

SC-CAMLR-XIV

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

**REPORT OF THE FOURTEENTH MEETING
OF THE SCIENTIFIC COMMITTEE**

HOBART, AUSTRALIA
23 - 27 OCTOBER, 1995

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Abstract

This document presents the adopted record of the Fourteenth Meeting of the Scientific Committee for the Conservation of Antarctic Marine Living Resources held in Hobart, Australia, from 23 to 27 October 1995. Major topics discussed at this meeting include: the CCAMLR ecosystem monitoring program, krill, fish, crab and squid resources, marine mammal and bird populations, assessment of incidental mortality, ecosystem monitoring and management, and management under conditions of uncertainty. Reports of meetings and intersessional activities of subsidiary bodies of the Scientific Committee, including the Working Groups on Ecosystem Monitoring and Management and on Fish Stock Assessment, are appended.

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**REPORT OF THE FOURTEENTH MEETING
OF THE SCIENTIFIC COMMITTEE**
(Hobart, Australia, 23 to 27 October 1995)

OPENING OF THE MEETING

1.1 The Scientific Committee for the Conservation of Antarctic Marine Living Resources met under the Chairmanship of Dr K.-H. Kock (Germany) from 23 to 27 October 1995 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, Russian Federation, South Africa, Spain, Sweden, Ukraine, United Kingdom of Great Britain and Northern Ireland and United States of America.

1.3 The Chairman noted that Ukraine had become a full Member of the Commission since the last meeting.

1.4 The Chairman welcomed to the meeting observers from the Netherlands, Uruguay, the Antarctic and Southern Ocean Coalition (ASOC), the Food and Agriculture Organization of the United Nations (FAO), the World Conservation Union (IUCN), the International Whaling Commission (IWC), the Scientific Committee on Antarctic Research (SCAR) and the Scientific Committee on Oceanographic Research (SCOR) and encouraged them to participate in the meeting as appropriate.

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

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

- Mr T. Ichii (Japan), Fishery Status and Trends;
- Dr I. Everson (UK), Species Monitored in the CCAMLR Ecosystem Monitoring Program;
- Dr J. Croxall (UK), Assessment of Incidental Mortality and Squid Resources;
- Dr B. Fernholm (Sweden), Marine Mammal and Bird Populations;
- Dr D. Miller (South Africa), Krill Resources;
- Mr R. Williams (Australia), Fish Resources;
- Dr G. Watters (USA), Crab Resources;

- Dr G. Kirkwood (UK), Ecosystem Monitoring and Management;
- Dr W. de la Mare (Australia), Management under Conditions of Uncertainty about Stock Size and Sustainable Yield; and
- Dr D. Agnew (Secretariat), all other matters.

Adoption of the Agenda

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

Report of the Chairman

1.8 The Chairman noted that Members had continued their work during the intersessional period with several meetings taking place. The Chairman expressed his gratitude to Italy for hosting the meeting of the Working Group on Ecosystem Monitoring and Management (WG-EMM).

1.9 The inaugural meeting of WG-EMM took place from 24 July to 3 August 1995 in Siena, Italy, and was chaired by its Convener, Dr Everson. Two ad hoc subgroups associated with this Working Group also met during the intersessional period:

- (i) an ad hoc subgroup on CEMP statistics met in Cambridge, UK, on 16 January 1995 under the convenership of Dr Agnew; and
- (ii) an ad hoc subgroup, which has been working towards coordination of research in the Antarctic Peninsula, met in Hamburg, Germany, from 17 to 21 July 1995 under the co-convenership of Drs S. Kim (Republic of Korea), V. Siegel (EEC), M. Naganobu (Japan) and R. Hewitt (USA), for a workshop entitled 'Temporal Changes in Marine Environments in the Antarctic Peninsula'.

1.10 The Working Group on Fish Stock Assessment (WG-FSA) met in Hobart, Australia, from 10 to 18 October 1995, and was chaired by its Convener, Dr de la Mare.

1.11 A Workshop on Methods for the Assessment of *Dissostichus eleginoides* (WS-MAD), also chaired by Dr de la Mare, was held prior to the meeting of WG-FSA in Hobart, from 5 to 9 October 1995.

1.12 There was no meeting of the ad hoc Working Group on Incidental Mortality Arising from Longline Fishing (WG-IMALF). A coordinating group, led by the Convener of the Working Group, Prof. C. Moreno (Chile), conducted its work by correspondence. The Chairman thanked Prof. Moreno for his efforts during the year. Work on incidental mortality was incorporated into the assessments of WG-FSA.

1.13 The Chairman expressed his thanks to Conveners, Members, Rapporteurs and the Secretariat for contributing to the success of these meetings.

1.14 The report of WG-EMM is attached as Annex 4 and that of WG-FSA as Annex 5. The report of WS-MAD is appended to the report of WG-FSA as Appendix E.

1.15 The Scientific Committee was represented as an observer at the following international meetings during the intersessional period:

- 1995 Annual Meeting of the IWC Scientific Committee, 8 to 20 May 1995, Dublin, Ireland - Dr W. de la Mare (Australia);
- IWC Steering Committee for Research Related to the Conservation of Large Baleen Whales in the Southern Ocean, 7 to 10 March 1995, Tokyo, Japan - Dr I. Everson (UK);
- Sixteenth Session of the CWP, 20 to 25 March 1995, Madrid, Spain - Executive Secretary;
- APIS Planning Meeting, 7 to 9 June 1995, Seattle, USA - Dr I. Boyd (UK);
- ICES International Symposium on Fisheries and Plankton Acoustics, 12 to 16 June 1995, Aberdeen, UK - Dr Everson;
- NAFO/ICES Symposium on the Role of Marine Mammals in the Ecosystem (6 to 8 September 1995, Dartmouth, Nova Scotia, Canada - Dr T. Øritsland (Norway);
- 83rd Statutory Meeting of ICES, 21 to 29 September 1995, Aalborg, Denmark - Ms I. Lutchman (UK); and
- The First Steering Committee Meeting of the SCAR CS-EASIZ, 25 August 1995, Cambridge, UK - Dr M. Fukuchi (Japan).

FISHERY STATUS AND TRENDS

Krill

2.1 The total catch of krill for the 1994/95 season was 33% more than in 1993/94 and totalled 118 715 tonnes, as shown in Tables 1 and 2.

2.2 Monthly catch data were submitted in accordance with Conservation Measure 32/X by Japan, Poland and Ukraine. However one non-member (Panama), which fished within the Convention Area, did not meet the requirements set out in Conservation Measure 32/X.

2.3 Catches reported by Japan and Poland were of the same order as in previous seasons. The increase in the total catch was due to an increase in the catch reported by Ukraine from 8 708 tonnes in 1993/94 to 48 886 tonnes in 1994/95. One Panamanian vessel was reported to have caught 637 tonnes of krill from mid-June to mid-July in Subarea 48.3.

2.4 Dr Miller indicated that the reported catch of krill by Panama represented somewhat of a precedent, as it was the first time that the catch by a non-member had been reported directly to the Commission. Consequently, there was a need to draw Panama's attention to the various requirements and related monthly data reporting provisions concerning krill set out in Conservation Measure 32/X.

2.5 The Data Manager informed the Scientific Committee that the UK had notified the Secretariat of Panama's catches, although information on the Panamanian vessel had been initially notified by Uruguay (an Acceding State).

2.6 In accordance with Article X of the Convention, the Scientific Committee recommended that the Commission continue to encourage any State which is not a Party to CCAMLR to join the Commission and to comply with conservation measures currently in force.

Table 1: National krill landings (in tonnes) since 1986/87 based on STATLANT returns.

Country	Split-Year*								
	1987	1988	1989	1990	1991	1992	1993	1994	1995
Chile	4063	5938	5329	4501	3679	6066	3261	3834	0
Germany	0	0	0	396	0	0	0	0	0
Japan	78360	73112	78928	62187	67582	74325	59272	62322	60303
Latvia								71	0
Republic of Korea	1527	1525	1779	4040	1211	519	0	0	0
Panama	0	0	0	0	0	0	0	0	141
Poland	1726	5215	6997	1275	9571	8607	15911	7915	9384
Spain	379	0	0	0	0	0	0	0	0
USSR**	290401	284873	301498	302376	275495	0	0	0	0
Russia						137310	4249	965	0
South Africa								3	0
Ukraine						61719	6083	8708	48886
Total	376456	370663	394531	374775	357538	288546	88776	83818	118714

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

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

Table 2: Total krill catch in 1994/95 by area and country. The catch for 1993/94 is indicated in brackets.

Subarea /Area	Chile	Japan	Latvia	Poland	Russia	South Africa
41.3.2						
48.1	(3834)	29070 (41251)		1278 (0)		
48.2		10216 (7029)		6563 (6833)		
48.3		19751 (13143)		1543 (1082)	(965)	(3)
48.6						
48.?			(71)			
58.4.1		1266 (899)				
Total	(3834)	60303 (62322)	(71)	9384 (7915)	(965)	(3)

Subarea /Area	Ukraine	Panama	Total
41.3.2			
48.1	4677 (0)		35025 (45085)
48.2	32054 (5253)		48833 (19115)
48.3	12155 (3455)	141 (0)	33590 (18648)
48.6			
48.?			(71)
58.4.1			1266 (899)
Total	48886 (8708)	141 (0)	118714 (83818)

2.7 With regard to the substantial increase in the catch of krill in 1994/95 by Ukraine, WG-EMM noted that no plans for expanding krill fishing were reported by Ukraine at the Commission meeting in 1994. It also reiterated the importance of continuing a dialogue with fishing nations in order to understand trends in krill fishing and the distribution of catches over the Convention Area.

2.8 Dr V. Yakovlev (Ukraine) indicated that the slight increase in the number of vessels and more favourable conditions for the fishery brought about the substantial increase in the Ukrainian catch.

2.9 The Scientific Committee expressed its continued interest in knowing the plans of Members with respect to potential krill catch levels and fishing areas.

2.10 The Scientific Committee recalled that in previous years it had received reports of krill catches outside the Convention Area in an area immediately west of Subareas 48.2 and 48.3, i.e. FAO Statistical Division 41.3.2 (see Annex 4, paragraph 3.10). It recommended that the Commission continue to seek access to information on krill catches taken outside the Convention Area and that data on such catches should be included in the CCAMLR database.

2.11 Chile and Russia, both of which fished for krill in previous seasons, reported no krill fishing activities in 1994/95. Dr V. Marín (Chile) indicated that it is unlikely that Chile will resume krill fishing unless there is a change in the market situation. Dr K. Shust (Russia) indicated that the current economic situation in Russia is not conducive to krill fishing.

2.12 The Scientific Committee was informed that the fishing plans of Japan and Ukraine for 1995/96 were similar to the fishing operations of those countries last season.

Fish

2.13 The total reported catch of all finfish species in 1994/95 was 12 933 tonnes (SC-CAMLR-XIV/BG/1), which was similar to that of the last few years. In Subarea 48.3 (South Georgia) 3 241 tonnes of *D. eleginoides* was taken by four Members and one Acceding State. In Division 58.5.1 (Kerguelen) the total reported catch consisted of 3 936 tonnes of *Champscephalus gunnari* and 5 564 tonnes of *D. eleginoides*. In Subarea 58.6 catches of 115 tonnes of *D. eleginoides* were reported.

2.14 Dr de la Mare informed the Scientific Committee that Australia took 450 tonnes of *D. eleginoides* by trawling in waters adjacent to the Convention Area (i.e., near Macquarie Island). Australia has made the data available to the CCAMLR database.

2.15 For the forthcoming season, an Australian vessel will be licensed by the Australian Fisheries Management Authority to harvest *D. eleginoides* and *C. gunnari* in the Exclusive Economic Zone (EEZ) around Heard Island (Division 58.5.2) in accordance with the TACs set in Conservation Measure 78/XIII (CCAMLR-XIV/8).

2.16 In addition, the Australian vessel will explore the stocks of *Dissostichus* spp. on the submarine banks in the adjoining Division 58.4.3. As there are no records in the CCAMLR database of either fishing or research in this area, such an activity would constitute a new fishery according to the definition contained in Conservation Measure 31/X. The Scientific Committee's advice with regard to this new fishery is contained in section 8.

2.17 The Chilean Delegation stated that Chile has no intention to increase its fishing effort in 1995/96 compared to the previous season. It indicated, however, that although one Chilean company has shown an interest in fishing for *D. eleginoides* in Subarea 48.4, no catches have yet been reported for this subarea in the 1994/95 season.

2.18 French fishing activities will take place on the Kerguelen Island shelf in 1995/96, with the same number of cruises as in the 1994/95 season. The target species will be *D. eleginoides*, and the trawlers will be required to comply with new French management measures (Annex 5, paragraphs 5.169 to 5.172), in both traditional and new fishing grounds. Japan and France have preliminary plans for a joint longline survey to obtain information on *D. eleginoides* in deep water.

2.19 Two or three Ukrainian vessels intend to fish for *D. eleginoides* at Kerguelen if they receive approval from French authorities.

2.20 In 1995/96 the Republic of Korea plans to conduct similar levels of fishing for *D. eleginoides* in Subarea 48.3 as in the 1994/95 season.

2.21 The Argentinian Delegation informed the Scientific Committee that fishing by Argentina in the 1995/96 season will be conducted at similar levels to the 1994/95 season.

