comparison.

7.12 With the aim of increasing participation in CEMP the Secretariat was asked to solicit contributions from Members not currently participating, by:

(i) writing to the ministries, directors of institutions and individual researchers at institutions known to have research programs of interest to CEMP. The Secretariat would provide details of the aims of the Program, lists of working documents at CEMP meetings and reports of the Working Group and solicit contributions to and encourage attendance at Working Group meetings; and

(ii) writing to Member contacts, pointing out the relevance of certain research programs under way in their national institutions to the work of CEMP and, through the Scientific Committee, to the work of the Commission.

CCAMLR/IWC Workshop on the Feeding Ecology
of Southern Baleen Whales

7.13 In August 1990 the Secretary of the IWC informed CCAMLR that:

> 'the terms of reference and participants for the Joint Workshop on the Feeding Ecology of Southern Baleen Whales should be expanded to cover studies of other major predators of krill, especially those pertinent to estimates of abundance and trends and that a joint workshop should be planned for 1992 (SC-CAMLR-IX/BG/12).'

7.14 In 1990 the Scientific Committee recorded in its report that it considered it inappropriate for the terms of reference to be expanded in this way, and asked the Executive Secretary to respond to IWC to request an explanation for this expansion and reiterate the original terms of reference of the workshop.

7.15 The IWC responded to CCAMLR's concerns in section 5.1.3 of its report, contained in a letter dated 24 June 1991 from the Secretary of the IWC (WG-CEMP-91/15). The Working Group noted that the response still failed to indicate the reasons for the suggested expanded terms of reference of the proposed workshop, and that the IWC planned to consult only informally with Members of the Scientific Committee on the terms of reference of the workshop.

7.16 The Working Group recalled that CCAMLR's original interest in this workshop was to facilitate the functional evaluation of the minke whale as a potential indicator of changes likely to result from harvesting krill. However, it recognized that since 1985 the approach adopted has been to develop standard methods of data collection, submission and analysis for specific parameters. Given the success of this approach WG-CEMP agreed that the best way for it to proceed now was to request Members wishing formally to incorporate the minke whale into CEMP to prepare a specific proposal (as was done in the case of the gentoo penguin - see WG-CEMP-90/14) including a definition of appropriate parameters for consideration by WG-CEMP. In the meantime the deletion of minke whale from the list of CEMP indicator species was recommended.

7.17 The requirement in the terms of reference of the workshop to evaluate the minke whale as a potential indicator of changes resulting from krill harvesting necessitated the use and analysis of data on trends in abundance of minke whale (and possibly other baleen whale species). The need to interpret these data has apparently led IWC to the view that the so-called 'krill surplus' hypothesis needed investigating. In view of the recommendation in paragraph 7.16 the need by CCAMLR for such analyses and investigations no longer applies.

7.18 The Working Group emphasized that both it and WG-Krill maintained a strong interest in the minke whale as an important component of the Southern Ocean ecosystem. In particular the development by IWC of a workshop on the foraging ecology of baleen whales (presumably with new terms of reference taking account of paragraph 7.17) would be of considerable interest to WG-CEMP. Furthermore WG-CEMP had already directed specific questions to IWC (paragraphs 6.16 and 6.17).

7.19 From a WG-CEMP perspective the need for it to address the krill surplus hypothesis was questionable. WG-CEMP noted that very few quantitative data exist with which to review the historical situation responsible for the hypothesis. Furthermore, WG-CEMP-91/28 provided plausible arguments suggesting that recent changes in penguin populations could be explained on the basis of systematic trends in the Antarctic physical environment (with concomitant effects on trends in prey abundance) rather than by involving the 'krill surplus' hypothesis.

7.20 The Working Group recommended that the Executive Secretary write to the Secretary of the IWC advising him of the position expressed in paragraphs 7.16 to 7.19.

Workshop on Southern Elephant Seals

7.21 The SCAR Group of Specialists on Seals convened a Workshop on Southern Elephant Seals in Monterey, California, USA from 22 to 23 May 1991 with financial assistance from CCAMLR. This workshop investigated the decline of southern elephant seals and its possible causes. The report of the workshop is given in SC-CAMLR-X/BG/3.

7.22 The workshop found that most populations of the Kerguelen Islands area (Marion, Heard, Kerguelen and Crozet Islands) and Macquarie Islands area (Macquarie, Campbell and Antipodes Islands) were declining at rates of 2 to 9% annually. The status of the South Georgia stock (South Georgia, South Orkney, Falkland, Gough, King George and Nelson Islands) was uncertain. The only population confirmed to be increasing was the Valdes Peninsula population (3 to 5% per annum).

7.23 Whilst no single factor was identified as contributing to this change, the workshop indicated there was no evidence that disease, predation or competition with fisheries were causing the decline, but that climate change may be a contributing factor.

7.24 Dr Focardi commented that a promising area of research could be pollutants, such as PCBs which were implicated in northern phocid declines and offered to coordinate analyses of such pollutants at his laboratory should any investigations require them.

CCAMLR System of Observation and Inspection

7.25 The Executive Secretary introduced CCAMLR-X/7 which described a system of scientific observation being developed by the Commission. The Working Group acknowledged the importance of such a system in ensuring the reliable collection of biological data from commercial operations.

7.26 The Working Group had discussed the value of haul-by-haul data in locating the distribution of krill in relation to the foraging ranges of predators (paragraphs 5.21 and 5.22). Several Members had indicated that reliable haul-by-haul data could best be collected by trained observers.

7.27 The Working Group encouraged the placement of observers on as many fishing vessels as possible.

7.28 The Working Group noted that forms developed by WG-Krill in 1990 and endorsed by WG-CEMP for use by observers had been circulated during the intersessional period. Minor refinements had been made at the recent meeting of WG-Krill.

7.29 It was agreed that in addition to these forms, special guidelines for the collection of haul-by-haul data by observers may be required.

7.30 Dr Shust suggested that during krill and fish surveys, sightings of birds, seals and other predators of krill could be recorded to provide information on their distribution and abundance. The Working Group agreed that such information could be useful for identifying important foraging areas for these species and for investigation of relationships between predators and krill distribution.

7.31 The Working Group also noted that to undertake the latter investigations it was essential to use standard methods, preferably those developed for the BIOMASS program (BIOMASS Handbooks 1 and 18) in estimating seal and seabird abundance. The Working Group encouraged Members where possible to collect such data during their krill and fish surveys.

New and Developing Fisheries

7.32 The Working Group noted that as a result of advice from the Scientific Committee last year, the Commission had agreed on the need for a conservation measure which would ensure that the development of new fisheries did not proceed before adequate data reporting and management procedures had been initiated.

7.33 Following this decision, the Commission asked the Executive Secretary to consult Members and other international organisations and to prepare a working paper on definitions for use in the formulation of the conservation measure. The Executive Secretary's response to that request is contained in CCAMLR-X/6 which was presented to the Working Group for comment.

7.34 The Working Group agreed that the idea of predictive management, implied in such a measure, was the only logical basis for the implementation of Article II of the Convention. It was noted, in this connection, that the advice from the Scientific Committee had included requirements for assessments of the potential impacts of fisheries on dependent and related species.

7.35 It was agreed that given the focus of WG-CEMP's ongoing deliberations on the status of dependent and related species and their interactions with other components of the ecosystem, the Working Group could provide essential assessments relevant to the Scientific Committee's work on new and developing fisheries. Therefore, WG-CEMP recommended that evidence or arguments that the proposed fishery will not adversely affect dependent and associated species should be presented. The Working Group expected to be actively involved in assessing the available evidence or arguments presented.

7.36 The Working Group noted the comments of WG-Krill concerning the definitions contained in CCAMLR-X/6 (Annex 5, paragraph 7.7). It was suggested that the reliance on reported data may not be effective in identifying the start of a fishery due to non-reporting of exploratory fishing data. The Data Manager however, confirmed that the Commission currently requires reporting of all catches in the Convention Area, irrespective of species or fishing method.

OTHER BUSINESS

8.1 Dr Kerry informed the Working Group that Ms L. Denham from the Australian Antarctic Division had compiled an index of all CEMP papers from the time of the first meetings of the *ad hoc* working group. Papers were indexed under Subject, Nationality, Author and CCAMLR number. The Working Group expressed its opinion that the index was a helpful aid and accepted Dr Kerry's offer to make the index available to Members through the Secretariat.