2.22 Dr Shust informed the Scientific Committee that at the moment there is no official information on fishing plans for 1995/96, but that one or two Russian vessels may operate in Subarea 48.3 depending on the available TAC.

2.23 Dr Miller informed the Scientific Committee that South African authorities were considering a number of applications to initiate a longline fishery for *D. eleginoides* on the South African

continental shelf, in areas adjacent to the continental shelf and in the EEZ of the Prince Edward Islands (Subarea 58.7) (CCAMLR-XIV/19) (see also paragraphs 8.7 to 8.9).

2.24 The US has expressed an interest in fishing for *D. eleginoides* in Subarea 48.3 but was unable to provide details of specific plans.

Crabs

2.25 Fishing for Antarctic crabs, *Paralomis spinosissima* and *P. formosa*, is now being carried out by one US vessel in Subarea 48.3. Dr Watters stated that the catch between 1 September 1995, when the fishery started, and 10 October 1995 was 79 tonnes (see Annex 4, paragraph 5.120).

2.26 Because the US crab fishery in Antarctic waters is still in the exploratory stage, plans for the 1995/96 season are uncertain but the US expects to continue fishing for crabs during part or all of the season.

Squid

2.27 There was no fishery for squid in the CCAMLR Convention Area in the 1994/95 season and no data on squid have been reported to the Secretariat.

DEPENDENT SPECIES

Species Monitored in the CCAMLR Ecosystem Monitoring Program

3.1 Dr Everson introduced the report of the first meeting of WG-EMM (Annex 4). The report covers all topics within the terms of reference for this Working Group agreed at the Thirteenth Meeting of the Scientific Committee (SC-CAMLR-XIII, paragraph 7.41). Sections of the report dealing with dependent species and with species specifically studied under the CCAMLR Ecosystem Monitoring Program (CEMP) were considered under this agenda item.

3.2 Recent and current CEMP-related activities are summarised in Annex 4, Appendix E. Reports on the initiation of CEMP research at new sites and on changes in CEMP research at existing sites are provided in Annex 4, paragraphs 5.2 to 5.13.

3.3 The Working Group welcomed the provision of information on CEMP-related programs from New Zealand for the first time. The Working Group regretted the continuing failure of France and Germany to send scientists and data from their active CEMP-related research programs on dependent species.

Scope of CEMP Activities

3.4 Data from CEMP sites have been submitted to the CEMP database by Argentina, Australia, Brazil, Chile, Italy, UK and USA. The Scientific Committee noted with pleasure that a joint Italian/Australian biological research program on Adélie penguins (*Pygoscelis adeliae*) had commenced during the 1993/94 season (Annex 4, paragraph 5.3). In addition, the USA informed WG-EMM of relevant long-term data from Anvers Island and Admiralty Bay, King George Island, and was requested to submit these as soon as possible.

3.5 New Zealand also has a long-term data set on the same species in the Ross Sea (Annex 4, paragraph 5.4), which it was requested to submit as soon as possible.

3.6 The Scientific Committee noted the recent work undertaken by Norwegian scientists on Antarctic petrels (*Thalassoica antarctica*) at Svarthamaren. WG-EMM noted the significance of this work and indicated that it would be happy to consider Norwegian proposals as to which data might be suitable for submission to CEMP.

3.7 Dr Fukuchi indicated that relevant data on Adélie penguins at several rookeries near Syowa station had been collected over a 20-year period and would be processed for submission to the CEMP database.

3.8 The Scientific Committee looked forward to receiving data from all these programs into the CCAMLR database in the near future.

3.9 Norway is planning to start CEMP research on chinstrap and macaroni penguins and fur seals at Bouvet Island in 1996/97. CEMP-related research on Antarctic petrels is expected to be continued on an ad hoc basis.

3.10 Dr Shust explained that Russian seal and ornithological research at Bellingshausen Station (King George Island) (see CCAMLR-XIV/MA/4) was still in progress and the field workers would not be returning to Russia until May or June 1996 and therefore might not be able to submit data for

some time after that. In the meantime he was requested to provide for consideration at the next meeting of WG-EMM, information on the nature of the research, and the extent to which elements of such research fall within CEMP and follow standard methods.

Methods

3.11 Revision of the protocols for the standard methods was completed following the meeting of WG-EMM. The relevant documents were translated and recently distributed to Members.

3.12 Text for new CEMP methods on fur seal (*Arctocephalus gazella*) (demography, diet and condition) and petrels (breeding success, annual survival, recruitment and diet) was to be provided for intersessional comment. Methods for crabeater seals (*Lobodon carcinophagus*) (arising from the Antarctic Pack Ice Seals (APIS) Program) (SC-CAMLR-XIV/BG/11) would be very useful (see also paragraph 3.67).

3.13 Methods were to be developed at a workshop on at-sea behaviour of predators. This had been scheduled for 1996, but several key members of the ad hoc organising subgroup were unable to attend the meeting of WG-EMM. Therefore WG-EMM agreed that the workshop would have to be delayed for a year. The Scientific Committee regretted that more progress had not been made on this important topic and agreed to carry forward the appropriate financial provisions from the 1996 to the 1997 budget. Dr Boyd had agreed to act as Convener of the Workshop.

3.14 The Working Group reviewed CEMP monitoring methods and agreed that research involving their use has progressed to the point where detailed revision of all methods should be considered. This would determine whether they are yielding the precise information required by WG-EMM and whether their usefulness could be improved by modification or whether new methods needed to be developed.

3.15 WG-EMM established a Subgroup on Monitoring Methods to:

- (i) circulate the existing proposals for changes to current methods and proposals for new ones, to all Members and to the SCAR Group of Specialists on Seals and the Bird Biology Subcommittee for comment and suggestions for improvement;
- (ii) invite all Members and the SCAR Group of Specialists on Seals and the Bird Biology Subcommittee to suggest new methods relevant to CEMP objectives;

- (iii) arrange a meeting to review the responses to (i) and (ii); and
- (iv) consider developing plans for a comprehensive review of methods.

3.16 Drs K. Kerry (Australia) and Agnew (Co-conveners) prepared an outline plan (SC-CAMLR-XIV/BG/7) which was adopted by the Scientific Committee (paragraph 13.4).

Data Analysis

3.17 In January 1995 the Subgroup on Statistics met in Cambridge, UK, to address problems in the interpretation of the CEMP indices, which had in the past prevented WG-CEMP from making the transition from a qualitative to a quantitative assessment of indices and trends. WG-EMM considered that further development of this work was essential intersessionally particularly involving linkages between the environment, harvested and dependent species.

3.18 Progress in this field has been improving the Working Group's ability to interpret trends in the data. The Working Group indicated that further work involving statistical analyses would be required to understand interactions involving dependent species and this was considered further by the Scientific Committee in paragraphs 5.17 to 5.20.

Proposals for CEMP Site Protection

3.19 No specific proposals for CEMP site protection were tabled at the meeting. However, information was brought forward regarding the status of various monitoring sites.

3.20 Dr Øritsland stated that Norway intended to nominate Bouvet Island as a CEMP monitoring site (see paragraph 3.9).

3.21 Dr R. Holt (USA) informed the Scientific Committee that US shore-based operations at Seal Island were being discontinued because the site of the field station was unsafe. A new site is being sought in the Antarctic Peninsula so that land-based work can continue. The series of krill surveys and other at-sea activities would be continued in the vicinity of Elephant Island.

3.22 A report on South African research activities indicated that various CEMP methods continued to be utilised in studies of gentoo and rockhopper penguins (*Pygoscelis papua* and *Eudyptes chrysocome*) at Marion Island. Furthermore, the land to the high-tide mark of Marion and Prince

Edward Islands is in the process of being proclaimed as a Special Nature Reserve under South African law. This development will heighten the conservation status of the islands and will require the continued collection of data likely to be of interest to CEMP. The management plan for the reserve will be sent to the Secretariat and a summary circulated to Members in advance of the next meeting of WG-EMM.

Advice to the Commission

3.23 The Scientific Committee repeated its request to Members collecting CEMP data to supply these to the Secretariat for incorporation into the CEMP database as soon as possible. These data are required to fill known gaps in the database as well as to provide the most up-to-date information for WG-EMM to use as a basis for its assessments.

3.24 The Scientific Committee noted the very great increase in the amount of data being supplied to the CEMP database, the time required for validation of the data and the more sophisticated analyses that are now being undertaken by the Secretariat Data Management team. This has been a major step forward. The Scientific Committee will inform the Commission that this increased workload is likely to result in calls for increased expenditure on computing equipment and for additions to staff in the near future.

3.25 The attention of the Commission is drawn to a change in the emphasis of WG-EMM to move from qualitative to quantitative assessments. In the longer term, this should improve the quality of advice being provided by the Scientific Committee.

Assessment of Incidental Mortality

Incidental Mortality in Longline Fisheries

3.26 The Scientific Committee noted with appreciation the substantial intersessional work on this topic (Annex 5, paragraphs 8.1 to 8.18) and thanked the ad hoc WG-IMALF, its Convener, Dr Moreno and the Secretariat for their contributions.

3.27 The Scientific Committee had insufficient information on responses to CCAMLR from organisations contacted intersessionally (as listed in Annex 5, paragraphs 8.5 and 8.7) to evaluate these responses and advise on appropriate further action. This evaluation would, therefore, need to be undertaken during the consideration of incidental mortality by the Commission. However the

Scientific Committee re-emphasised the importance of working internationally to tackle the problem of incidental mortality of seabirds from the Convention Area (Annex 5, paragraph 8.89).

3.28 The Scientific Committee endorsed the recommendations by WG-FSA that:

- (i) Members be requested to inform CCAMLR of the steps they have taken or are planning to take to address the topic of incidental mortality of seabirds associated with fisheries, especially longline fishing, in waters under their jurisdiction adjacent to the Convention Area and in other regions where seabirds from the Convention Area might be affected (Annex 5, paragraph 8.21);
- (ii) the proposed handbook entitled 'Catching fish not birds: a guide to improving longline fishing efficiency' should be produced as soon as possible during the intersessional period (Annex 5, paragraph 8.22);
- (iii) New Zealand be encouraged to complete production of its seabird identification manual for scientific observers on longline vessels (Annex 5, paragraph 8.23). It was emphasised, however, that this handbook would help reduce but not eliminate difficulties with identification of seabirds by observers and in no way reduced the need for retention of specimens of all birds killed;
- (iv) Members (especially Chile, New Zealand and South Africa) able to initiate and/or continue long-term demographic studies of albatrosses, additional to those already extensively documented, be encouraged to do so (Annex 5, paragraph 8.28(i));
- (v) Members be encouraged to collaborate on larger scale banding of albatrosses, particularly to help determine the provenance of birds caught at sea (Annex 5, paragraph 8.28(ii));
- (vi) Members be asked again to provide the Scientific Committee, via the ad hoc WG-IMALF, with information on their existing and proposed monitoring studies of albatrosses, giant petrels and white-chinned petrels (the species in the Convention Area of greatest vulnerability to longline fishing) (Annex 5, paragraphs 8.32 and 8.33); and
- (vii) the new guidelines and data forms for observers of incidental mortality of seabirds and marine mammals be published in logbook format and also appended to the revised edition of the *Scientific Observers Manual* (Annex 5, paragraphs 8.75 and 8.82).

3.29 The Scientific Committee noted the detailed information available from scientific observers on longline vessels which had enabled WG-FSA to undertake the first systematic analyses of such data and reports (Annex 5, paragraphs 8.35 to 8.58). Summaries of these analyses are presented in Annex 5, Tables 27 and 28.

3.30 The Scientific Committee noted that the estimates of seabird by-catch in Annex 5, paragraph 8.41 and Table 27 (which are nominally expressed as birds per thousand hooks set), are minimum estimates because:

- (i) few reports recorded the actual observer coverage (in terms of the proportion of hooks observed) achieved (Annex 5, paragraph 8.38). Without this information, the overall by-catch of seabirds can not be estimated; and
- (ii) even where observer coverage is known:
 - a proportion of hooks remain unbaited; this can be substantial (c. 30%) when using autolining techniques; and
 - a proportion (c. 30% in studies outside the Convention Area) of birds caught during the set are not retrieved during the haul.

3.31 Comments by scientific observers in situations where streamer lines of designs different from that specified in Conservation Measure 29/XIII were used indicate that such lines had not been particularly effective (Annex 5, paragraphs 8.36 and 8.39). The Scientific Committee reiterated its advice of last year of the need to adhere strictly to the principles of streamer line construction and deployment described in WG-IMALF-94/19¹. Streamer lines of other designs and deployment should be used, and evaluated, only in addition to lines of CCAMLR specification and under the supervision of scientific observers.

3.32 The Scientific Committee:

- (i) recommended that Members indicate how many specimens (and of what species) have been collected by the scientific observers, where these are deposited and who is responsible for checking identifications and retaining appropriate material (e.g., for genetic studies to investigate provenance); and

¹ Brothers, N. 1994. Principles of birdline construction and use to reduce bait loss and bird deaths during longline setting. Document *WG-IMALF-94/19*. CCAMLR, Hobart, Australia.

- (ii) recognised that research into ways of reducing the by-catch of white-chinned petrels at night was urgently needed and should include further work on relationships between hook size and the level of by-catch of petrels.

3.33 The Scientific Committee noted that the problems referred to in paragraph 3.30, together with additional uncertainties and errors in reported data which require clarification (see especially Annex 5, paragraph 8.55), meant that the estimates of seabird mortality provided by WG-FSA must be regarded as provisional.

3.34 Nevertheless, the Scientific Committee endorsed the conclusions of WG-FSA (Annex 5, paragraphs 8.50 and 8.87) that:

- (i) the revised mitigating measures adopted last year in Conservation Measure 29/XIII had significantly reduced the overall incidental mortality of seabirds;
- (ii) in particular, the restriction of setting longlines only at night had significantly reduced the by-catch of albatrosses; greater compliance with this part of Conservation Measure 29/XIII would virtually have eliminated mortality of these birds; and
- (iii) night-time setting was associated with increased mortality of white-chinned petrels and research into ways of reducing this is urgently needed.

3.35 The Scientific Committee also shared the concerns of WG-FSA that failure to comply with Conservation Measure 29/XIII had caused significant mortality of seabirds and reduced fishing efficiency (Annex 5, paragraph 8.88); in particular:

- (i) the discharge of offal when hauling takes place on the same side of the vessel as lines are hauled contributed very substantially to the observed incidental mortality of seabirds;
- (ii) daytime sets caught disproportionate numbers of albatrosses; and
- (iii) failure to use streamer lines was associated with higher catch rates of birds.

3.36 The Scientific Committee noted that the acquisition of data to undertake the appropriate analyses had only been possible through comprehensive observer coverage. Furthermore, sufficiently comprehensive data on incidental mortality had only been obtained when two scientific observers were deployed. The Scientific Committee congratulated Argentina and Chile for arranging this on a number of vessels fishing in Subarea 48.3.

3.37 The Scientific Committee repeated its recommendation that, wherever possible, two scientific observers should be used to collect the data on fish and incidental mortality necessary for appropriate assessments by CCAMLR. It further noted that, where only one scientific observer was available, helpful prioritisation of tasks had been undertaken (Annex 5, paragraph 8.79) or was in progress (Annex 5, paragraphs 8.80 and 8.81).

3.38 The Scientific Committee noted that without detailed reports from scientific observers it would have been impossible to detect and correct substantial errors in data reported from the commercial fishery (Annex 5, paragraph 8.55).

3.39 The Scientific Committee endorsed the need for further intersessional analysis of data on incidental mortality of seabirds and interactions with marine mammals (Annex 5, paragraphs 8.53, 8.55 and 8.56). The ad hoc WG-IMALF should liaise with the Secretariat to specify and prioritise the necessary work.

3.40 The Scientific Committee emphasised that further reductions in incidental mortality were likely to be possible only through educating the captains, fishing masters and crews of fishing vessels. It is important to explain to them that not only is compliance with Conservation Measure 29/XIII a requirement, but that there are advantages, in terms of catching more fish, of reducing bird by-catch by complying with the various elements of this measure (particularly using CCAMLR streamer lines, setting at night and discharging offal only on the side of the vessel opposite to that where hauling takes place). Scientific observers should also be able to assist them in the practical aspects of complying with the conservation measure.

3.41 A valuable part of this education process will be the provision of the handbook on improving fishing efficiency (paragraph 3.28(ii)). In addition, there is a need to provide scientific observers with training in the use and deployment of streamer lines of CCAMLR specification and to ensure they are able to explain the aims and advantages of all CCAMLR mitigating measures to the captains and crews of vessels. Such advice and education was particularly needed for fisheries operating in waters adjacent to the Convention Area; this topic was discussed at the recent International Albatross Conference which had recommended the formation of a task group to address the matter.

3.42 The Scientific Committee appreciated the provision of data from Argentina and South Africa on incidental mortality of seabirds from the Convention Area in fisheries operating in adjacent waters (Annex 5, paragraphs 8.59 to 8.63). The high levels of estimated mortality, particularly of albatrosses and petrels, were noted with concern.

3.43 The Scientific Committee also noted the intentions of some Members to expand their longline fishing operations, especially in waters adjacent to the Convention Area (paragraphs 2.23 and 2.24). It therefore endorsed the recommendation (Annex 5, paragraphs 8.61, 8.63 and 8.89) that Members fishing in these waters be encouraged to implement appropriate mitigating measures as a matter of priority.

3.44 Dr D. Robertson (New Zealand) indicated that New Zealand was continuing to monitor incidental mortality associated with the southern bluefin tuna fishery in that country's waters. In 1995, 329 (15%) of 2 127 sets were observed and 111 birds reported killed at a catch rate of 0.12 birds per thousand hooks. Of birds identified according to species, 72% were albatrosses and 27% white-chinned petrels (*Procellaria aequinoctialis*). He also reported that New Zealand was conducting three other investigations of interest to CCAMLR. The first two of these will be funded by a fishing industry levy and will include research on the implementation of mitigation measures to minimise seabird by-catch and the monitoring of seabird populations affected by fishing. Species to be monitored include wandering albatross (*Diomedea exulans*), light-mantled sooty albatross (*Phoebetria palpebrata*) and black petrel (*Procellaria parkinsoni*). A third study will assess two populations of the southern Buller's albatross (*Diomedea bulleri*) and its interactions with fisheries.

3.45 The Scientific Committee particularly welcomed the detailed review of the Spanish method of longline fishing (Annex 5, paragraphs 8.65 to 8.68) on a vessel fishing in Falklands/Malvinas waters (but which had been designated to fish in Subarea 48.3). The report (WG-FSA-95/58) illustrated what could be achieved by using scientists specialised in relevant seabird research as observers on longline vessels. The Scientific Committee noted and endorsed the Working Group's assessments of the implication of this study for CCAMLR in general and specifically in terms of Conservation Measure 29/XIII (see also Annex 5, paragraph 8.73).

3.46 The potential of longline systems which release baited lines under water was highlighted (Annex 5, paragraph 8.68). Members using such techniques were requested to undertake detailed observations of their effectiveness in terms of reducing or eliminating seabird by-catch and to report the results to the Scientific Committee.

3.47 The Scientific Committee noted that detailed research by Members on the effectiveness of measures for reducing seabird by-catch should be undertaken independently of their actual commercial fishing and in a manner consistent with the spirit of Conservation Measure 64/XII.

3.48 The Scientific Committee noted the discussion relating to the timing of the *D. eleginoides* fishery in relation to albatross by-catch in Subarea 48.3 (Annex 5, paragraphs 8.70 to 8.72). The Scientific Committee noted that any delay in the opening of the fishery in order to reduce albatross

by-catch had the risk of overlapping the fishery and the spawning season of *D. eleginoides*. It noted, therefore, the need for better data on catch rates and reproductive status in the period from July to October in order to assess the significance of this possibility.

3.49 The Scientific Committee reviewed the various suggestions and recommendations relating to Conservation Measure 29/XIII (Annex 5, paragraphs 8.64, 8.67, 8.73 and 8.74). It recommended to the Commission that:

- (i) Conservation Measure 29/XIII, paragraph 3, be revised to prohibit the discharge of offal during setting or hauling on the side of the vessel on which longlines are set or hauled;
- (ii) a footnote be added to paragraph 2 stating that, in setting longlines after dark, the period of three hours in advance of dawn should be avoided whenever possible (in order to try to reduce by-catch of white-chinned petrels - see Annex 5, paragraph 8.64);
- (iii) a footnote be added to paragraph 1 recommending that weights be released before line tension occurs and, where possible, that weights of 6 kg mass spaced at 20 m intervals be used (in order to achieve maximum sinking rate of the line to minimise the risk of catching birds during the set - see Annex 5, paragraph 8.67); and
- (iv) Members be encouraged to undertake research into the improvement of existing measures and the development of new ones for further reducing, even eliminating, by-catch of seabirds in longline fisheries.

Incidental Mortality in Trawl Fisheries

3.50 The Scientific Committee noted that this topic was reviewed in Annex 5, paragraphs 9.1 to 9.6. It endorsed the advice to the Commission (Annex 5, paragraph 9.7) that the French authorities be encouraged to extend the provisions of Conservation Measure 30/X to the Crozet and Kerguelen area. Prof. G. Duhamel (France) advised that a prohibition on the use of net-sonde cables within the Kerguelen EEZ will be introduced at the beginning of the 1995/96 season.

Marine Debris

3.51 Dr Miller presented SC-CAMLR-XIV/BG/17, summarising observations of seals seen entangled at Marion Island from 1991 to 1995. The records involve 28 different animals, comprising 21 (75%) sub-Antarctic fur seals, 6 (21%) Antarctic fur seals (*Arctocephalus gazella*) and 1 (4%) southern elephant seal (*Mirounga leonina*). The overall incidence of entanglement of fur seals was estimated as being between 0.014% and 0.016% of the population. Entangling materials are mainly packaging straps (48%), synthetic string/rope (26%) and fishing net (19%).

3.52 Dr Miller also introduced SC-CAMLR-XIV/BG/18 which reported similar data for seabirds, totalling six individuals of six different species, covering the period from 1985 to 1993. There will be continued monitoring of interactions between marine debris and seabirds and marine mammals at Marion Island.

3.53 Dr Croxall introduced SC-CAMLR-XIV/BG/8, summarising observations in 1995 of Antarctic fur seals entangled in marine debris at South Georgia, the fifth successive winter and seventh successive summer of the study. In both 1995 seasons, the incidence of entanglement was the lowest yet recorded, as was the proportion of the entanglement in packaging bands. This is most encouraging, but as yet does not provide unequivocal evidence of commensurate improvement in the disposal of debris at sea because fishing effort in Subarea 48.3 was also very low in 1994 and 1995. Furthermore, entanglement rates of seals were highest in March 1995, coinciding with the start of longline fishing around South Georgia.

3.54 Dr Croxall also presented SC-CAMLR-XIV/BG/9, reporting that the incidence of fishing hooks and related debris associated with seabirds at their colonies on Bird Island, South Georgia, was reduced from the high levels in 1994 (but was higher than in 1993). This is also encouraging, but most observations were in March 1995, coinciding with the start of the longline fishery in the area.

3.55 From Members' reports of assessment and avoidance of incidental mortality in the Convention Area, there was a record by Chile of entanglement of two adult female Antarctic fur seals at Cape Shirreff (CCAMLR-XIV/BG/24).

Advice to the Commission

3.56 Members should be requested to inform CCAMLR of the steps they have taken or are planning to take to address the topic of incidental mortality of seabirds associated with fisheries, especially longline fishing, in waters under their jurisdiction adjacent to the Convention Area and in other regions where seabirds from the Convention Area might be affected (paragraph 3.28(i)).

3.57 Members should be encouraged to initiate and/or continue demographic studies of albatrosses, including larger-scale banding operations (paragraph 3.28(iv) and (v)).

3.58 The Commission should note the successful expansion of the Scheme of International Scientific Observation in terms of recording and analysing data on incidental mortality of seabirds and the value of the data collected thereby (paragraphs 3.29 and 3.38), the emphasis on the need for two scientific observers to collect full appropriate data (paragraph 3.36) and the proposed improvements, especially in terms of reporting (paragraph 3.28(vii)).

3.59 The Commission is advised of the success of Conservation Measure 29/XIII in reducing incidental mortality of seabirds, especially albatrosses, but should note the need for further research to reduce the mortality of white-chinned petrels (paragraph 3.34).

3.60 The Commission is advised of deficiencies in compliance with some of the provisions in Conservation Measure 29/XIII, especially in relation to the discharge of offal, daytime setting and the use of streamer lines, and is requested to ask Members to ensure compliance with all aspects of the conservation measure, thereby achieving further reduction in seabird by-catch and considerably more cost-effective fishing (paragraph 3.35 above and Annex 5, paragraph 8.88).

3.61 The Commission should note the advice that further reduction in by-catch of seabirds will require greater effort to educate fishermen as to the benefits accruing to them by complying with Conservation Measure 29/XIII (paragraph 3.40); it should note the Scientific Committee's suggestions in this regard (paragraph 3.41), including the importance of producing the handbook 'Catching fish not birds: a guide to improving longline fishing efficiency' (paragraph 3.28(ii)).

3.62 The Commission should note that:

- (i) data provided from Members on their fisheries in waters adjacent to the Convention Area support the conclusion of the ad hoc WG-IMALF and Scientific Committee last year that the greater part of seabird mortality relating to birds breeding in the Convention Area arises from fisheries outside the Convention Area (SC-CAMLR-XIII, paragraph 9.56; Annex 5, paragraph 8.89);
- (ii) accordingly, the Scientific Committee endorsed the advice of WG-FSA (Annex 5, paragraph 8.89) to request that the Commission encourage Members to be active in:

- drawing CCAMLR's concerns to the attention of appropriate national authorities and organisations;
 - implementing appropriate mitigating measures to reduce incidental mortality of seabirds in fisheries in waters under these bodies' control outside the Convention Area as a matter of priority (paragraph 3.43); and
- (iii) the Scientific Committee also re-emphasised the need to work internationally to tackle the problem of incidental mortality of seabirds from the Convention Area (paragraph 3.27).

3.63 The Commission should note the forthcoming prohibition on the use of net-sonde cables in the Kerguelen EEZ (paragraph 3.50), which will extend the provisions of Conservation Measure 30/X to the whole Convention Area.