FUTURE WORK

9.1 The Working Group reviewed progress made, work discussed and tasks identified at the meeting. The principal tasks in the coming year are as follows:

(i) to review the summaries of all predator data held at the CCAMLR Data Centre (paragraph 4.34);

(ii) to discuss indices calculated from predator data (paragraph 4.34);

(iii) to discuss summary of changes and trends in predator parameters between years and between sites and species as appropriate (paragraph 4.34);

(iv) to review progress in planning for an at-sea behaviour workshop (paragraphs 4.48 and 4.52);

(v) to discuss results of intersessional consultations, progress with data syntheses, and prospects for a future workshop on the prey requirements of predators (paragraphs 6.11, 6.12, 6.15, 6.17, 6.18 and 6.20);

(vi) to develop interim estimates and report to the Scientific Committee on the prey requirements of predators (paragraph 6.21 and 6.22);

(vii) to review the results of the pilot study on sea-ice data and recommend future actions, including discussions of appropriate sites and extent of satellite coverage (paragraph 4.93);

(viii) to formulate advice to the Scientific Committee based on discussions of predator indices (paragraph 5.2);

(ix) to discuss interactions among predator, prey, and environmental features and advise the Scientific Committee on the outcome of these discussions (paragraph 5.7); and

(x) to contribute to dialogue exploring the consequences of various potential conservation measures associated with a precautionary approach to management (paragraph 5.20).

9.2 To undertake assessments and provide advice to the Scientific Committee (items (viii) to (x) above) WG-CEMP will need extensive discussions of items (ii) and (iii); these discussions cannot be effective without a meeting.

9.3 However, effective discussions and useful advice require the availability of sufficient data. The requirement for prompt submission of due and outstanding data is strongly emphasized.

9.4 Accordingly, the Working Group recommended that it hold a meeting during the 1992 intersessional period.

Recommendations to the Scientific Committee

9.5 The Working Group made the following recommendations to the Scientific Committee:

(i) a revised draft management plan for the protection of the CEMP site at the Seal Islands, South Shetland Islands, should be reviewed by the Scientific Committee at its next meeting (paragraph 4.2);

(ii) funds should be provided for the conduct of a pilot study involving the acquisition of AVHRR satellite sea-ice imagery by the Secretariat. The aim of the project is to establish the feasibility of using satellite imagery to monitor sea-ice distribution and extent in relation to CEMP sites. The pilot study should be conducted for two CEMP sites during a two-month period for which images would be obtained and processed every five days (paragraph 4.92);

(iii) the Scientific Committee should take steps to initiate a dialogue, especially with Members conducting fishing in the Convention Area, to explore the consequences of various types of potential conservation measures associated with a precautionary approach to management (paragraph 5.20);

(iv) contingency funds should be provided to enable two or three scientists to meet for a day to consider the initial parameters necessary for the review of prey requirements for krill predators. The meeting, which would be necessary to identify relevant species and activity-specific energy consumption coefficients would take place in conjunction with one of the already-scheduled international meetings in July to September 1992 (paragraph 6.20);

(v) minke whales should be deleted from the list of CEMP indicator species (paragraph 7.16);

(vi) the Executive Secretary should be asked to write to the Secretary of the IWC advising him of the current CCAMLR position in respect of the Workshop on the Feeding Ecology of Southern Baleen Whales expressed in paragraphs 7.16 to 7.19;

(vii) in connection with the Scientific Committee's work on new and developing fisheries, the Working Group recommended that:

(a) evidence or arguments should be presented that the proposed fishery would not adversely affect dependent and associated species; and

(b) WG-CEMP should be invited to comment on the available evidence and arguments presented (paragraph 7.35);

(viii) WG-CEMP should hold a meeting during the 1992 intersessional period (paragraph 9.4).

CLOSE OF THE MEETING

10.1 The Report of the Meeting was adopted.

10.2 The Convener thanked participants, rapporteurs, subgroups, the Secretariat and staff of the Instituto Español de Oceanografía for their work during the meeting at which considerable progress had been made. The quality and relevance of working papers prepared during the intersessional period by the Secretariat and by participants had contributed significantly to this progress.

10.3 Particular thanks and gratitude were extended to the organizers, and the Instituto Español de Oceanografía, for hosting and providing the facilities for an efficient, productive and delightful meeting in Santa Cruz de Tenerife.

Table 1: Summary of Members’ CEMP activities on monitoring approved predator parameters.

Method Sheet Number	Parameter	Species: A-Adélie penguin M-Macaroni penguin C-Chinstrap penguin G-Gentoo penguin B-Black-browed albatross F-Fur seal						Country	Site Name/ Integrated Study Region/ Network Site	Site Location	Year Started	1989/90 Data Submission	1990/91 Data Submission
		A	M	C	G	B	F						
-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-
Penguins													
A1	Weight on arrival at breeding colonies	X						Australia	Magnetic Is Davis Station/ Prydz Bay	68°33’S 77°54’E	1983/84	Being prepared	Being prepared
		X						Argentina	King George Is Stranger Point/ S. Shetland Is	62°14’S 58°30’W	1987/88	Being prepared	Being prepared
		X						Argentina	Laurie Is Mossman Peninsula/ S. Orkney Is	60°45’S 44°44’W	1987/88	Being prepared	Being prepared
								Argentina	Esperanza Station/ Ant. Peninsula	63°24’S 57°00’W	1990/91		
		X						Germany	Ardley Is/ Ant. Peninsula	62°11’S 58° 55’W	1990/91		
			X					UK	Bird Is/ South Georgia	52°00'S 38°02'W	1988/89	Submitted	Submitted
A2	Length of the first incubation shift	X						Australia	Magnetic Is Davis Station/ Prydz Bay	68°33’S 77°54’E	1983/84	Submitted	Submitted
		X						Australia	Béchervaise Is/ Mawson/Prydz	67°36’S 62°53’E	1990/91		Submitted
		X						Argentina	King George Is Stranger Point S. Shetland Is	62°14’S 58°30’W	1987/88	Being prepared	Being prepared
								Argentina	Esperanza Station/ Ant. Peninsula	63°24’S 57°00’W	1990/91		
		X						Germany	Ardley Is/ Ant. Peninsula	62°11’S 58° 55’W	1990/91		
A3	Annual trends in breeding population size	X						Australia	Magnetic Is Davis Station/ Prydz Bay	68°33’S 77°54’E	1983/84	Being prepared	Being prepared
		X						Argentina	King George Is Stranger Point/ S. Shetland Is	62°14’S 58°30’W	1987/88	Being prepared	Being prepared
			X	X				Brazil	Elephant Is S. Shetland Is/ Ant. Peninsula	61°04’S 55°21’W	1986	No inf. available	No inf. available
		X		X				Chile	Ardley Is S. Shetland Is/ Ant. Peninsula	62°11’8”S 58°55’W	1982	Being prepared	Being prepared
		X						Japan	Syowa Station/ Network site	69°00’S 39°30’E	1970	No inf. available	No inf. available
			X		X			UK	Bird Is/ South Georgia	52°00'S 38°02'W	1975/76	Submitted	Submitted
		X		X	X			UK	Signy Is/ Network site	60°43'S 45°38'W	1978/79	Submitted	Submitted
		X						Germany	Ardley Is/ Ant. Peninsula	62°11’S 58° 55’W	1990/91		
A4	Demography			X				Chile	Ardley Is S. Shetland Is/ Ant. Peninsula	62°11’8”S 58°55’W	1982	Being prepared	Being prepared
			X	X				Brazil	Elephant Is S. Shetland Is/ Ant. Peninsula	61°04’S 55°21’W	1986	Data not requested	Data not requested
			X	X				USA	Seal Is S. Shetland Is/ Ant. Peninsula	60°59.5’S 55°24.5’W	1987/88	Data not requested	Data not requested
		X						USA	Anvers Is Palmer Station/ Ant. Peninsula	64°06’S 64°03’W	1987/88	Data not requested	Data not requested
A5	Duration of foraging trips	X						Australia	Magnetic Is Davis Station/ Prydz Bay	68°33’S 77°54’E	1983/84	Being prepared	Being prepared
				X				USA	Seal Is S. Shetland Is/ Ant. Peninsula	60°59.5’S 55°24.5’W	1987/88	Submitted	Submitted
		X						USA	Anvers Is Palmer Station/ Ant. Peninsula	64°06’S 64°03’W	1989/90	Submitted	Submitted

Table 1 (continued)