Marine Mammal and Bird Populations

Status of Marine Mammal Populations

3.64 Last year the Scientific Committee agreed on close coordination and effective communication with SCAR's APIS Program (SC-CAMLR-XIII, paragraphs 8.3, 8.4 and 8.7).

3.65 The Scientific Committee welcomed the report of the 1995 APIS Program planning meeting (Seattle, USA, 7 to 9 June 1995) which was partly funded by CCAMLR (SC-CAMLR-XIII, paragraph 8.5).

3.66 The APIS Program aims to promote cooperative international studies on the status of Antarctic pack-ice seal populations and their role in the Antarctic marine ecosystem. In particular, the proposed research on crabeater seals, a CEMP species selected for monitoring, will cover topics of direct relevance to CCAMLR (Annex 4, paragraphs 5.34 to 5.37).

3.67 APIS intends to produce recommended standard methods for crabeater seals. The Chairman was asked to write to the Convener of the SCAR Group of Specialists on Seals requesting the group to consider the collection and analysis of data relevant to the aims of CCAMLR and the CEMP program in particular. The Scientific Committee should continue its close liaison with SCAR in the planning and implementation of the APIS Program.

3.68 As decided in 1987 (SC-CAMLR-VI, paragraph 8.7) and as was done in 1988 and 1992, the Chairman was requested to write to the Convener of the SCAR Group of Specialists on Seals and ask for reports on the status of Antarctic seals for review at the 1996 meeting of the Scientific Committee.

3.69 The Scientific Committee decided that the Chairman should also write to the Scientific Committee of the IWC to request reports on the status of Antarctic whales for review at the 1996 meeting of the Scientific Committee.

Status of Marine Bird Populations

3.70 As decided in 1987 (SC-CAMLR-VI, paragraph 8.7) and as was done in 1988 and 1992, the Chairman was requested to write to the Chairman of the SCAR Bird Biology Subcommittee and ask for reports on the status of Antarctic birds.

HARVESTED SPECIES

Krill

Methods for Krill Assessment

4.1 The Scientific Committee noted the discussions of WG-EMM on various methods for the assessment of krill biomass (B_0) and demography (Annex 4, paragraphs 4.2 to 4.14).

4.2 These discussions focussed on estimating krill distribution and standing stock, krill recruitment and production, survey design, the quantification of errors from such surveys, multifrequency acoustic techniques and a variety of problems associated with echosounder systems.

4.3 The Scientific Committee endorsed WG-EMM's recommendation that submissions on survey designs to be implemented in Area 48 should be prepared during the intersessional period and discussed at the next meeting of WG-EMM (Annex 4, paragraph 4.8).

4.4 The Scientific Committee noted that Russia (in Subareas 48.1 and 48.2) (CCAMLR-XIV/MA/4), India (Division 58.4.2), Japan (Division 58.4.1), Argentina (Subareas 48.2 and 48.3) and the USA (Subarea 48.1) all planned krill surveys during the forthcoming season

covering parts of the indicated subareas. Most notably, Australia planned to carry out a survey in Division 58.4.1 to estimate B_0 (see paragraph 4.18 below).

4.5 Dr Shust welcomed a discussion on survey design which might be incorporated into the Russian research plan. Therefore, a subgroup met to review past WG-EMM and Working Group on Krill (WG-Krill) advice on this subject (SC-CAMLR-X, Annex 5, Appendix D and WG-EMM-95/71). Dr Shust indicated he would prepare a research plan intersessionally and forward it to the Secretariat for circulation to Members.

4.6 Dr S. Abidi (India) stated that India proposes to send a scientific research expedition to Area 58 by the end of 1995 to assess krill and other fishery resources in relation to oceanographic parameters. India is committed to the development and conservation of Antarctic marine living resources. As requested by Conservation Measure 64/XII, India will soon provide details of the planned research to the CCAMLR Secretariat, for circulation to Members for comment.

4.7 The Scientific Committee urged all the nations concerned, especially Russia and India, to make the details of their proposed surveys available as soon as possible as the experience and advice from other Members could be used to enhance the effectiveness of the survey designs, which would in turn assist in the work of WG-EMM.

4.8 The Scientific Committee noted that systematic and random errors may arise from acoustic surveys of krill, particularly with regard to system calibration, the estimation of acoustic target strength, diurnal migration and the effective identification of acoustic targets. It also noted that these components of uncertainty in the estimation of krill biomass may vary from survey to survey. Such uncertainty may be as large as (or larger than) sampling error (see Annex 4, paragraph 4.12). The Scientific Committee urged Members with information on the above topics to submit papers and data to the next meeting of WG-EMM.

4.9 The Scientific Committee endorsed WG-EMM's conclusion regarding the importance of developing multifrequency acoustic techniques for the survey of krill abundance/distribution. It supported WG-EMM's recommendation that future acoustic surveys of krill abundance and distribution should be undertaken using at least two frequencies in order to facilitate the discrimination of acoustic targets (Annex 4, paragraph 4.13).

Krill Distribution and Abundance
(Annex 4, paragraphs 4.15 to 4.49)

4.10 In accordance with WG-EMM's views, the Scientific Committee encouraged further research on the effects of krill flux (i.e., movement) and aggregation, as well on other issues associated with krill spatial distribution (Annex 4, paragraphs 4.15 to 4.25).

4.11 The Scientific Committee noted that recent studies have confirmed a local decline of krill abundance in both Subareas 48.3 (South Georgia) and 48.2 (South Orkneys) during 1994. The possibility of a general decline in krill abundance in Area 48 between the periods 1977-83 and 1985-94 was also discussed by WG-EMM, and the Scientific Committee noted the importance of this in terms of possible variations in krill recruitment.

4.12 WG-EMM indicated that there may have been changes in the pattern of krill recruitment in Area 48 in recent years. The Scientific Committee endorsed WG-EMM's recommendation that the examination of information relevant to this subject should be assigned a high priority and that a steering committee (to be convened by Dr Agnew) should complete the required analyses by correspondence during the forthcoming intersessional period. The planned approach set out in Appendix D of WG-EMM's report was accepted by the Scientific Committee as offering the most useful course to be followed.

4.13 Given uncertainties regarding krill recruitment in recent years, the Scientific Committee agreed that the provision of further advice concerning a precautionary catch limit for krill in Area 48 should be deferred until further information on variability in krill recruitment, including the analysis described in paragraph 4.12, becomes available.

4.14 With respect to the estimation of B_0 , the Scientific Committee noted WG-EMM's discussions on the low priority to be given to the recalculations of the coefficient of variation (CV) in the FIBEX survey to estimate B_0 (as used in the current krill yield model) since this would little affect the Scientific Committee's advice on the precautionary krill catch limit (Annex 4, paragraphs 4.51 to 4.56).

4.15 The Scientific Committee concurred with WG-EMM's conclusion that it was not necessary at this time to re-analyse the FIBEX data in order to improve the current estimate of B_0 for krill in Area 48 (35.4 million tonnes) and in Division 58.4.2 (3.9 million tonnes).

4.16 The Scientific Committee endorsed WG-EMM's conclusion, however, that a new survey of krill in Area 48 is desirable (Annex 4, paragraph 4.61) since:

- there are technological and methodological problems associated with the collection and analysis of the FIBEX data;
- the survey coverage of Subarea 48.3 during FIBEX was inadequate;
- there may have been biotic and abiotic changes in the marine environment of the South Atlantic since the FIBEX survey in 1981;
- both acoustic survey technology and the survey design methodology have improved since FIBEX; and
- any new survey could be designed in such a way as to take specific account of the krill yield model currently employed by CCAMLR in the estimation of krill yield and in the subsequent derivation of precautionary catch limits.

4.17 The Scientific Committee therefore supported WG-EMM's conclusion that a new survey of krill biomass in Area 48 should be carried out and that Members should be encouraged to develop plans for such a survey (Annex 4, paragraph 4.67). The Scientific Committee recommended that papers on potential survey designs to be implemented in Area 48 should be submitted to the next meeting of WG-EMM.

4.18 With respect to Division 58.4.1, the Scientific Committee again noted Australia's intention to undertake an acoustic survey in this division during the forthcoming austral summer (1995/96) and supported implementation of the survey (Annex 4, paragraph 4.9).

Harvesting Mortality

4.19 The Scientific Committee noted that in accordance with concerns expressed over the past couple of years (SC-CAMLR-XII, paragraph 2.25) there is still uncertainty as regards the potential mortality of krill passing through meshes of trawl nets (Annex 4, paragraph 3.18). While the matter remains a concern of both the Scientific Committee and Commission, the Scientific Committee noted that initial modelling efforts by Russian scientists cannot be continued.

4.20 The Scientific Committee therefore urged Members to submit information on the mortality caused by fishing operations which is additional to reported catches.

Krill Fisheries in Other Areas

4.21 The Scientific Committee noted that WG-EMM-95/48 had been tabled in response to a request by WG-Krill for information on krill fisheries outside the Convention Area.

4.22 The Scientific Committee welcomed this paper and recognised that important information on the Japanese *Euphausia pacifica* fishery contained therein is of particular interest to CCAMLR since it describes various management approaches and the ancillary use of environmental information in their formulation.

Future Euphausiid Symposium

4.23 The Scientific Committee noted WG-EMM's views on the desirability of conducting an international symposium on Euphausiid biology and ecology in the near future (Annex 4, paragraphs 9.1 to 9.5).

4.24 Although preparations for this symposium are at an early stage, the Scientific Committee agreed that CCAMLR has a strong interest in its proceedings. Therefore, it encouraged Dr Miller and Dr J. Watkins (UK) to continue with plans for the symposium's implementation and suggested that CCAMLR should support these by making a financial contribution in the next year or two. The Scientific Committee therefore proposed that a sum of around A\$11 500 should be included within the Scientific Committee's budget for 1996 and 1997 for this purpose as detailed in Annex 6.

Data Requirements

4.25 The Scientific Committee noted that there are a number of continuing requirements for data on krill and the krill fishery. In brief these include:

- examination of the precision of estimates of krill length/weight relationships;
- demographic data (especially as parameters for the krill yield model);
- krill flux data;
- length frequency data from the fishery;

- haul-by-haul data from the fishery;
- submission of fine-scale data from the fishery (e.g., as per the Japanese 10 x 10 n mile data reporting);
- estimates of biomass within the Integrated Study Regions (ISRs);
- monthly reporting of krill catches;
- data on the quantity and viability of krill passing through trawl meshes;
- historical fine-scale data from the fishery (especially from the ex-Soviet fishery);
- information on proposed acoustic surveys of krill biomass in Area 48 (including possible survey designs and minimum data requirements);
- examination and assessment of variability in krill recruitment; and
- data on the by-catch of fish in krill trawls.

Advice to the Commission

4.26 The Scientific Committee drew the Commission's attention to the need for a survey of krill biomass in Area 48 (paragraphs 4.15 and 4.16 above) and encouraged the development of plans for such a survey.

4.27 The Scientific Committee re-affirmed both WG-Krill's (in 1994) and WG-EMM's advice that the current best estimate of B_0 for krill is 35.4 million tonnes in Area 48 and 3.9 million tonnes in Division 58.4.2.

4.28 The Commission's attention is drawn to the extensive discussions conducted by the Scientific Committee at its 1994 meeting on the calculation of the precautionary limit for Area 48 (SC-CAMLR-XIII, paragraphs 5.31 to 5.45). Based on acceptance of the value of $\gamma = 0.116$ (in the equation $\text{Yield} = \gamma B_0$), a precautionary limit of 4.1 million tonnes is obtained for Area 48 (i.e., an estimate of 35.4 million tonnes for B_0). An alternative view is that there is no need to revise the precautionary limit of 1.5 million tonnes set out in Conservation Measure 32/X until various refinements in the krill yield calculation (as in paragraphs 4.12 and 4.13) have been completed (Annex 4, paragraph 7.102).

4.29 For Division 58.4.2, no further data are available to refine the value of γ . The Scientific Committee therefore advises that the current best estimate of a precautionary krill catch limit in this division is 450 000 tonnes (B_0 of 3.9 million tonnes combined with γ of 0.116) as opposed to the 390 000 tonnes contained in Conservation Measure 45/XI.

4.30 The Scientific Committee agreed that further advice concerning the revision of the precautionary krill catch limit for Area 48 should be deferred until more information on variability in krill recruitment becomes available (paragraphs 4.12 and 4.13).

4.31 Concerning the subdivision of precautionary catch limits within Area 48, the Scientific Committee concurred with WG-EMM's conclusion that no further advice can be given until the analyses described in Annex 4, paragraphs 4.46 to 4.48 and 7.80, have been completed and evaluated by WG-EMM at its next meeting.

Fish Resources

Data Requirements Endorsed by the Commission in 1994

4.32 At its last meeting WG-FSA identified specific data that were required for its future work (SC-CAMLR-XIII, Annex 6, Appendix D). Some of the requested information on *D. eleginoides* has been acquired through scientific observers, the completion of new data reporting forms, and catch data from *D. eleginoides* fisheries in areas adjacent to the CCAMLR Convention Area (see Annex 5, Appendix D). Little of the information requested from other fisheries, however, has been forthcoming, and the Scientific Committee endorsed the new approach of specific requests for data in section 11 of the WG-FSA report (Annex 5).

Fisheries and Observer Information

4.33 The Scientific Committee endorsed the Working Group's comments in Annex 5, paragraphs 3.3 to 3.14, and requested WG-FSA and the Secretariat to take the necessary steps to improve the quality of catch, effort and length-at-age and other biological data (Annex 5, section 12).