-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-
A6	Breeding success	X						Australia	Magnetic Is Davis Station/ Prydz Bay	68°33’S 77°54’E	1983/84	Being prepared	Being prepared
		X						Argentina	King George Is Stranger Point/ S. Shetland Is	62°14’S 58°30’W	1987/88	Being prepared	Being prepared
			X	X				Brazil	Elephant Is S. Shetland Is/ Ant. Peninsula	61°04’S 55°21’W	1986	Submitted	Submitted
				X				Chile	Ardley Is S. Shetland Is/ Ant. Peninsula	62°11’8”S 58°55’W	1982	Being prepared	Being prepared
			X		X			UK	Bird Is/ South Georgia	52°00'S 38°02'W	1975/76	Submitted	Submitted
		X		X	X			UK	Signy Is/ Network site	60°43'S 45°38'W	1978/79	Submitted	Submitted
			X	X				USA	Seal Is S. Shetland Is/ Ant. Peninsula	60°59.5’S 55°24.5’W	1987/88	Proc.A sub. Proc.C(b,c) submitted	Proc.A sub. Proc.C(b,c) submitted
		X						USA	Anvers Is Palmer Station/ Ant. Peninsula	64°06’S 64°03’W	1987/88	Submitted	Submitted
		X						Germany	Ardley Is/ Ant. Peninsula	62°11’S 58° 55’W	1990/91		
A7	Fledging weight	X						Australia	Magnetic Is Davis Station/ Prydz Bay	68°33'S 77°54'E	1983/84	Being prepared	Being prepared
		X						Argentina	King George Is Stranger Point/ S. Shetland Is	62°14’S 58°30’W	1987/88	Being prepared	Being prepared
		X						Argentina	Laurie Is Mossman Peninsula/ S. Orkney Is	60°45’S 44°44’W	1987/88	Being prepared	Being prepared
								Argentina	Esperanza Station/ Ant. Peninsula	63°24’S 57°00’W	1990/91		
			X	X				Brazil	Elephant Is S. Shetland Is/ Ant. Peninsula	61°04’S 55°21'W	1986	Submitted	
			X		X			UK	Bird Is/ South Georgia	52°00'S 38°02'W	1988/89	Submitted	Submitted
				X				USA	Seal Is S. Shetland Is/ Ant. Peninsula	60°59.5’S 55°24.5’W	1987/88	Proc. A submitted	Proc. A submitted
		X						USA	Anvers Is Palmer Station/ Ant. Peninsula	64°06’S 64°03’W	1987/88	Submitted	Submitted
		X						Germany	Ardley Is/ Ant. Peninsula	62°11’S 58° 55’W	1990/91		
A8	Chick diet	X						Australia	Magnetic Is Davis Station/ Prydz Bay	68°33’S 77°54’E	1983/84	Being prepared	Being prepared
		X						Australia	Béchervaise Is/ Mawson/ Prydz Bay	67°36’S 62°53’E	1990/91		Submitted
		X						Argentina	King George Is Stranger Point/ S. Shetland Is	62°14’S 58°30’W	1987/88	Being prepared	Being prepared
		X						Argentina	Laurie Is Mossman Peninsula/ S. Orkney Is	60°45’S 44°44’W	1987/88	Being prepared	Being prepared
								Argentina	Esperanza Station/ Ant. Peninsula	63°24’S 57°00’W	1987/88	Being prepared	Being prepared
			X	X				Brazil	Elephant Is S. Shetland Is/ Ant. Peninsula	61°04’S 55°21’W	1986	Submitted	
				X				Chile	Ardley Is S. Shetland Is/ Ant. Peninsula	62°11’8”S 58°55’W	1982	No inf. available	No inf. available
			X		X			UK	Bird Is/ South Georgia	52°00'S 38°02'W	1985/86	Submitted	Submitted
				X				USA	Seal Is S. Shetland Is/ Ant. Peninsula	60°59.5’S 55°24.5”W	1987/88	No info available	No info available
		X						USA	Anvers Is Palmer Station/ Ant. Peninsula	64°06’S 64°03’W	1987/88	Submitted	Being prepared
		X						Germany	Ardley Is/ Ant. Peninsula	62°11’S 58° 55’W	1990/91		

Table 1 (continued)

-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-
A9	Breeding chronology	X						Australia	Magnetic Is Davis Station/ Prydz Bay	68°33'S 77°54'E	1983/84	Being prepared	Being prepared
		X						Australia	Béchervaise Is/ Mawson/ Prydz Bay	67°36'S 62°53'E	1990/91		Submitted
		X						Argentina	Laurie Is Mossman Peninsula/ S. Orkney Is	60°45'S 44°44'W	1987/88	Being prepared	Being prepared
				X				USA	Seal Is Anvers Is S. Shetland Is/ Ant. Peninsula	60°59.5'S 64°06'S 55°24.5''W	1987/88	Submitted	Submitted
Flying Birds													
B1	Breeding population size					X		UK	Bird Is/ South Georgia	52°00'S 38°02'W	1976/77	Being prepared	Being prepared
B2	Breeding success					X		UK	Bird Is/ South Georgia	52°00'S 38°02'W	1976/77	Being prepared	Being prepared
B3	Age-specific annual survival and recruitment					X		UK	Bird Is/ South Georgia	52°00'S 38°02'W	1976/77	Being prepared	Being prepared
Seals													
C1	Cow foraging/ attendance						X	Chile	Cape Shirreff/ Ant. Peninsula	62°27'S 60°47'W	1987/88	No inf. available	No inf. available
	cycles						X	UK	Bird Is/ South Georgia	52°00'S 38°02'W	1978/79	Submitted	Submitted
							X	USA	Seal Is S. Shetland Is/ Ant. Peninsula	60°59.5'S 55°24.5W	1987/88	Proc. A submitted	Proc. A submitted
C2	Pup Growth						X	Chile	Cape Shirreff/ Ant. Peninsula	62°28'S 60°47"W	1984/85	No inf. available	No inf. available
							X	UK	Bird Is/ South Georgia	52°00'S 38°02'W	1972/73 1977/78	Submitted	Submitted
							X	USA	Seal Is S. Shetland Is/ Ant. Peninsula	60°59.5'S 55°24.5'W	1987/88	Proc. B submitted	Proc. B submitted

Table 2: Summary of Members' directed programs on assessing the utility of potential predator parameters.

Parameter	Areas[(a)] from which data are available for analysis/ evaluation	Members' Research Activity					
		Undertaken 1989/90		Undertaken 1990/91		Proposed for 1991/92	
		Analysis of existing data	Acquisition of new data	Analysis of existing data	Acquisition of new data	Analysis of existing data	Acquisition of new data
-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-
Penguins[(b)]							
- Incubation shift (M)	2,4,5,11,14	Brazil(2)	Brazil (2)	S.Africa (14,M)	S.Africa (14,M)		
- Weight prior to moult (M)	2,15,14,4,5?	Brazil (2)	Brazil (2)	S.Africa (14,M)	S.Africa (14,M)		
- At-sea diving behaviour and activity patterns (A,C,M)	2,4,6	Australia (6,A) UK (4,M,G) USA (2,C,M) Germany (11,A)	Australia (6,A) USA (2,C,M,G) Germany (11,A)	Australia (6,A) USA (2,C,M) Germany (11,A,G)	UK (4,M) USA (2,C,M) Germany (11,A,G)	Australia (6,A) UK (4,M) USA (2,C,M) Germany (11,A,G)	Australia (6,A) UK (4,G) USA (2,C,M) Germany (11,A,C,G)
- Weight recovery during incubation (A,C,M)	4,6	Australia (6,A)	Australia (6,A)	Australia (6,A)			
- Survival (A,C,M)	1,2,6,11	Australia (6,A) UK (4,M,G) USA (2,C;11,A)	Australia (6,A) UK (4,M,G) USA (2,C;11,A)	UK (4,M) USA (2,C;11,A)	UK (4,M,G) USA (2,C;11,A)	USA (2,C)	UK (4,M,G) USA (2,C)
- Chick growth rate	2,11	UK (4,M,G) USA (2,C;11,A)	USA (2,C;11,A)	Spain (2,C)	UK (4,G)	USA (2,C)	UK (4,G) USA (2,C)
- Bioenergetics				Spain (2,C) USA (2,C,M;11,A)	USA (2,C,M)	USA (2,C,M)	USA (2,C,M)
- Reproductive strategies (C)	2			Spain (2,C)			

Table 2 (continued)

-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-
Flighted seabirds							
Black-browed albatross							
- Breeding population size	4,9?,15		UK (4)		UK (4)	UK (4)	UK (4)
- Breeding success	4,9?,15		UK (4)		UK (4)	UK (4)	UK (4)
- Duration of foraging trips	4		UK (4)			UK (4)	UK (4)
- Activity budget at sea	4		UK (4)				UK (4)
- Prey characteristics (diet)	4		UK (4)				UK (4)
Antarctic/Cape petrel							
- Breeding success	2,3,6,8,11		UK (3,CP)		UK (3,CP)	USA (2,CP)	USA (2,CP)
- Chick weight at fledging	2,6,8,11	Brazil (2)	Brazil (2)			USA (2,CP)	USA (2,CP)
- Prey characteristics (diet)	2,6,8,11	Brazil (2)	Brazil (2)				
Fur seals							
- Reproductive success	4,2		UK (4) USA (2)		UK (4) USA (2)	UK (4)	USA (2)
- Prey characteristics (diet)	4,2	USA (2)	UK (4) USA (2)	USA (2)	UK (4) USA (2)	USA (2)	USA (2)
- At-sea diving behaviour and activity pattern	2,4	UK (4) USA (2)	UK (4) USA (2)	UK (4) USA (2)	UK (4) USA (2)	USA (2)	USA (2)
- Bioenergetics					UK (4)		UK (4)
- Indices of physiological condition	11		UK (4)				UK (4)
- Fine structure of teeth	4	UK (4)	UK (4)		UK (4)		
Crabeater seal							
- Reproductive rates	2,3,8,10-12	USA (11,12) Sweden (11,12)	USA (12)	USA (11,12) Sweden (11,12)		USA (11,12) Sweden (11,12)	
- Age at sexual maturity	2,3,8,10-12	USA (10,11,12) Sweden (11,12)	USA (12)	USA (11,12) Sweden (11,12)		USA (11,12) Sweden (11,12)	
- Cohort strength	2,3,8,10-12	USA (10,11,12)	USA (12)	USA (11,12)		USA (11,12)	

Table 2 (continued)

-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-
- Indices of physiological condition	11,12	USA (11,12)	USA (12)			USA (11,12)	
- Instantaneous growth rate	11,12		USA (12)				
- Prey characteristics (diet)	11,12	USA (11)	USA (11)	USA (11)		USA (11,12)	
- At-sea diving behaviour and activity pattern	11,12	USA (11,12)	USA (11,12)	USA (11,12)		USA (11,12)	
- Satellite telemetry		USA (11,12)	USA (11,12)	USA (11,12)		USA (11,12) Sweden (11,12)	
Minke whales							
- Reproductive rate	13,1	Japan	Japan	Japan	Japan	Japan	Japan
- Age of sexual maturity	13,1	Japan	Japan	Japan	Japan	Japan	Japan
- Cohort strength	13,1	Japan	Japan	Japan	Japan	Japan	Japan
- Analyses of existing data:							
- stomach contents	13,1	Japan	Japan	Japan	Japan	Japan	Japan
- blubber thickness	13,1	Japan	Japan	Japan	Japan	Japan	Japan
- density/patchiness	13,1	Japan	Japan	Japan	Japan	Japan	Japan
- school size	13,1	Japan	Japan	Japan	Japan	Japan	Japan
- Feeding activity patterns	13,1	Japan	Japan	Japan	Japan	Japan	Japan

(a) Areas:

1. Ross Sea
2. South Shetland Is
3. S. Orkney Is
4. S. Georgia Is
5. Macquarie Island
6. Davis Station
7. Syowa Station
8. Dumont d'Urville Sea
9. Crozet Island
10. Balleny Is
11. Antarctic Peninsula
12. Weddell Sea
13. Mainly from the Indian Ocean (IWC Areas III and IV)
14. Marion Is
15. Kerguelen Is

(b) Penguin species: A - Adélie, C - Chinstrap, M - Macaroni/Royal, G - Gentoo

(c) Petrel species: CP - Cape petrel, AP - Antarctic petrel

Table 3: Summary of Members' directed research on predator parameters 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)
PENGUINS		
- Foraging areas	Chile, Japan USA, South Africa	Australia (1990/91)
- Energy requirements	USA, UK, Germany	UK (1990/91)
- Seasonal movements	South Africa	
- Relationships between monitored parameters and physical environment (e.g. distribution and structure of sea ice and frontal systems)	Chile UK/USSR USA South Africa (Frontal systems)	Australia (1990/91) UK (1992/93)
FUR SEALS		
- Local abundance/population structure	Argentina, Chile, UK, USA	Brazil Chile (1990/91)
- Energy requirements/life history	UK	USA (1991/92)
- Foraging areas	Chile, USA	UK (1992/93) Japan (1990/91, with USA)
- Relationships between monitored parameters and physical environment (e.g. distribution and structure of sea-ice and frontal systems)	Chile (partial), USA UK/USSR	
CRABEATER SEALS		
- Foraging areas	USA	USA (1991/92, with Sweden)
- Energy requirements/life history	USA, Sweden	USA (1991/92)
- Stock discreteness/seasonal movements	USA	USA (1991/92, with Sweden)
- Relationships between monitored parameters and physical environment (e.g. distribution and structure of sea-ice and frontal systems)	USA	

APPENDIX A

AGENDA

Working Group for the
CCAMLR Ecosystem Monitoring Program
(Santa Cruz de Tenerife, Spain, 5 to 13 August 1991)

1. Opening of the Meeting

2. Adoption of the Agenda

3. Review of Members' Activities
   - 3.1 Monitoring
   - 3.2 Directed Research
   - 3.3 Plans for Future Field Work

4. Monitoring Procedures
   - 4.1 Predator Monitoring
     - 4.1.1 Sites and Species
       - 4.1.1.1 Proposals for Site Protection
       - 4.1.1.2 Other Proposals
     - 4.1.2 Proposals for New Procedures
       - 4.1.2.1 Data Collection Methods
       - 4.1.2.2 Processing/Analysis Methods
       - 4.1.2.3 Reporting Formats and Requirements
     - 4.1.3 Field Research Procedures
   - 4.2 Prey Monitoring
     - 4.2.1 Review of WG-Krill and SGSD Reports
     - 4.2.2 Other Species
   - 4.3 Environmental Monitoring
     - 4.3.1 Land-Based Observations
     - 4.3.2 Remote Sensing

5. Ecosystem Assessment
   5.1 Review of Monitoring Results
      5.1.1 Predator Data
      5.1.2 Prey Data
      5.1.3 Environmental Data
   5.2 Formulation of Advice and Recommendations to the Scientific Committee

6. Estimates of Prey Requirements for Krill Predators
   6.1 Review of Current Information
   6.2 Status of Proposed Workshop

7. General Matters
   7.1 Approaches to Integrated Analyses of Predator/Prey/Environmental Data
   7.2 Review of Opportunities for Collaborative CEMP Studies
   7.3 Workshop on the Feeding Ecology of Southern Baleen Whales
   7.4 Workshop on Southern Elephant Seals
   7.5 CCAMLR Scheme of International Scientific Observation
   7.6 New and Developing Fisheries

8. Other Business

9. Summary of Recommendations and Advice

10. Adoption of the Report

11. Close of the Meeting.

APPENDIX B

LIST OF PARTICIPANTS

Working Group for the
CCAMLR Ecosystem Monitoring Program
(Santa Cruz de Tenerife, Spain, 5 to 13 August 1991)

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APPENDIX C

LIST OF DOCUMENTS

Working Group for the
CCAMLR Ecosystem Monitoring Program
(Santa Cruz de Tenerife, Spain, 5 to 13 August 1991)

WG-CEMP-91/1	AGENDA
WG-CEMP-91/2	LIST OF PARTICIPANTS
WG-CEMP-91/3	LIST OF DOCUMENTS
WG-CEMP-91/4	TEMPORAL AND SPATIAL SCALES FOR MONITORING CEMP PREDATOR PARAMETERS (WG-CEMP)
WG-CEMP-91/5	THE USE OF MORPHOMETRIC PARAMETERS FOR THE DETERMINATION OF SEX OF ADELIE PENGUINS K.R. Kerry, D.J. Agnew, J.R. Clarke and G.D. Else (Australia)
WG-CEMP-91/5 Rev. 1	THE USE OF MORPHOMETRIC PARAMETERS FOR THE DETERMINATION OF SEX OF ADELIE PENGUINS K.R. Kerry, D.J. Agnew, J.R. Clarke and G.D. Else (Australia)
WG-CEMP-91/6	CHANGES TO STANDARD METHODS REQUIRED BY THE INCLUSION OF GENTOO PENGUIN Secretariat
WG-CEMP-91/7	DRAFT MANAGEMENT PLAN FOR THE PROTECTION OF SEAL ISLANDS, SOUTH SHETLAND ISLANDS, AS A SITE INCLUDED IN THE CCAMLR ECOSYSTEM MONITORING PROGRAM Delegation of the USA
WG-CEMP-91/8	A PROPOSAL FOR CEMP PREDATOR PARAMETER INDICES Secretariat
WG-CEMP-91/9	ACQUISITION AND ARCHIVING OF SATELLITE IMAGERY OF SEA-ICE DISTRIBUTION Data Manager (CCAMLR)
WG-CEMP-91/10	DEVELOPMENT OF THE CCAMLR ECOSYSTEM MONITORING PROGRAM 1985 TO 1991 Secretariat
WG-CEMP-91/11	AMLR 1990/91 FIELD SEASON REPORT Delegation of the USA