Research Surveys

4.34 The results of several research surveys and exploratory fisheries were reported. These were an Argentinian survey in Subarea 48.3 (paragraph 4.63), French exploratory trawling in Subarea 58.6 (Crozet Archipelago), a French survey of myctophids in Division 58.5.1 (Kerguelen Islands), an Italian survey of ichthyoplankton in the Ross Sea (Subarea 88.1) and Australian exploratory fishing for *D. eleginoides* around Macquarie Island, just outside the Convention Area. Results of these activities are detailed in Annex 5, paragraphs 3.15 to 3.21.

Fish Biology/Demography/Ecology

4.35 A number of observations on fish biology, demography and ecology were detailed in Annex 5, paragraphs 3.26 to 3.38. Of particular concern was the need for a better standardisation of the technique for determining gonad maturity stages of *D. eleginoides*, and the need to improve methods for ageing *D. eleginoides* before the extensive collections of otoliths and scales can be analysed.

Developments in Assessment Methods

4.36 The Scientific Committee endorsed the advice of WG-FSA (Annex 5, paragraphs 3.39 to 3.47). In particular, it noted with approval the development of the generalised yield model which extends the analysis method developed for krill to deal with uncertainty in the assessment of other resources such as finfish. This new model was used to great effect in assessments.

Report of the Workshop on Methods for the Assessment of *Dissostichus eleginoides* (WS-MAD)

4.37 The Workshop on Methods for the Assessment of *Dissostichus eleginoides* (WS-MAD) was held at CCAMLR Headquarters, Hobart, Australia from 5 to 9 October 1995. The main aim of the Workshop was to develop methods for assessing the biomass and status of *D. eleginoides* stocks. The full terms of reference of the Workshop are given in SC-CAMLR-XIII, paragraph 2.17.

4.38 The Workshop first reviewed the approaches taken in previous CCAMLR assessments of *D. eleginoides*, taking account of similar assessments of longline fisheries for *D. eleginoides* in Chile and the relationship between trawl and longline catches in the experimental longline fishery for hake off South Africa. Key problem areas in CCAMLR assessments were identified and potential solutions

were discussed. A brief summary of key sections of the Workshop report is given in Annex 5, paragraphs 4.5 to 4.19, and the full proceedings are in Annex 5, Appendix E.

4.39 The Scientific Committee endorsed the Workshop recommendations relating to the accuracy of estimates of total catches, the need for the development of new assessment methods, and the need for a research program directed to cover the full bathymetric range of all size classes of fish in the stocks being investigated. It emphasised that given the perceived inadequacies in the reporting of total removals (Annex 5, paragraph 4.15), it is not sufficient to rely solely on fishery-dependent data to estimate stock yields (Annex 5, paragraph 4.21).

Assessments and Management Advice

Statistical Area 48 (South Atlantic)

Dissostichus eleginoides (Subarea 48.3)

4.40 The Scientific Committee noted that the Working Group had to address the problem of substantial unreported catches of *D. eleginoides* in Subarea 48.3. Information from a number of sources was used by the Working Group to estimate the total removals of fish from Subarea 48.3 and adjacent banks. The best estimates of these catches are given in Table 3 (Annex 5, paragraphs 5.10 to 5.12). The Commission's attention is drawn to the problems of estimating total removals from this fishery and the difficulties that imprecise catch data pose in assessments.

Table 3: Estimated catches of *D. eleginoides* in Subarea 48.3 and adjacent Rhine and North Banks and TACs agreed by the Commission for Subarea 48.3.

Split-year	TAC (tonnes)	CCAMLR Catch (tonnes)	Estimate of Additional Catch	Best Estimate of Real Catches ¹
1990	-	8156.0	345	8501.0
1991	2500	3639.0	565	4206.0
1992	3500	3841.6	3470	6309.6
1993	3350	3088.5 ⁴	2500	5588.5
1994	1300	459.5 ³	6145	6604.5
1995	2800	3301.1 ²	2870	6171.1

¹ Includes the adjacent banks.

² Includes 180 tonnes taken by Bulgaria in August 1994, and 59 tonnes taken outside Subarea 48.3 on Rhine and North Banks and reported to CCAMLR. The total catch reported from Subarea 48.3 for the 1994/95 season (1 March to 16 May) was therefore 3 062 tonnes.

³ 180 tonnes of this TAC was taken after 1 July and appears below, under 1995.

⁴ Fishery closed early due to non-reporting of zero catches. Closure date was projected from previous non-zero catch rates. In all other cases, the difference between TAC and actual catch is due to differences between 5-day reports and final reports from the fishery.

4.41 The Scientific Committee welcomed the Working Group's considerable progress in developing new assessment techniques which take account of uncertainty in available data. Details of these analyses are in Annex 5, paragraphs 5.22 to 5.49. The Scientific Committee recognised that further testing of the new methods was required, and encouraged this work.

4.42 The Scientific Committee considered that the assessment of *D. eleginoides* in Subarea 48.3 using the generalised yield model is far superior to any that has been conducted previously for this species. In particular, it noted that:

- (i) previous assessments have used abundance estimates based on analysis of short to medium term trends in CPUE. At best, this technique produces indirect estimates of density, and in practice the failure to observe consistent depletion (Annex 5, paragraphs 5.17 and 5.18) has often meant that no such estimates can be calculated;
- (ii) a current WG-FSA assessment, however, uses direct estimates of absolute recruitment obtained from fishery-independent scientific surveys. This is not only likely to be much more reliable than those based on CPUE analyses, but it has also been possible to quantify both estimation uncertainty and interannual variability in recruitment; and
- (iii) the generalised yield model has allowed specific account to be taken of various sources of uncertainty and variability and has the flexibility to be modified to allow for new data which may alter some of the important assumptions made in the current assessment (Annex 5, paragraph 5.74).

4.43 The Working Group compared the results of projections of population size over a 35-year period using the yield model to the decision rule for γ_1 adopted for krill and for *D. eleginoides* in Division 58.5.2 (Heard Island) at last year's meeting of the Scientific Committee. This decision rule requires that the probability during the projection period of the spawning stock biomass falling below 20% of its initial level should not exceed 10% (SC-CAMLR-XIII, paragraphs 5.18 to 5.26 and 2.70). Twenty per cent of the initial level of the spawning stock biomass has become a standard biological reference point used in fisheries management, based on Beddington and Cooke (1983)², in which the probability of stock depletion influencing recruitment was found to increase once the spawning stock declines below 20% of its equilibrium level.

² Beddington, J.R. and J.G. Cooke. 1983. The potential yield of fish stocks. *FAO Fisheries Technical Paper*, 242: 47 pp.

4.44 The Scientific Committee noted that the Working Group had tested this model against other stock assessment models used in the past. However when the $F_{0.1}$ strategy previously applied in assessments of stocks in the Convention Area was used, there is a 60 to 80% chance of the spawning stock biomass falling below 20% of its initial level over the 35-year period. This violates the γ_1 decision rule by a considerable margin. In addition, at the end of the projection period, the spawning stock biomass would be reduced to only 20 to 30% of the pre-exploitation level.

4.45 The Scientific Committee also noted that the generalised yield model had revealed that an $F_{0.1}$ harvesting strategy was not appropriate for this fishery due to the uncertainty and variability in recruitment. Harvesting at $F_{0.1}$ over the period of the projection would, in fact, result in considerable depletion of the spawning stock.

4.46 Projections carried out to identify the catch level at which γ_1 was satisfied, taking into account uncertainty surrounding the estimate of mean recruitment, interannual variability in recruitment and the fixed estimate of natural mortality, indicate that an annual yield of 4 000 tonnes would satisfy the γ_1 criterion. At this level of catch the median spawning stock at the end of the projection period is likely to be approximately 74% of the pre-exploitation level.

4.47 The Scientific Committee noted that the Working Group considered that the γ_1 decision rule, as it had been applied at this year's meeting, was a reasonable basis for setting guidelines for the limits on total removals of *D. eleginoides* in Subarea 48.3 during the 1995/96 season. The Scientific Committee also noted that the application of the γ_1 decision rule would be kept under review by the Working Group.

4.48 It was also noted that the appropriateness of the probability level (10%) used in the γ_1 decision rule was not purely a scientific question and that the Commission may wish to consider this matter further. Before this could be done, however, the Scientific Committee recognised that the Commission would require more information and advice from the Scientific Committee. The Scientific Committee noted that the Working Group would give this detailed consideration at its next meeting. This may involve presentation of a wider range of options corresponding to different levels of risk.

4.49 Lic. E. Marschoff (Argentina) considered that, bearing in mind the different biological parameters of *D. eleginoides* and krill (where $P = 10\%$ was also used), the probability level should be selected from the lower end of the range in Table 14 of the Working Group report (Annex 5).

4.50 Other Members stated that at this year's meeting the Working Group had not considered probability levels other than the 10% adopted by the Scientific Committee for krill and

D. eleginoides in Division 58.5.2 (Heard Island) at last year's meeting (SC-CAMLR-XIII, paragraphs 2.70, and 5.18 to 5.26) and that the results shown in Table 14 of the Working Group report (Annex 5) did not constitute a range of options.

4.51 The Scientific Committee recognised the importance of further work aimed at reducing uncertainties about the assumptions made in this assessment or in the estimates used as inputs to the generalised yield model. It endorsed the recommendations of WG-FSA on the subjects requiring attention (Annex 5, paragraphs 5.75 and 5.76).

Management Advice

4.52 The results of the projections over a period of 35 years using the generalised yield model indicated that to have a probability of no greater than 10% that the spawning stock biomass will fall to below 20% of its unexploited level, the annual catch should not exceed 4 000 tonnes. At this level of catch the ratio of median spawning stock biomass at the end of the projection period to the pre-exploitation level was about 74%. These criteria have been used in the past as a basis for setting catch limits, and 20% of unexploited spawning stock biomass has become a standard biological reference point used in fisheries management (paragraph 4.43). The Scientific Committee noted, however, that this assumed that the actual removals of fish would be no greater than the catch limit (i.e., no unreported catch). Total annual removals exceeding 4 000 tonnes would increase the probability of stock depletion.

4.53 The Scientific Committee stressed, however, that this assessment may change in future as more data become available and the analysis can be refined.

4.54 Lic. Marschoff, referring to paragraphs 4.49 and 4.50, stated that the appropriate catch level is 3 000 tonnes, the level associated with a probability of 7% that the spawning stock biomass will fall below 20% of its unexploited level over a period of 35 years (Annex 5, Table 14).

4.55 The Scientific Committee noted that the assessment of yield was based on the expectation that future catches will be taken only by longline vessels. Use of other types of fishing gear would change the age structure of the catch. The Scientific Committee made no assessment of the effects of such catches at this meeting. It therefore recommended that the directed fishery for *D. eleginoides* in Subarea 48.3 during the 1995/96 season should be restricted to longliners.

4.56 The Scientific Committee recalled that in previous years it had been agreed that fishing effort should be distributed in such a way as to ensure that catch and effort data are able to contribute to assessments of the stock (SC-CAMLR-XIII, paragraph 2.20). It also recalled that in 1994 some

Members had suggested that it would be beneficial to distribute effort throughout the subarea and over a period longer than a single reporting period, but consistent with periods fished in previous seasons (SC-CAMLR-XIII, paragraph 2.21). In particular, effort should not be concentrated in too short a time period in one area.

4.57 The Scientific Committee noted that Conservation Measure 80/XIII restricted the 1994/95 fishing season to the period 1 March to 31 August in order to assist other measures adopted by the Commission to reduce incidental mortality of seabirds in the longline fishery. However it also noted:

- the argument advanced in Annex 5, paragraphs 8.70 and 8.71, based on avoiding the period of maximum potential incidental mortality of wandering albatrosses breeding at South Georgia, for delaying the start of fishing until 1 May; and
- the concerns that such a delay might result in the fishery operating during the spawning season of *D. eleginoides* (July to August) (Annex 5, paragraph 8.71).

4.58 On the understanding that there would be full compliance with Conservation Measure 29/XIII (thereby protecting albatrosses), the Scientific Committee recommended the retention of the fishing season of 1 March to 31 August for 1995/96. It requested Members, however, to collect and/or provide data for assessing the consequences of delaying the start of a fishing season for *D. eleginoides* until 1 May.

4.59 The Scientific Committee noted with concern the apparent high level of unreported catches of *D. eleginoides* in Subarea 48.3. At this year's meeting of WG-FSA an attempt was made to estimate total removals and to take these into account in the assessment. However the Scientific Committee noted that future illegal catches would continue to hinder severely attempts to make reliable stock assessments and requested that the problem be addressed by the Commission as a high priority.

4.60 The Scientific Committee also noted that since catches of *D. eleginoides* are taken both inside and outside the Convention Area in waters adjacent to Subarea 48.3, this species constituted a straddling stock. This further complicated the assessments of total removals from the stock. Issues relating to conservation and management of straddling stocks are also discussed in paragraph 9.9 and Annex 5, paragraphs 10.10 to 10.14.