WG-CEMP-91/12	REPORT OF THE WORKSHOP ON SOUTHERN ELEPHANT SEALS SCAR Group of Specialists on Seals
WG-CEMP-91/13	TEMPORAL VARIABILITY IN ANTARCTIC MARINE ECOSYSTEMS: PERIODIC FLUCTUATIONS IN THE PHOCID SEALS J.W. Testa *et al.* (USA)
WG-CEMP-91/14	SURVEYS OF BREEDING PENGUINS AND OTHER SEABIRDS IN THE SOUTH SHETLAND ISLANDS, ANTARCTICA JANUARY-FEBRUARY 1987 W.D. Shuford and L.B. Spear (USA)
WG-CEMP-91/15	CCAMLR/IWC WORKSHOP ON THE FEEDING ECOLOGY OF SOUTHERN BALEEN WHALES PROGRESS REPORT Secretariat
WG-CEMP-91/16	INTERACTIONS OF ANTARCTIC MARINE MAMMALS AND BIRDS WITH FISHERIES K.-H. Kock (Germany)
WG-CEMP-91/17	MYCTOPHIDS IN THE DIET OF ANTARCTIC PREDATORS E. Sabourenkov (CCAMLR Secretariat)
WG-CEMP-91/18	DIVING PATTERN AND PERFORMANCE IN RELATION TO FORAGING ECOLOGY IN THE GENTOO PENGUIN, *PYGOSCELIS PAPUA* T.D. Williams *et al.* (UK)
WG-CEMP-91/19	DIVING PATTERNS AND PROCESSES IN EPIPELAGIC AND BENTHIC FORAGING SUB-ANTARCTIC SEABIRDS T.D. Williams *et al.* (UK)
WG-CEMP-91/20	ANNUAL VARIATION IN RETURN RATE, MATE AND NEST-SITE FIDELITY IN BREEDING GENTOO AND MACARONI PENGUINS T.D. Williams and S.R. Rodwell (UK)
WG-CEMP-91/21	AGE DISTRIBUTION OF BREEDING FEMALE ANTARCTIC FUR SEALS IN RELATION TO CHANGES IN POPULATION GROWTH RATE I.L. Boyd *et al.* (UK)
WG-CEMP-91/22	PUPPING-SITE FIDELITY OF ANTARCTIC FUR SEALS AT BIRD ISLAND, SOUTH GEORGIA N.J. Lunn and I.L. Boyd (UK)

WG-CEMP-91/23 DIVING BEHAVIOUR OF LACTATING ANTARCTIC FUR SEALS
I.L. Boyd and J.P. Croxall (UK)

WG-CEMP-91/24 TIME BUDGETS AND FORAGING CHARACTERISTICS OF LACTATING ANTARCTIC FUR SEALS
I.L. Boyd *et al.* (UK)

WG-CEMP-91/25 KRILL CATCHES AND CONSUMPTION BY LAND-BASED PREDATORS IN RELATION TO DISTANCE FROM COLONIES OF PENGUINS AND SEALS IN THE SOUTH SHETLANDS AND SOUTH ORKNEYS, 1987-1990
D.J. Agnew (Secretariat)

WG-CEMP-91/26 INVESTIGATION OF THE MARINE LIVING RESOURCES IN ANTARCTIC WATERS: A COLLECTION OF SHORT PAPERS
Delegation of the USA

WG-CEMP-91/27 PROSPECTS FOR A WORKSHOP ON METHODS TO STUDY AT-SEA BEHAVIOR OF MARINE MAMMALS AND BIRDS
J.L. Bengtson, Convener, WG-CEMP

WG-CEMP-91/28 INCREASES IN ANTARCTIC PENGUIN POPULATIONS: REDUCED COMPETITION WITH WHALES OR A LOSS OF SEA-ICE DUE TO ENVIRONMENTAL WARMING?
W.R. Fraser *et al.* (USA)

WG-CEMP-91/29 CENSUS TECHNIQUES FOR GREY SEAL POPULATIONS
A.J. Ward *et al.* (UK)

WG-CEMP-91/30 MIXED FUNCTION OXIDASE ACTIVITY AND CHLORINATED HYDROCARBON RESIDUES IN ANTARCTIC SEABIRDS: SOUTH POLAR SKUA (*CATHARACTA MACCORMICKI*) AND ADELIE PENGUIN (*PYGOSCELIS ADELIAE*)
S. Focardi *et al.* (Italy)

WG-CEMP-91/31 IDENTIFICATION OF SEX OF ADELIE PENGUINS FROM OBSERVATION OF INCUBATING BIRDS
K.R. Kerry *et al.* (Australia)

WG-CEMP-91/32 ESTIMATION OF PRIMARY ORGANIC MATTER PRODUCTION INTENSITY AND ITS INTERANNUAL CHANGEABILITY IN THE COOPERATION SEA REGION
A.T. Kochergin (USSR)

WG-CEMP-91/33 FORAGING BEHAVIOR AND REPRODUCTIVE SUCCESS IN CHINSTRAP PENGUINS: THE EFFECTS OF TRANSMITTER ATTACHMENT
Delegation of the USA

WG-CEMP-91/34 ACTIVITIES RELATED TO CEMP
Delegation of Spain

WG-CEMP-91/35 MODELING THE ENERGETICS OF ADELIE PENGUIN POPULATIONS
Delegation of the USA

WG-CEMP-91/36 COMMENTS OF WG-CEMP-91/8 BY DR P. ROTHERY (BAS)

WG-CEMP-91/37 ESTIMATES OF PREY REQUIREMENTS FOR KRILL PREDATORS
J. Croxall (UK)

OTHER DOCUMENTS

WG-KRILL-91/7 CHARACTERISTICS OF KRILL SWARMS FROM PRYDZ BAY
D.J. Agnew (Secretariat) and I.R. Higginbottom (Australia)

WG-KRILL-91/9 FINE-SCALE CATCHES OF KRILL IN AREA 48 REPORTED TO CCAMLR 1989 TO 1990
Secretariat

WG-KRILL-91/10 ON CONSTRUCTION OF MULTIDISCIPLINARY AND STOCK ASSESSMENT SURVEYS AS WELL AS ON COLLECTION OF MATERIAL ON *EUPHAUSIA SUPERBA* AND ENVIRONMENTAL CONDITIONS IN THE FISHING AREAS AND ADJACENT WATERS
R.R. Makarov and V.V. Maselnnikov (USSR)

WG-KRILL-91/11 PECULIARITIES OF *EUPHAUSIA SUPERBA* SIZE COMPOSITION IN STATISTICAL SUBAREA 48.2 (SOUTH ORKNEY ISLANDS)
V.I. Latogursky and R.R. Makarov (USSR)

WG-KRILL-91/12 REPORT OF THE BIOLOGIST-OBSERVER FROM THE COMMERCIAL TRAWLER *GRIGORY KOVTUN*, SEASON 1989/90
A.V. Vagin (USSR)

WG-KRILL-91/14 OCEANIC CONDITION AND ZOOPLANKTON DISTRIBUTION/ABUNDANCE IN BRANSFIELD STRAIT DURING AUSTRAL SUMMER 1989/90
S.M. Kim and M.S. Suk (Korea)

WG-KRILL-91/15 ESTIMATION OF KRILL (*EUPHAUSIA SUPERBA*) MORTALITY AND PRODUCTION RATE IN THE ANTARCTIC PENINSULA REGION
Delegation of Germany

WG-KRILL-91/22 KRILL (*EUPHAUSIA SUPERBA*) DISTRIBUTION IN RELATION TO WATER MOVEMENT AND PHYTOPLANKTON DISTRIBUTION OFF THE NORTHERN SOUTH SHELTAND ISLANDS
Delegation of Japan

WG-KRILL-91/23 BRIEF REPORT OF THE SIXTH ANTARCTIC SURVEY CRUISE OF JFA R/V *KAIYO MARU*
Mikio Naganobu, Taro Ichii and Haruto Ishii (Japan)

WG-KRILL-91/27 KRILL AGGREGATION CHARACTERISTICS IN SOUTH ORKNEY ISLAND AREA IN APRIL 1990
P.P. Fedulov *et al.* (USSR)

WG-KRILL-91/34 KRILL DISTRIBUTIONS AND THEIR DIURNAL CHANGES
M. Godlewska and Z. Klusek (Poland)

WG-KRILL-91/37 CPUES AND BODY LENGTH OF ANTARCTIC KRILL WITHIN COMMERCIAL HAULS OF POLISH TRAWLER FV *LEPUS* IN THE FISHING GROUND OFF SOUTH ORKNEYS IN JANUARY AND FEBRUARY 1991
I. Wójcik and R. Zaporowski (Poland)

WG-KRILL-91/38 VOLUMETRIC ANALYSES OF ANTARCTIC MARINE ECOSYSTEM DATA
Delegation of the USA

WG-KRILL-91/39 CHILEAN KRILL FISHERY: ANALYSIS OF THE 1991 SEASON
Victor H. Marín *et al.*

CCAMLR-X/6 NEW AND DEVELOPING FISHERIES
Executive Secretary

CCAMLR-X/7 CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION
Executive Secretary

SC-CAMLR-X/4 REPORT OF THE THIRD MEETING OF THE WORKING GROUP ON KRILL
(Yalta, USSR, 22 to 30 July 1991)

APPENDIX D

REPORTS OF MEMBERS' ACTIVITIES WITH REGARD TO CEMP

This appendix contains descriptions of Members' activities in relation to CEMP that were either submitted to the meeting by participants (reports of Australia, Italy, Japan, Korea, Norway, Spain, Sweden, USSR, UK and USA) or by correspondence with the Convener (Germany and New Zealand).

2. Australia has two major programs that concern CEMP. The first, the 'Prydz Bay Adélie penguin/prey stock interaction program', investigates the predator-prey interaction in the Adélie penguin population of Magnetic Island, Princess Elizabeth Land, and its food sources in Prydz Bay. The following parameters are being studied: A1, A2, A3, A5, A6, A7 and A8. In addition nest-specific survival, chick growth rates, energy budgets, diving behaviour and foraging location are being investigated. Data for some parameters have been collected at the site since 1980/81 and the data are expected to be made available to CEMP at the completion of the current research project (1992/93).

3. The second Australian project is the deployment at Béchervaise Island near Mawson Station of an automated system for weighing and recording tagged birds within breeding colonies. The system will be used to monitor Adélie penguins, in accordance with CEMP Standard Methods.

4. The program has the following elements: installation, testing, modification and calibration of the existing automated monitoring system; development of methods for determining sex of birds of all ages but particularly chicks; evaluation of the performance of the birds when carrying various accoutrement associated with the program including flipper bands, electronic tags glued to feathers, radio or satellite tracking devices etc.; evaluation of the results obtained by the automated system by comparison with similar data gathered by manual means as described in the CEMP Standard Methods; studies on the food and foraging area by satellite tracking of the birds in the monitored colony; evaluation of new tagging systems including implanted tags for ease of operation, for least trauma to the birds and least effect on the monitored parameter; and installation of the full monitoring system at a number of additional sites along the coast, initially at Davis and Mirny.

5. Additional routine monitoring has been conducted on Béchervaise Island, near Mawson Station, MacRobertson Land, during the 1989/90 and 1990/91 seasons. Data from the project have been submitted to CCAMLR.

6. Germany continues directed research in the Antarctic Peninsula area on the at-sea diving behaviour of Adélie and gentoo penguins. At Ardley Island modelling of the energetics of locomotion and the food requirement of penguins and studies on the relationship between monitored parameters and the physical environment are currently underway. Studies on foraging areas are planned for the future. The feasibility of collecting data for predator parameters A5 (Adélies) and A1 to A8 (gentoos) at Ardley Island is currently being evaluated. Data on abundance of the gentoo and Adélie penguins are available for the last 10 years.

7. Studies by Italy in 1990/91 of interest to CEMP were concentrated on the time-space variability of zooplankton communities in the Strait of Magellan, focusing on their species composition and ecological differences. During the next two to three years zooplankton research will be directed at modelling and system analysis of upper levels of the planktonic food chain in this area and the investigation of pelagic living resources, particularly of *Euphausia superba*, in the Ross Sea using hydroacoustic methods.

8. Italy is using biomarkers to evaluate the exposure to, and long-term ecological effects of contaminants on Antarctic organisms. Attention is focused on higher vertebrates, particularly birds and mammals, belonging to the upper trophic levels of the marine food chain, and consequently more exposed to damage from xenobiotic elements. Studies on Adélie penguin and South Polar skua were conducted in Ross Island in cooperation with New Zealand.

9. Japan continues to monitor the annual trends in breeding population size of Adélie penguins near Syowa Station. In the 1990/91 season, a survey of krill distribution in the vicinity of the South Shetland Islands and Elephant Island together with the collection of data on some hydrological parameters was conducted by the RV *Kaiyo Maru*. At the same time, the foraging areas of fur seals and penguins breeding ashore at Seal Island were investigated in collaboration with US scientists. A Japanese scientist also participated with Australian scientists in a survey of the zooplankton in the Prydz Bay area in the 1990/91 season.

10. 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 on survey design will continue. Japan intends to continue cooperative work on CEMP monitoring and directed research with US scientists.

11. Korea conducted a meso-scale multidisciplinary survey between December 1990 and January 1991 to investigate the changes and fluctuation in the distribution and the biomass of marine organisms. A total of 37 stations were chosen from Bransfield Strait and Gerlache Strait. Bacteria, phytoplankton, micro-zooplankton, zooplankton and benthos were collected. Samples are presently being analyzed. Preliminary results show low biomass of micro-phytoplankton but high biomass of nano-phytoplankton. Of the microzooplankton, flagellates were dominant, ranging from 10^2 to 10^4 cells/ml.

12. It was noted that several New Zealand research projects were under way at Ross Island, investigating foraging behaviour of Adélie penguins, and the effects of tagging on penguin foraging performance. In association with a US collaborator, research into factors affecting the foraging trips of Adélie penguins during the incubation period is underway. This work has included behavioural observations, manipulations of physiological status prior to foraging, assaying levels of steroid hormones from blood samples and the use of satellite telemetry to monitor the movements of penguins at sea. During the 1990/91 season the feeding behaviour of chicks was investigated in cooperation with US scientists. Satellite transmitters to track the movements of penguins during the winter period were also deployed.

13. Norway does not conduct any routine monitoring of CEMP parameters directly. However, a Norwegian expedition monitored the populations of seals and penguins on Bouvetøya (Bouvet Island) in December/January 1989/90. The penguin numbers were estimated by counts from aerial photographs and direct counts in 4 to 5 m transects by walking through the colonies. Populations of fur seal and elephant seal were also monitored and for all colonies except at Nyrøysa, counts were done from aerial photographs. Results indicated that since the previous censuses in 1979/80 elephant seal abundance has declined whereas the breeding population of Antarctic fur seals has increased.

14. Norwegian scientists investigated the diet of penguins and seals at Bouvetøya. Samples of stomach contents of chinstrap and macaroni penguins were collected using a stomach pump (five samples from each species). Faeces were collected from 21 fur seals. In addition, investigations were carried out on small petrels to identify species and their population sizes.

15. During the 1990/91 austral summer, Spain conducted a CEMP related program at Deception Island (South Shetlands). Investigations mainly focused on reproductive strategies

of chinstrap penguins (*Pygoscelis antarctica*). The specific investigations carried out were sex determination using discriminant analysis, breeding success studies, genetics studies and blood analyses.

16. A prey survey was conducted by Spain near the South Orkney Islands (Subarea 48.2) in January and February 1991. The aim of the survey was to evaluate the state of fish stocks occurring in this subarea using the ‘swept area method’. The results of the cruise will be submitted to the next meeting of the CCAMLR Working Group on Fish Stock Assessment.

17. Sweden does not currently participate in routine monitoring as part of CEMP. However, it is conducting research at South Georgia on southern elephant seals and king penguins, in collaboration with the UK, and studies of crabeater seals in collaboration with the US.

18. The elephant seal research (currently in its fourth year) involves work on reproductive energetics and behaviour, demography, foraging behaviour and diet, genetics and pollutants (see WG-CEMP-91/12, Appendix 4). The project on king penguins, due to commence in 1992, will focus on breeding and foraging strategies.

19. The crabeater seal research includes work on vital population parameters pertinent for evaluation and modelling of population dynamics of phocid seals. The studies focus on establishing better criteria for estimating age specific fertility rates including mean age at first parturition, and causes for sterility in older year classes.

20. The CEMP-related work of the Soviet Union includes surveys of krill and fish as predators of krill around Prydz Bay, Lazarev Sea and Enderby Land (SC-CAMLR-IX, Annex 4, paragraphs 27 and 28). These surveys have been performed each year since 1986. The Soviet Delegation indicated that the results, which will include an analysis of the relative consumption of *Euphausia crystallorophias* and *E. superba* by fish will be presented at a future WG-CEMP meeting. In addition, two krill surveys will be performed around the South Shetlands and South Georgia (1991/92) and will include an investigation of fish as predators of krill. The collection of haul-by-haul and biological data from the krill fishery will continue in the 1991/92 seasons with at least two observers being present on commercial krill vessels.

21. The United Kingdom land-based research in support of CEMP is conducted at Signy Island, South Orkney Islands, and Bird Island, South Georgia. At Signy Island, parameters A3 and A6 are monitored for Adélie, chinstrap and gentoo penguins, and breeding success

continues to be monitored for Cape (and snow) petrels. At Bird Island, parameters currently monitored are A1, A3, A6, A7, A8 (macaroni penguin), A3, A6, A7, A8 (gentoo penguin), B1 to B3 (black-browed albatross), C1 and C2 (Antarctic fur seal). In addition, comprehensive demographic programs are conducted annually on grey-headed and wandering albatrosses and Antarctic fur seal. Some standardized demographic data are obtained annually for gentoo and macaroni penguins.

22. There are currently no bird or seal research programs at Signy Island. The current Bird Island penguin research program was concluded in early 1991. Of the papers tabled last year, WG-CEMP-90/13, 16, 17, 18 (on inter-annual variation in breeding chronology and biology and chick fledging weight and intra-annual variation in diet) are now published. New material of particular interest to CCAMLR concerns at-sea diving and activity budgets (WG-CEMP-91/18, 19) and inter-annual variation in survival and mate and site fidelity (WG-CEMP-91/20) in penguins.