4.61 The need for regular re-assessment of the stock using the generalised yield and CPUE models highlights the importance of collecting catch and effort information on as fine a scale as possible. The Scientific Committee recommended the continuation of the current procedures for reporting haul-by-

haul and biological information from the fishery, and strongly encouraged the reporting of historical haul-by-haul data from the longline fishery prior to 1992. It also recognised the importance for the assessment work of the biological data and information collected by scientific observers. The Scientific Committee recommended that the 100% observer coverage applied to this fishery over the past two seasons be continued.

Champscephalus gunnari (Subarea 48.3)

Commercial Catch

4.62 The fishery for *C. gunnari* was closed for the 1994/95 fishing season in accordance with Conservation Measure 86/XIII. There has now been no substantial reported commercial catch of *C. gunnari* in Subarea 48.3 since March 1990.

4.63 A research survey conducted by Argentina on this species provided some qualitative evidence that the stock has increased compared to 1994, but did not provide sufficient information for the Working Group to carry out a quantitative assessment (Annex 5, paragraphs 5.90 to 5.97).

4.64 In the absence of recent data on the population status of *C. gunnari*, some proposals were made concerning the determination of population status in order to assess the dynamics of this stock (Annex 5, paragraphs 5.98 to 5.100).

4.65 To assess the stock dynamics most effectively, it is necessary to review as many historical research and commercial trawl data as possible. This will also help define the optimum design and timing of trawl surveys in Subarea 48.3 and to standardise the research survey results. The Scientific Committee endorsed the Working Group's recommendation that these data be submitted to the Secretariat in the appropriate format and be reviewed by an intersessional group convened by Dr Holt.

4.66 The Working Group was unable to make further progress in the development of a long-term management plan for the *C. gunnari* fishery as requested by the Commission last year (CCAMLR-XIII, paragraph 8.38). The Scientific Committee reiterated the need for such a plan, especially in the light of the high interannual recruitment variability, uncertainty in biomass estimates and potential variability in natural mortality with age and between years. Any estimates of yield will need to incorporate the possibility of major mortality occurring every few years. Members were encouraged to address these topics.

Management Advice

4.67 The Scientific Committee recommended that bottom trawling should continue to be prohibited in the directed fishery for *C. gunnari* in Subarea 48.3.

4.68 The Scientific Committee endorsed the Working Group's advice that the most reliable estimate of abundance for *C. gunnari* around South Georgia and Shag Rocks was still that from the 1994 UK survey (see SC-CAMLR XIII, Annex 4, Table 3). Given the uncertainty associated with the state of this stock, the Working Group further recommended that the lower confidence interval of that estimate be used if TACs are considered. The lower 95% confidence limit was 13 295 tonnes.

4.69 The Working Group considered two options for setting a TAC for *C. gunnari*:

- (i) no TAC should be set until a new research survey to assess the status of the stock has been conducted. This new estimate would then be considered by WG-FSA as a basis for providing new management advice; and
- (ii) a TAC should be set (at some proportion of the lower confidence limit of the 1994 UK survey estimate), but this TAC would be dependent on two things; a research survey being carried out before the commercial operation, and an international scientific observer being on board each vessel fishing commercially.

4.70 The Scientific Committee preferred option (i) but some Members stated that option (ii) was also acceptable. If the Commission decides to re-open the fishery (option (ii)), it is recommended that a TAC be set at a level which is considerably below 13 295 tonnes, that a research survey be carried out prior to the commercial fishery in accordance with the design recommended by WG-FSA in 1992, and that an international scientific observer be on board any commercial fishing vessel.

4.71 The Scientific Committee recommends that a high priority should be given to the development of a long-term management plan for this fishery.

Chaenocephalus aceratus, *Gobionotothen gibberifrons*³,
Notothenia rossii, *Pseudochaenichthys georgianus*,
*Lepidonotothen squamifrons*⁴ and *Patagonotothen guntheri*
(Subarea 48.3) - Management Advice

4.72 The Scientific Committee endorsed the previous advice of the Working Group concerning these species (SC-CAMLR XIII, Annex 4, paragraphs 4.98, 4.102 and 4.103). In the absence of any substantive new information, a directed fishery on these species should remain prohibited (Conservation Measures 2/III, 3/IV, 76/XIII and 85/XIII).

Electrona carlsbergi (Subarea 48.3)

4.73 The Scientific Committee endorsed the view of the Working Group that, given the limited new information on this stock (Annex 5, paragraphs 5.114 and 5.115), the precautionary yields based on the revised krill yield model are appropriate estimates of yield for this species, pending a revision of the biological parameters. The estimate of yield will be smaller with greater uncertainty in the estimates of these parameters (SC-CAMLR-XIII, paragraphs 5.18 to 5.26).

Management Advice

4.74 The Scientific Committee recommended that TACs for *E. carlsbergi* should be 14 500 tonnes for the region around Shag Rocks and 109 000 tonnes for all of Subarea 48.3, as recommended last year (SC-CAMLR-XIII, Annex 4, paragraphs 4.91 to 4.93). A consequence of this recommendation is that any potential by-catch of other pelagic species taken in the *E. carlsbergi* fishery is likely to be reduced proportionately to the reduction of the precautionary limit from the 200 000 tonnes set by Conservation Measure 84/XIII.

4.75 In addition, the Scientific Committee agreed that the implementation of the conservation measure pertaining to the collection of biological information on *E. carlsbergi* from the commercial fishery (Conservation Measure 54/XI) should follow the format of the reporting of this information from other fisheries, including monthly reporting of by-catch and biological information on all species found in the catch. The Scientific Committee also noted that this fishery may take other pelagic species. If Conservation Measure 84/XIII is continued, then it should contain a reference to

³ Formerly known as *Notothenia gibberifrons*

⁴ Formerly known as *Notothenia squamifrons*

Conservation Measure 52/XI rather than Conservation Measure 54/XI, with the following provisions for setting a TAC and reporting conditions on this fishery:

- the target species is designated as *E. carlsbergi*;
- by-catch species are all other species caught during fishing operations;
- the relative densities of each species of fish in catches from each fishing ground should be reported; and
- length composition data of 500 specimens of each species taken randomly from catches in this fishery from each fishing ground should be reported.

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

4.76 In the absence of new information on stocks in these areas, the Scientific Committee reiterated its advice of last year (SC-CAMLR-XIII, Annex 4, paragraph 4.116) that fisheries in Subareas 48.1 and 48.2 should remain closed until a survey is conducted to provide more accurate estimates of the status of these stocks.

South Sandwich Islands (Subarea 48.4)

4.77 Although a small fishery for *D. eleginoides* was open in this area, no catches were reported. In the absence of further information, the Scientific Committee could not update its advice from 1993 (SC-CAMLR-XII, Annex 5, paragraph 6.4) when a TAC of 28 tonnes was recommended.

Statistical Area 58

Notothenia rossii and *Lepidonotothen squamifrons*
(Division 58.5.1) - Management Advice

4.78 Given that no new data are available this year for either of these species, the Scientific Committee recommended that the fisheries for *N. rossii* and *L. squamifrons* remain closed until new data are available which indicate that a fishery can be supported (Annex 5, paragraphs 5.136 and 5.139 respectively).

Champscephalus gunnari (Division 58.5.1)

4.79 New information provided in WG-FSA-95/15 Rev. 1 on the Soviet fishery for *C. gunnari* will necessitate a considerable revision of the catch data in Subarea 58.5 between 1970 and 1978. In addition, the Scientific Committee noted that there was heavy fishing of young age classes, which may have affected cohort strength in subsequent years (Annex 5, paragraphs 5.140 to 5.145).

4.80 The Scientific Committee recommended that the Data Manager verify the accuracy and completeness of the data reported in WG-FSA-95/15 Rev. 1, and if appropriate check with Russian authorities to see if additional catch data from this fishery are stored with them. If he is satisfied that the new data are correct, the *Statistical Bulletin* should be updated.

4.81 *C. gunnari* was fished for the first time since the 1991 season. The 1991 cohort, now at age 3+, was exploited and the catch was low compared to other seasons when a strong year class has been predicted (Annex 5, paragraphs 5.146 to 5.150). The abundance index for this cohort was much lower than for the three previous cohorts at the same age, and CPUE also declined markedly through the season. This continues the trend of decline in cohort strength over the last 12 years, even though no fishing had taken place since the present cohort was born in 1991. The previous strong cohort had been heavily fished when the fish were 2+ years old and before most of them had spawned.

Management Advice

4.82 The Scientific Committee advised in its 1993 and 1994 reports that because of the consistent decline in abundance of the strong cohorts which appear every three years, it would be appropriate to delay fishing of the present strong cohort until it has had at least one chance to reproduce. Thereafter fishing should be kept to a low level to allow sufficient escapement of fish to spawn a second time. This is in fact what has applied up to 1994/95.

4.83 Given the continuation of the decline in cohort strength, the Scientific Committee endorsed the Working Group's recommendation that this policy be continued. Therefore the fishery for *C. gunnari* in Division 58.5.1 should be closed until at least the 1997/98 season, when the cohort born in 1994 will have had an opportunity to spawn. Before this cohort is fished, it is recommended that a pre-recruit biomass survey be conducted in the 1996/97 season to evaluate the strength of the

cohort at age 2+. The data obtained should be evaluated at the 1997 meeting of WG-FSA, and an appropriate level of catch recommended.

Dissostichus eleginoides (Division 58.5.1)

4.84 Fishing for this species continued in the 1994/95 season as a longline fishery on the western slope and a trawl fishery on the northern shelf. Trawling also commenced on a recently discovered ground on the eastern part of the shelf.

4.85 Standardisation of CPUE data for the *D. eleginoides* fishery was also conducted for Division 58.5.1 (Annex 5, paragraphs 5.157 to 5.168). For the trawl fishery, although depth, year and vessel factors were significant components of the variance, there are probably other variables contributing to variation in CPUE that were not considered in the analysis. The Scientific Committee recommended that during the intersessional period the haul-by-haul data from the trawl fishery be analysed to identify additional predictor variables.

4.86 For the longline fishery, data were not available on a genuinely haul-by-haul basis, and factors that are known to be significant for the fishery in Subarea 48.3 (i.e., month, soak time and depth) were not found to be significant here. The Scientific Committee noted that haul-by-haul data are critical for proper standardisation of CPUE data and recommended that every effort should be given to providing these data to future meetings of WG-FSA.

Management Advice

4.87 The Scientific Committee felt that the analysis of factors affecting CPUE in longline and trawl fisheries is a potentially useful technique to improve its interpretation. However the analyses described in Annex 5, paragraphs 5.157 to 5.168, were limited by the lack of data on a genuinely haul-by-haul basis for the longline fishery, and by lack of data prior to 1994 for the trawl fisheries. The Scientific Committee recommended that in future, catch and effort data be collected and reported to CCAMLR on a haul-by-haul basis for the longline fishery. In addition, the Secretariat should acquire haul-by-haul data from Ukrainian authorities for the fisheries in previous years.

4.88 French authorities have already set TACs for the three sectors fished for the 1995/96 season. These are: 2 800 tonnes for the trawl fishery in the northern sector, 1 000 tonnes for the trawl fishery in the eastern sector, and 500 tonnes until the end of 1995 for the longline fishery in the western sector. These TACs were supported by the assessments of WG-FSA (Annex 5, paragraphs

5.169 to 5.172) and those made in previous years (SC-CAMLR-XIII, Annex 4, paragraph 4.134). Therefore the Scientific Committee endorsed these TACs. It further recommended that for the western sector longline fishery, as a 500-tonne catch has already been authorised for the first half of the split-year, this would imply a catch limit for the January to June 1996 period of 900 tonnes.

4.89 The Scientific Committee recommended, however, that further analysis of the *D. eleginoides* stocks exploited by the longline and trawl fisheries should be undertaken at the next meeting using the improved techniques recently established by WG-FSA.

Ob and Lena Banks (Division 58.4.4)

4.90 At CCAMLR-XIII, a conservation measure to allow a commercial catch of 1 150 tonnes of *L. squamifrons* to be taken over a two-year period (Conservation Measure 87/XIII) was approved at the request of Ukraine, provided a biomass survey was undertaken. Despite this, no fishing took place during the 1994/95 season, and so no new data are available.

4.91 Revised catch figures for both banks submitted to last year's meeting (SC-CAMLR-XIII/BG/13⁵) differ little from the previously accepted data set (Annex 5, Table 24), and did not warrant a re-assessment of the stocks.

Management Advice

4.92 The Scientific Committee reiterates its opinion held for the past few years that a biomass survey is necessary to provide a valid assessment of the fish stocks on the two banks.

4.93 As Conservation Measure 87/XIII, allowing a catch of 1 150 tonnes of *L. squamifrons* on the two banks provided an approved biomass survey is undertaken, is still valid until the end of the 1995/96 season, the Scientific Committee encourages this option to be taken up. This should provide data on which a new assessment can be based.

4.94 As the revised catch data now describe catches for Ob and Lena Banks separately, it is recommended that separate statistical subdivisions be made for each bank and that in future catch and effort data be continued to be reported separately for each bank.

⁵ Ukraine. 1994. Ob and Lena Banks: Report of Observer. Document SC-CAMLR-XIII/BG/13. CCAMLR, Hobart, Australia.

Heard and McDonald Islands (Division 58.5.2)

4.95 No fishery has been reported since 1978, but Conservation Measure 78/XIII set precautionary TACs of 311 tonnes and 297 tonnes for *C. gunnari* and *D. eleginoides* respectively on the basis of results from Australian biomass surveys.

4.96 Assessments carried out by WG-FSA at this year's meeting (Annex 5, paragraphs 5.180 and 5.181) indicated that these TACs remained valid.

Management Advice

4.97 The Scientific Committee recommended that Conservation Measure 78/XIII, establishing a TAC of 311 tonnes for *C. gunnari* and 297 tonnes for *D. eleginoides* in Division 58.5.2, should remain in force. In the light of experience in the *C. gunnari* fishery in Division 58.5.1 (Annex 5, paragraphs 5.146 to 5.153), it is recommended that the fishery for *C. gunnari* in Division 58.5.2 delay catching these fish until they have had an opportunity to spawn (about 28 cm total length).

4.98 Additional advice on by-catches is given in paragraph 8.4.

Pacific Ocean Sector (Area 88)

4.99 There was no fishing reported in the area, and no information was available to make any assessment of stocks in this area.

Crab Resources

4.100 The Scientific Committee noted that a single US fishing vessel (*American Champion*) has started fishing for crabs in Subarea 48.3 under the experimental harvest regime set forth in Conservation Measure 75/XII (Annex 5, paragraph 5.119). Preliminary catch and effort data for the period 1 September to 10 October 1995 have been submitted to the Secretariat (Annex 5, Table 18) and, to date, the total reported catch of crabs is about 79 tonnes.

4.101 The Scientific Committee recognised that there were not enough data available to make an assessment of the crab stock at the 1995 meeting of WG-FSA (Annex 5, paragraph 5.128). The

Scientific Committee further noted WG-FSA's observation that crabs may not be abundant off the southern and eastern coasts of South Georgia (Annex 5, paragraph 5.122) and supported the Working Group's concern that future assessments may need to take account of geographic differences in crab density (Annex 5, paragraph 5.123).

4.102 The pots used on board the *American Champion* are different from those used during the 1991/92 crab fishing season (Annex 5, paragraph 5.125). The Scientific Committee shared WG-FSA's concern that there is a large by-catch of small *D. eleginoides* in the pots currently used by the *American Champion* (Annex 5, paragraph 5.126 and Table 19).

4.103 The Scientific Committee noted the slow development of the crab fishery and endorsed WG-FSA's opinion that Conservation Measure 75/XII should be extended to remain in force through the 1997/98 crab fishing season (Annex 5, paragraph 5.130).

4.104 Dr Holt identified the need for a minor revision to Phase 2 of the experimental harvest regime set forth in Conservation Measure 75/XII. Information obtained from the fishery after the 1995 meeting of WG-FSA indicates that the boundaries of the small squares delineated in Conservation Measure 75/XII (Annex 75/A, Table 2) bisect the normal crab fishing grounds. The *American Champion* fishes in a narrow depth range, and the square boundaries currently set for Phase 2 will severely limit the vessel's ability to collect experimental data from the normal fishing grounds. If experimental data are not collected from the normal fishing grounds, WG-FSA may have difficulty interpreting results from the experimental harvest regime.

4.105 Adjusting the square boundaries of Phase 2 to include the normal fishing grounds is consistent with the WG-FSA's opinion that during this phase it would be better for the vessel to occupy three squares in an area of high crab density (Annex 5, paragraph 5.124).

4.106 The Scientific Committee agreed that Conservation Measure 75/XII, paragraph 5, should be redrafted so that fishing vessels could conduct the Phase 2 experimental operations in the preferred depth range. This redrafting would not compromise the scientific objectives of Phase 2. In general, a redrafted paragraph would eliminate the need for Table 2 of Annex 75/A and allow vessel captains to determine (subject to various limitations) the locations of square boundaries. Such a redraft would also preserve the current limitations on the size of experimental squares, the amount and distribution of fishing effort to be expended in each square and the minimum distance between squares.

4.107 The Scientific Committee endorsed WG-FSA's recommendation that additional data be collected to determine an appropriate size limit for male *P. formosa* (Annex 5, paragraph 5.127).

4.108 The Scientific Committee agreed that studies of technological methods (Annex 5, paragraph 5.126) to reduce the by-catch of *D. eleginoides* in crab pots should receive a high priority and urged this work to be undertaken as soon as possible.

Management Advice

4.109 Since the crab stock could not be re-assessed, the Scientific Committee endorsed WG-FSA's opinion that the fishery should be controlled by direct limitations on catch and effort as well as by limitations on the size and sex of crabs that can be retained in the catch (Annex 5, paragraph 5.128). In this regard, the Scientific Committee recommended that Conservation Measure 79/XIII should be applied to the 1995/96 crab fishing season.

4.110 The Scientific Committee noted that the experimental harvest regime can provide valuable information about the crab stock (Annex 5, paragraph 5.129) and recommended that Conservation Measure 75/XII should be revised in light of the issues presented in paragraphs 4.104 to 4.106.

4.111 The Scientific Committee further recommended that Conservation Measure 75/XII be extended to remain in force through the 1997/98 crab fishing season.

Squid Resources

4.112 Dr Croxall introduced this topic by recollecting that in previous years the UK had presented data and reports indicating that the ommastrephid squid, *Martialia hyadesi*, has significant potential for commercial exploitation in the waters of the Convention Area and adjacent areas and is also an important prey of several species of seabirds and marine mammals breeding in the Convention Area.

4.113 This year, the UK reports in SC-CAMLR-XIV/BG/22 Rev. 1:

- (i) a catch of about 18 000 tonnes of *M. hyadesi* in waters adjacent to Subarea 48.3 in 1995;

- (ii) advances in technical processing that may enhance the commercial value of this species; and
- (iii) continuing interest from fishing agencies, including those of non-members of the Commission, in fishing for this species of squid.

4.114 The paper suggests that given the increasing likelihood of commercial exploitation of stocks of this squid which occur in or near the Convention Area there needs to be enhanced acquisition of biological data relevant to developing appropriate management measures. Paper SC-CAMLR-XIV/BG/22 Rev. 1 also draws attention to a recent review by UK and Spanish scientists of stock assessment methods used for cephalopod fisheries. Current data on distribution and demography of *M. hyadesi*, however, would be inadequate for the development of effective regulatory measures, such as exist for some species in waters adjacent to the Convention Area.

4.115 Prof. Duhamel reported the first substantial incidental catch of squid, similar to *M. hyadesi*, in the French trawl fisheries around Kerguelen (Division 58.5.1). Given the potential commercial significance of this discovery, full information will be reported to the Scientific Committee in due course.

4.116 The Scientific Committee agreed that the evidence of increased interest in fishing for squid in the Convention Area (or on stocks of species that straddle the Convention Area and adjacent waters) warranted greater attention and research than hitherto.

4.117 The Scientific Committee encouraged Members to acquire relevant biological data for such squid species/stocks so that appropriate management measures might be developed as soon as possible.

4.118 Last year the UK had planned to test a longlining system developed by Japanese scientists for catching squid in the Convention Area (SC-CAMLR-XIII, paragraph 4.5). Paper SC-CAMLR-XIV/BG/22 Rev. 1 reports that this trial has been postponed until 1996. The UK indicated that it would ensure that measures mitigating potential seabird mortality (as far as they could be envisaged for this new and specialised type of fishing), would be available for use during the trial, and that the trial would be conducted in accordance with Conservation Measure 64/XII.

4.119 Paper SC-CAMLR-XIV/BG/21 summarised recent data indicating that the trophic system involving squid as predators of myctophid fish is particularly well developed in the vicinity of the Antarctic Polar Frontal Zone (at least in Subarea 48.3) and concluded that this system has much greater ecological importance than hitherto envisaged.

Development of a Strategy for Ecosystem Monitoring and Management

5.1 The Scientific Committee noted that WG-EMM reviewed its terms of reference (SC-CAMLR-XIII, paragraphs 7.41 to 7.43) and agreed that a useful synthesis of these was:

- (i) to provide advice on an ecosystem assessment combining information from dependent and harvested species and the environment; and
- (ii) to use this assessment to provide advice on management.

5.2 Development of an ecosystem assessment was seen as being fundamental to its role, and WG-EMM had agreed that an ecosystem assessment consisted of two parts:

- (i) an analysis of the status of key biotic components of the ecosystem; and
- (ii) a prediction of the likely consequences of alternative management actions on the future status of these components.

5.3 A simple schematic diagram of the components and linkages involved in monitoring and management of the Antarctic ecosystem is shown in Figure 1. The primary components are the environment, harvested species, dependent species and the fisheries. The system as a whole is completed by a link between these components and management approaches. The ecosystem assessment is conducted using information on the non-management components and linkages between them. The relevance to the components and links in Figure 1 of various ecosystem parameters, including those currently being assessed and reviewed by CCAMLR, is illustrated in Annex 4, Figure 2.

5.4 Strategic modelling is a vital tool in evaluating the procedures involved in an ecosystem assessment and in any system of providing management advice. In the context of the work of WG-EMM, a strategic model incorporates the biological and fishery components, the links between them, the procedures for ecosystem assessment and for the provision of management advice, and the resulting management actions. It is distinguished by explicit consideration of uncertainties and evaluation of the efficacy of management advice from the ecosystem assessment.

5.5 As a first step towards constructing a strategic model, WG-EMM developed a conceptual framework of the system processes in the Antarctic ecosystem. This is shown in Figure 2.

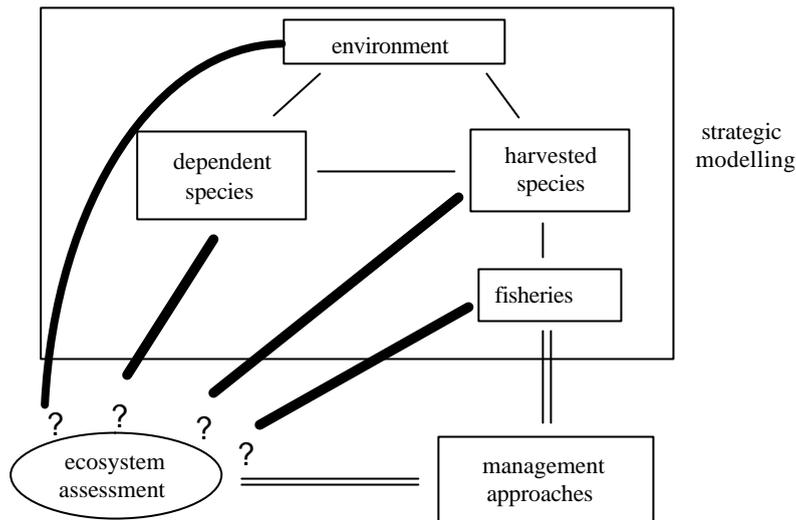


Figure 1: Schematic diagram of the processes involved in ecosystem monitoring and management. The basic ecosystem COMPONENTS are Environment, Dependent species, Harvested species and Fisheries. They interact via ecosystem LINKS (thin lines). They also all have an as yet undefined relationship (thick lines) with an 'ecosystem assessment' which incorporates ecosystem monitoring. Strategic modelling is the process whereby the links between components, and between components and the ecosystem assessment are evaluated. The final step in the scheme is the evaluation of management approaches, and the determination of its links with the ecosystem assessment (double lines).

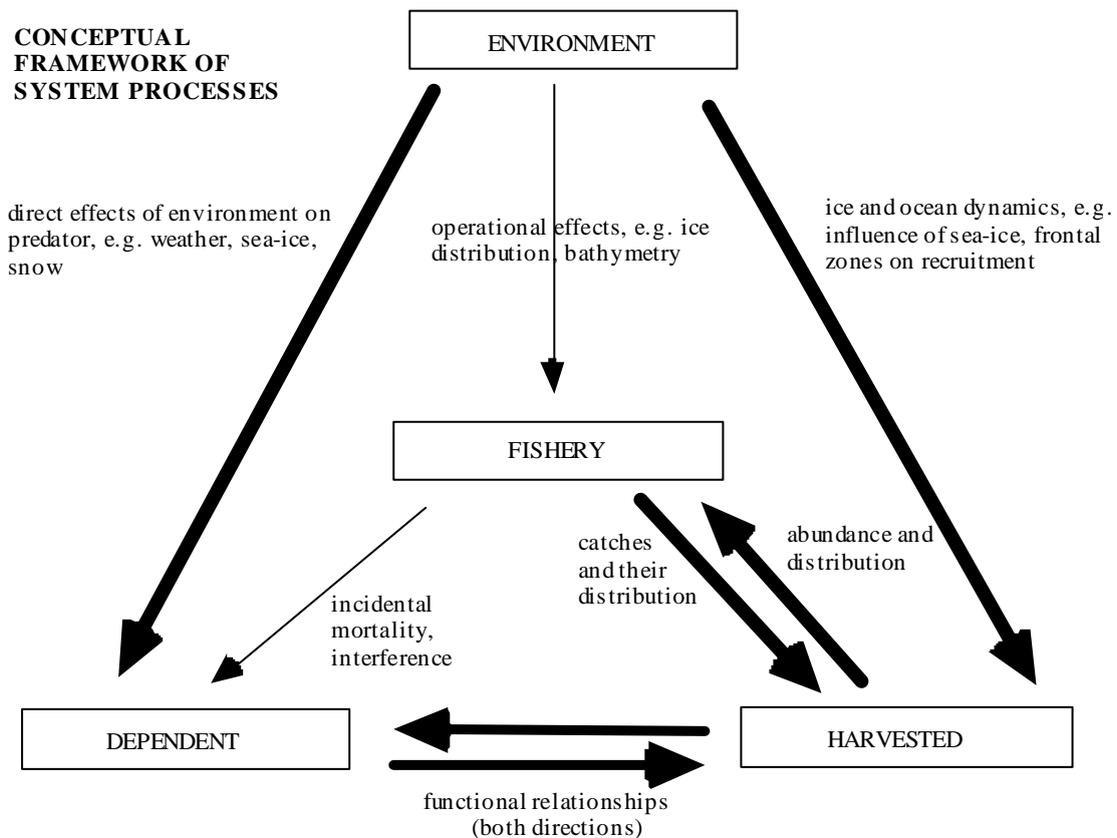


Figure 2: Conceptual framework of system processes. This figure describes the first step in a strategic modelling exercise and demonstrates the relationships between ecosystem components. The direction of arrows indicates the effect of one component on another, and the thickness of an arrow indicates the perceived importance of that link.