23. The field component of the project on reproductive performance of fur seals was completed in 1991; initial outputs from this concern population age structure (WG-CEMP-91/21) pupping and site fidelity (WG-CEMP-91/22). Of particular relevance to CEMP are detailed analyses of relationships between time and activity budgets at sea and foraging-attendance cycle duration (WG-CEMP-91/24) and studies of diving pattern and performance (WG-CEMP-91/23).

24. Studies of activity-specific energy budgets of fur seals, gentoo penguins and albatrosses started in 1991. Further research on black-browed albatross at-sea activity budgets and chick growth patterns ashore will be conducted in 1993 as a prelude to more extensive research in conjunction with the predator-prey research cruise in 1994.

25. Although there has been no UK research aimed at CEMP prey monitoring, surveys around South Georgia in January/February 1991 provided observations that give an indication of the status of krill in this area. In general, krill standing stock was low at this time, particularly at the west end of the island. The largest krill concentrations were found off the northeast coast.

26. Results from a UK fish stock assessment survey around South Georgia in January/February 1991 indicated that the standing stock of icefish, *Champsocephalus gunnari*, was approximately one quarter of last year's level. Although krill is a major component in the diet of icefish only a small proportion of these fish (about 20%) were feeding on krill suggesting that krill were scarce during the period of the survey.

27. United States CEMP related activities in 1990/91 consisted of three components:

(i) land-based predator studies at Seal Island, near Elephant Island and at Palmer Station, Anvers Island;

(ii) predator tracking studies in collaboration with Japanese and Chilean scientists; and

(iii) repeated surveys of hydrographic conditions, phytoplankton production, and krill distribution in the waters surrounding Elephant Island.

28. At Seal Island, directed research and monitoring activities were conducted on fur seals, chinstrap penguins, and macaroni penguins. The following parameters were monitored: A5, A6a and c, A7, A8, A9, C1 and C2. In addition, directed research was completed on foraging areas for seals and penguins, energy requirements of penguins, relationships between krill predators and physical environment (e.g. sea-ice, frontal systems), and crabeater seal satellite telemetry.

29. Fur seals and macaroni and chinstrap penguins at Seal Island were instrumented with radio transmitters and time/depth recorders and followed during foraging trips to sea. This collaborative work was conducted aboard the Japanese research vessel *Kaiyo Maru* (in January) and the Chilean research vessel *Alcazar* (in February). Complementary observations of the distribution of prey were obtained with acoustic equipment and plankton nets.

30. At Palmer Station, parameters A5, A6a and c, A7, A8 and A9 were monitored for Adélie penguins. A Long-Term Ecological Research (LTER) project, soon to be initiated at this station, will investigate the interactions between oceanographic features, predators (including Adélie penguins and skuas) and prey (krill and *Pleuragramma antarcticum*). This project is expected to generate an entire suite of new predator parameters.

31. Two 30-day cruises were conducted aboard the NOAA Ship *Surveyor* from mid-January to mid-March, 1991. Chlorophyll-*a* concentrations, primary production rates, organic carbon concentrations, phytoplankton species compositions, nutrient concentrations, and solar irradiance were measured and mapped around Elephant, King George, and Clarence Islands. In addition, the distribution and abundance of krill were measured with acoustic instrumentation.

32. Anticipated field work in 1991/92 will include penguin and fur seal monitoring at Seal Island and at Palmer Station. Shipboard surveys of hydrographic conditions, phytoplankton production, krill distribution and abundance, and krill demography will be conducted around Elephant Island. Other studies may include detailed mapping of selected krill aggregations and a census of fur seal and seabird colonies in the South Shetland Islands.

APPENDIX E

TEMPORAL AND SPATIAL SCALES FOR MONITORING CEMP PREDATOR PARAMETERS (WG-CEMP)

Summary of temporal and spatial scales relevant to monitoring
of land-based predators, using approved Standard Methods
in each of the Integrated Study Regions.
Updated at the 1991 meeting of WG-CEMP.

Parameter[1]	Integrated Study Region	Species	Time of Year of Measurement[2]	Duration of Measurement[3]	Integration Period[4]	Foraging Range/Area[5] (km)	Foraging Depth Mean (m)	Foraging Depth Max (m)	Comments
A1 Adult Arrival Weight	Prydz Bay	Adelie	15-30 October	20 days	6-7 months	100s	30	175	
	Antarctic Peninsula	Adelie (A*)	1 Oct - 30 Oct	20 days	6-7 months	100s	30-50	~ 100	
		(B**)	20 Oct	1 day	6-7 months	100s	30-50	~ 100	
		Chinstrap (A)	23 Oct - 12 Nov	20 days	6-7 months	100s	40	120	
		(B)	~ 2 Nov	1 day	6-7 months	100s	40	120	
		Macaroni (A)	15 Oct - 5 Nov (M) 22 Oct - 11 Nov (F)	20 days	6-7 months	100s	40 ~ 100		
		(B)	~ 20 Oct (M) ~ 8 Oct (F)	1 day	6-7 months	100s	40 ~ 100		
	South Georgia	Macaroni (A)	14 Oct - ~ 5 Nov	1 day each	6-7 months	100s	20-30	150	
		(B)	~ 28 Oct ~ 8 Nov						
A2 Duration of First Incubation Shift	Prydz Bay	Adelie	Nov - Dec	8-20 days	7-8 months	~ 100-150	30	175	
	Antarctic Peninsula	Adelie	20 Oct - 15 Nov	8-20 days	7-8 months	~ 100	30-50	~ 100	
		Chinstrap	20 Nov - 5 Dec	5-10 days	7-8 months	25-50	40	120	
		Macaroni	15 Nov - 5 Dec (M) 1 Dec - 20 Dec (F)	~ 15 days	7-8 months	25-50	40 ~ 100		
	South Georgia	Macaroni	23 Nov - 6 Dec	9-12 days	7-8 months	50-100?	20-30	150	

Parameter[1]	Integrated Study Region	Species	Time of Year of Measurement[2]	Duration of Measurement[3]	Integration Period[4]	Foraging Range/Area[5] (km)	Foraging Depth Mean (m)	Foraging Depth Max (m)	Comments
A3 Breeding Population Size	Prydz Bay	Adelie	22 Oct - 15 Nov	1 week	> 1 year	100s	30	175	
	Antarctic Peninsula	Adelie	27 Oct - 15 Nov	1 day	> 1 year	100s	30-50	~ 100	
		Chinstrap	15 Nov - 5 Dec	1 day	> 1 year	100s	40	120	
		Macaroni	15 Nov - 5 Dec	1 day	> 1 year	100s	40	~ 100	
		Gentoo							
	South Georgia	Macaroni	~ 30 Nov	1 day	> 1 year	100s	20-30	150	
		Gentoo							
A4 Age Specific Survival	Prydz Bay	Adelie					30	175	
	Antarctic Peninsula	Adelie							
		(A)	15 Oct - 15 Nov	2 months	1 year	100s	30-50	~ 100	
		(B)	15 Oct - 5 Feb	4.5 months	1 year	100s	30-50	~ 100	
		Chinstrap							
		(A)	23 Oct - 5 Dec	2.5 months	1 year	100s	40	120	
		(B)	23 Oct - 2 Feb	4.5 months	1 year	100s	40	120	
		Macaroni							
		(A)	15 Oct - 5 Dec	2 months	1 year	100s	40 ~ 100		
		(B)	15 Oct - 15 Feb	4 months	1 year	100s	40 ~ 100		
		Gentoo							
	South Georgia	Macaroni	14 Oct - Feb	3-4 months	1 year	100s	20-30	150	
		Gentoo							

Parameter[1]	Integrated Study Region	Species	Time of Year of Measurement[2]	Duration of Measurement[3]	Integration Period[4]	Foraging Range/Area[5] (km)	Foraging Depth Mean (m)	Foraging Depth Max (m)	Comments
A5 Foraging Trip Duration	Prydz Bay	Adelie	December - February	2 months	2 months	50	30	175	
	Antarctic Peninsula	Adelie	10 Dec - 5 Feb	2.5 months	2.5 months	50	30-50	~ 100	
		Chinstrap	1 Jan - 15 Feb	2 months	2 months	25	40	120	
		Macaroni	1 Jan - 15 Feb	2 months	2 months	35	40 ~ 100		
	South Georgia	Macaroni	January - February	2 months	2 months	50	20-30	150	
A6 Breeding Success	Prydz Bay	Adelie	October - February	2 months	~ 4 months	100s	30	175	
	Antarctic Peninsula	Adelie							
		(A)	25 Dec - 7 Jan	1 day	1 year	100s	?	?	
		(B)	20 Oct - 15 Jan	2 months	2 months	100s	?	?	
		(C)	20 Oct - 15 Jan	2 months	2 months	100s	?	?	
		Chinstrap							
		(A)	15 - 21 Jan	1 day	1 year	100s	40	120	
		(B)	15 Nov - 1 Feb	2 months	2.5 months	25	40	120	
		(C)	15 Nov - 1 Feb	2 months	2.5 months	25	40	120	
		Macaroni							
		(A)	10 Jan - 30 Jan	1 day	1 year	100s	40 ~ 100		
		(B)	15 Nov - 30 Jan	2 months	2.5 months	35	40 ~ 100		
		(C)	15 Nov - 30 Jan	2 months	2.5 months	35	40 ~ 100		
		Gentoo							
	South Georgia	Macaroni							
		(C)	~ 16 Feb	1 day	3 months	50 - 100	20-30	150	
		Gentoo							

Parameter[1]	Integrated Study Region	Species	Time of Year of Measurement[2]	Duration of Measurement[3]	Integration Period[4]	Foraging Range/Area[5] (km)	Foraging Depth Mean (m)	Foraging Depth Max (m)	Comments
A7 Chick Fledging Weight	Prydz Bay	Adelie	February	3-4 weeks	2 months	50	30	175	
	Antarctic Peninsula	Adelie							
		(A)	15 Jan - 10 Feb	25 days	2 months	50	30-50	~ 100	
		(B)	~ 30 Jan	1 day	2 months	50	30-50	~ 100	
		Chinstrap							
		(A)	1 Feb - 28 Feb	25 days	2 months	25	40	120	
		(B)	10 Feb - 25 Feb	1 day	2 months	25	40	120	
		Macaroni							
		(A)	10 - 20 Feb	25 days	2 months	35	40 ~ 100		
		(B)	~ 14 Feb	1 day	2 months	35	40 ~ 100		
		Gentoo							
	South Georgia	Macaroni	~18 Feb	1 day	2 months	50	20-30	150	
		Gentoo							
A8 Chick Diet	Prydz Bay	Adelie	Jan - Feb	2 months	2 months	50	30	175	
	Antarctic Peninsula	Adelie (A,B)	10 Dec - 30 Jan	2 months	2 months	50	30-50	~ 100	
		Chinstrap (A,B)	1 Jan - 15 Feb	2 months	2 months	25	40	120	
		Macaroni (A,B)	1 Jan - 15 Feb	2 months	2 months	35	40 ~ 100		
	South Georgia	Macaroni	25 Jan - 15 Feb	1.5 months	1 month	50	20-30	150	

Parameter[1]		Integrated Study Region	Species	Time of Year of Measurement[2]	Duration of Measurement[3]	Integration Period[4]	Foraging Range/Area[5] (km)	Foraging Depth Mean (m)	Max (m)	Comments
B1	Breeding Population Size	South Georgia	Black-browed albatross	19 Oct - 11 Nov	1 month	> 1 year	100s - 1 000s			
B2	Breeding Success	South Georgia	Black-browed albatross	19 Oct - 9 May	7 months	7 months	100s			
B3	Age-Specific Annual Survival	South Georgia	Black-browed albatross	19 Oct - 11 Nov	1 month	1 year	100s - 1000s			
C1	Foraging Trip Duration	Antarctic Peninsula	Fur seal (A,B)	1 Dec - 10 Feb	60-70 days	60-70 days	25-250	25	120	
		South Georgia	Fur seal (A,B)	~ 5 Nov - ~ 20 March	80 - 100 days	80 - 100 days	20 - 100	30	150	
C2	Pup Growth	Antarctic Peninsula	Fur seal (A)	1 Dec - 30 Mar	120 days	120 days	25-250	25	120	
			(B)	10 Jan - 30 Mar	80 days	80 days	25-250	25	120	
		South Georgia	Fur seal (A)	~ 5 Dec - 30 Mar	110 days	110 days	20 - 100	30	150	
			(B)	~ 5 Jan - 5 Mar	60 days	60 days	20 - 100	30	150	

1 Use separate sheet for each parameter
2 Calendar date of start and finish
3 In days, months etc
4 Timespan over which parameter potentially integrates prey abundance/availability
5 Foraging range at the time of measuring parameter
* General Procedure A
** General Procedure B

CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION

CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION

Functions and Tasks of International Scientific Observers
On Board Commercial Fishing Vessels

The function of scientific observers on board commercial fishing vessels is to observe and report on the operation of fishing activities in the Convention Area with the objectives and principles of the Convention for the Conservation of Antarctic Marine Living Resources firmly in mind.

2. In fulfilling this function, scientific observers will undertake the following tasks or see that they are undertaken, using the observation formats appended to the Report of the Working Group on Fish Stock Assessment (Appendix D, Annex 6):

(i) record details of the vessel's operation (e.g. partition of time between searching, fishing, transit etc., and details of hauls);

(ii) record details of finfish and krill catches and take samples to determine biological characteristics;

(iii) record the procedures by which catch weight is measured and determine the conversion factor between green weight and final product;

(v) record by-catch species, their quantity and other biological data;

(vi) observe and record entanglement and incidental mortality of birds and mammals;

(vii) prepare reports of their observations.

ANNEX 9

SCIENTIFIC COMMITTEE BUDGET FOR 1992
AND FORECAST BUDGET FOR 1993

SCIENTIFIC COMMITTEE BUDGET FOR 1992 AND FORECAST BUDGET FOR 1993

The Scientific Committee's program is mainly comprised of working group meetings and workshops for which a significant part of the expenditure is for translation and preparation for publication of reports. In order to minimize publication costs and to improve translation quality, both of these functions are carried out by contracted staff in the Secretariat. Thus, although the Scientific Committee's budget is presented as a list of distinct projects (e.g. working group meetings) some of the costs would be incurred whether or not particular projects were approved.

2. Annex 7 of SC-CAMLR-IX contains forecasts of funding requirements for the scientific program in 1992 and has been used as a basis for estimating expenditure in this item. The budgeted amount of A$129 700 includes allowance for the following:

1992		1993
	Working Group on Krill	
19 200	Meeting	21 100
6 400	Re-analysis of FIBEX data	10 000
	Ecosystem Monitoring Program	
22 100	Meeting	20 000
14 400	Pilot Study on acquisition of satellite imagery	15 000
400	Preliminary meeting on prey requirements of krill predators	0
0	Workshop on methodologies of at-sea energy budgets studies	6 000
	Working Group on Fish Stock Assessment	
26 000	Meeting	27 200
6 000	Workshop on demersal trawl survey design	0
33 100	Travel for Scientific Committee Program	34 600
3 500	Representation at ICES	0
6 700	Contingency	7 500
137 800	Sub Total	141 400
8 100	Less drawings from the Norwegian Contribution Special Fund	8 100
A$129 700	Total from Commission Budget	A$133 300

3. The Working Groups on Krill, CEMP and Fish Stock Assessment all met in 1991. These Working Groups will all need to meet in 1992. The budget of A$22 200 for CEMP includes an amount for translation and circulation of additions to the CEMP Standard Methods.

4. 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.

5. The Scientific Committee has supported a recommendation by WG-CEMP (SC-CAMLR-X, Annex 7, paragraph 9.5(ii)) that the Secretariat proceed with a pilot study involving the acquisition of satellite imagery of sea-ice distribution in the vicinity of CEMP sites. The Scientific Committee accepted the detailed proposal for this study prepared by the Secretariat as SC-CAMLR-X/7. The Scientific Committee understood that the proposal involved the acquisition of AVHRR (Advanced Very High Resolution Radiometry) data from two CEMP sites for a two month period, with images being obtained and processed every five days. The total cost of the pilot study is A$14 400.

6. The Scientific Committee has identified as a matter of priority the re-analysis of FIBEX acoustic data from Statistical Area 48. This would utilise the BIOMASS database and would involve computing facilities and consultant support of A$6 400.

7. The Scientific Committee has supported a proposal from the WG-FSA (SC-CAMLR-X, Annex 6, paragraph 9.6) that a workshop on survey design and the analysis of research vessel surveys, in particular aimed at resolving the problems in assessing fish stocks such as *Champsocephalus gunnari* in Subarea 48.3 (SC-CAMLR-X, Annex 6, paragraph 7.24) from demersal trawl surveys. Dr K.-H. Kock (Germany) has offered to host this workshop in June 1992 in Hamburg, Germany. The costs involved in the workshop will be for translating and printing only, A$6 000.

8. WG-CEMP has requested that contingency funds be made available to enable two or three scientists to meet for one day to consider the initial parameters necessary for the review of prey requirements for krill predators (SC-CAMLR-X, Annex 7, paragraph 9.5(ii)). The meeting would take place in conjunction with already scheduled meetings in July/September 1992 and would cost A$400.

9. WG-CEMP has also identified the need for a workshop on the methodologies used in investigation of at-sea activity budgets of birds and seals. The workshop would standardise sampling protocols, setup, use and data analysis from instruments used in these studies (SC-CAMLR-X, Annex 7, paragraph 4.46). The workshop would be held over two days probably in late 1993, and the Scientific Committee agreed that the cost of this workshop should be included in its 1993 forecast budget.