5.6 WG-EMM also conducted a preliminary review of the availability of existing models to describe the different components and links in this system, on both small (local) and large (regional) spatial scales. The availability of such models is essential if information on the key components is to be integrated into management advice. This review (Annex 4, paragraphs 7.47 to 7.60 and Figure 4) highlighted the fact that there are important components and linkages between them for which no models currently exist.

5.7 The Scientific Committee noted that this is the first time that a strategy for developing an ecosystem assessment for the Antarctic has been explicitly mapped out. Although clearly this represents only the first step in such a process, the Scientific Committee endorsed the approach taken by WG-EMM as being a very effective way to proceed. It also noted that the approach incorporates many of the components recommended by the FAO/Government of Sweden Technical Consultation on the Precautionary Approach to Fisheries (paragraphs 6.1 and 6.2), and as such it fits in with the latest views.

5.8 Both at WG-EMM (Annex 4, paragraphs 9.9 and 9.10) and subsequently in a paper to this meeting (SC-CAMLR-XIV/8), Dr Kock had proposed the preparation of a high quality booklet describing in non-specialised language the CCAMLR approach to ecosystem monitoring and management. This would not only be a useful guide for the CCAMLR community, but it would also assist in raising the profile of CCAMLR in international scientific and fisheries management communities.

5.9 The Scientific Committee endorsed this proposal and recommended that a subgroup (Dr Agnew, Prof. D. Butterworth (South Africa), Drs de la Mare, Everson, Miller, Naganobu and Miss R. Thomson (South Africa)) work with Dr Kock by correspondence in the intersessional period, with a view to presenting a first draft of the booklet for consideration at the next meeting of the Scientific Committee. It also agreed that the work of WG-EMM should be communicated to the wider scientific community through a WG-EMM newsletter to be written by the Convener (Dr Everson).

Review of Current Knowledge on Dependent Species, Harvested Species and the Environment

5.10 Considerable time was devoted by WG-EMM to reviewing current knowledge on the status of dependent and harvested species and on the environment, with particular emphasis on interactions amongst them. Detailed discussion of these topics is found in sections 4, 5 and 6 of Annex 4, with further information on linkages being given in paragraphs 7.16 to 7.19 of Annex 4. The findings

directly relating to krill were discussed under Agenda Item 4 and dependent species under Agenda Item 3 of the Scientific Committee (see paragraphs 4.1 to 4.31). A brief summary of discussions on environmental variables and of the findings on linkages is given below.

Environment

5.11 The value of a review of historical data on water mass distribution was emphasised. Issues of access to such data and the facilitation of analyses should be reviewed (Annex 4, paragraphs 6.2 to 6.4). The acquisition of comprehensive bathymetric and sea surface temperature (SST) data by the Secretariat should also be pursued.

5.12 Dr Marín advised the Scientific Committee of plans to develop a database as part of a Geographic Information System (GIS), which would include digitised bathymetric data for the region north of the South Shetland Islands. Notice of a related workshop on the use of information technology and GIS is given in SC-CAMLR-XIV/BG/33. It may be possible to arrange the extraction of relevant data for submission to CCAMLR. The Scientific Committee encouraged dialogue on this, believing that the provision of such information could greatly facilitate the work of WG-EMM.

5.13 Dr Siegel emphasised the importance of analysing data that allowed the detection of both interannual and decadal changes. He reported preliminary plans for a workshop to analyse such data and advised that a more formal proposal will be tabled at the next meeting of WG-EMM.

5.14 The Scientific Committee noted that a number of prey-based analyses of environmental data, which investigated the effects of large-scale and continental shelf water circulation, sea-ice and climate on krill and krill flux, had been discussed at WG-EMM (Annex 4, paragraphs 6.8 to 6.21). Other papers had reported results of integrated ecosystem analyses of environmental data (Annex 4, paragraphs 6.22 to 6.32).

5.15 In relation to sea-ice, a task group to be convened by Dr Miller was set up by WG-EMM to facilitate the formulation of specific hypotheses on the potential effects of sea-ice on components of the Antarctic marine ecosystem (see Annex 4, paragraph 6.49 for membership and terms of reference). This group is to work intersessionally and report to the next meeting of WG-EMM.

Relationships Between Dependent Species and Other Ecosystem Components

5.16 The Scientific Committee noted that progress has been made in modelling functional relationships between krill and several dependent species (black-browed albatross, fur seals and Adélie penguins - see Annex 4, paragraphs 5.104 to 5.112). Final calculations for the albatross and fur seal models should be completed by the 1996 WG-EMM meeting. Work on the Adélie penguin model may take longer to complete.

5.17 Progress has also been made on the evaluation of krill selectivity by predators (Annex 4, paragraphs 5.114 to 5.118). This is an important input to the krill yield model. The principal problem is still the ability to obtain fully representative length frequency distributions of krill, given the effects of different spatio-temporal scales of sampling. It was believed, however, that for most major predators diet and scat samples do provide representative samples of the length frequency of krill consumed by them. Progress is also being made on other approaches to this problem, as indicated in Annex 4, paragraphs 5.119 to 5.124.

Overlap Between Krill Harvesting and Dependent Species Foraging Areas

5.18 The nature and significance of the overlap between the location of krill fisheries and the foraging areas of krill-dependent predator species during the breeding season is a vital link in the Antarctic ecosystem. This interaction is currently assessed through the critical period-distance (CPD), which at present is taken to be a range of 100 km from breeding sites over the period December to March inclusive. Data on the overlap between the location of krill fishing and predator CPDs were provided to WG-EMM by the Data Manager (Annex 4, paragraphs 5.88 to 5.91).

5.19 At WG-EMM, the Data Manager reported that in 1995 there had been a substantial increase in the catch of krill by Ukraine in Subareas 48.1, 48.2 and 48.3. Paper SC-CAMLR-XIV/BG/3 analysed data on the overlap between krill fishing and predator CPDs. This demonstrated that most of the increased catch in 1995 was taken in Subarea 48.2 outside predator CPDs, and that overall the degree of overlap was similar to that in 1994. Further information on Ukrainian krill fishing in 1995 is given in SC-CAMLR-XIV/BG/29.

5.20 A number of potential difficulties associated with the use of the CPD were identified by WG-EMM, and different views were expressed as to whether application of the CPD concept under- or over-estimates the extent of overlap between predators and krill fishing (Annex 4, paragraphs 7.25 to 7.34). The interaction is complex, and it is very important that more empirical studies be

undertaken. The Scientific Committee agreed that the concept and details of the CPD needed further critical re-examination. It noted that this topic will be considered further at the next meeting of WG-EMM.

Taking Account of Land-based Predator Populations when Setting Precautionary Catch Limits

5.21 A proposal was made at WG-EMM that local precautionary catch limits for krill should be set taking into account the krill requirements of land-based predators (WG-EMM-95/17). The aim was to develop methods that would produce management advice designed to meet the aims of Article 2 of the Convention. Extensive discussion of this proposal is reported in Annex 4, paragraphs 7.61 to 7.76.

5.22 The Scientific Committee endorsed the following conclusions of WG-EMM:

- (i) there is a continuing need to ensure that krill catches are not concentrated in such small areas and over such short periods of time that local populations of dependent species may be adversely affected;
- (ii) when determining precautionary catch limits, and subdividing precautionary limits set for larger areas, as much relevant environmental and biological information as possible should be used; and
- (iii) the approach in WG-EMM-95/17, which makes use of extensive predator food consumption data, represents a valuable new thrust towards achieving these goals.

5.23 The Scientific Committee noted that a small subgroup, coordinated by Drs Everson and Boyd, was to carry out further work intersessionally on the incorporation of information on predator demand in the calculation of precautionary catch limits and their allocation to subarea in Area 48 (Annex 4, paragraphs 7.77 to 7.80 and Appendix H).

Other Interactions

5.24 Several other interactions between dependent species, harvested species and the environment were noted. These include links between sea-ice, krill abundance and penguin breeding (Annex 4, paragraphs 7.7 to 7.9); penguin chick starvation at Béchervaise linked to poor krill

availability (Annex 4, paragraphs 7.10 to 7.11); the effect of krill flux and other factors on local krill availability (Annex 4, paragraphs 7.12 to 7.15); patterns of breeding success of birds at Bird Island and the South Orkneys linked to krill and the environment (Annex 4, paragraphs 7.16 to 7.19); and the small numbers of albatross breeding linked to snowfall (Annex 4, paragraphs 7.20 to 7.22).

Preliminary Ecosystem Assessment

5.25 The Scientific Committee noted that for an ecosystem assessment, it was essential that integrated data be available on population size, adult survival rate, reproductive rate and recruitment of dependent species. At present, such data are only available for:

- Subarea 48.3 - Antarctic fur seal (South Georgia)
Black-browed albatross (South Georgia)

- Subarea 48.1 - Adélie and gentoo penguin (King George Island)
Adélie penguin (Palmer)

- Division 58.4.2 - Adélie penguin (Béchervaise).

Historical data covering all these variables are available for Adélie penguins at Cape Crozier and crabeater seals in Subarea 48.1.

5.26 WG-EMM attempted to draw together into a preliminary ecosystem assessment the information presented to it on the status of krill populations and the krill fishery, the status of dependent species, and the interactions amongst dependent species, harvested species and the environment (Annex 4, paragraphs 7.81 to 7.93). Discussions centred around summary tables of this information, which were similar to those previously used by WG-CEMP for dependent species only (Annex 4, Tables 3.1 to 3.10).

5.27 A lack of time during the meeting to complete some sections of these tables and the subjective nature of the interpretation of trends led WG-EMM to conclude that it was not yet possible to use this information to develop an ecosystem assessment. WG-EMM then identified a number of steps that needed to be taken urgently to improve the usefulness of the information and the tables. These are listed in Annex 4, paragraph 7.96. These topics were referred for consideration by the ad hoc intersessional Subgroups on Statistics and Methods.

Interactions with WG-FSA

5.28 WG-EMM discussed several research topics relating to fish-based dependent species/harvested species interactions. These included: the continuing status of *Pleuragramma antarcticum* as a CEMP species; the use of the diet of blue-eyed shags for providing local indices of abundance for *N. rossii* and *G. gibberifrons*; and the species and amounts of fish in the diets of king penguins and fur seals (see Annex 4, paragraphs 5.129 to 5.135).

5.29 The growing importance of considering such fish-based interactions in the deliberations of WG-EMM was recognised. This highlights the need for coordination of studies and evaluation of results between WG-EMM and WG-FSA.

5.30 The Scientific Committee noted that WG-FSA had also discussed several topics of relevance to WG-EMM, including some that arose directly from the report of the intersessional WG-EMM meeting. It had also directly posed some questions for consideration by WG-EMM. These are discussed in Annex 5, paragraphs 6.1 to 6.15.

5.31 A topic of particular relevance to both Working Groups is the by-catch of fish in the krill fishery. Two papers tabled at WG-EMM had been referred to WG-FSA for further consideration, and a further analysis of data in one of these papers was also tabled at WG-FSA. These are discussed in Annex 5, paragraphs 6.16 to 6.22. WG-FSA had concluded that it was still unable to provide a clear indication of the likely impact of krill harvesting on juvenile fish.

5.32 Dr Yakovlev suggested that, since the topic had been under discussion for several years, it was now time to indicate a by-catch limit for fish in the krill fishery.

5.33 The Scientific Committee noted that there were four components to the problem: the fish species, the location of hauls, the time of year and the amount of by-catch taken. All of these would need to be considered by the Scientific Committee in developing its management advice.

5.34 The Scientific Committee noted that a correspondence group coordinated by Dr E. Sabourenkov (Secretariat) planned to work intersessionally on this topic (Annex 5, paragraph 6.24), and that fish by-catch would be allocated a specific agenda item at next year's meeting of WG-FSA.

5.35 Mr Ichii welcomed the constructive criticism that had been made of the studies of fish by-catch on Japanese krill vessels in relation to the extent of their coverage in space and time. He noted, however, that four studies have now been completed and reported by Japanese and US

scientists (e.g., WG-EMM-95/56 and SC-CAMLR-XIV/BG/10 Rev. 1), and that despite difficulties in interpretation, the results all suggest that the by-catch in areas where Japanese vessels fish is low. He also pointed out that Japanese krill trawlers will avoid areas where a high level of fish by-catch occurs in order to ensure good quality product. He advised that these studies will continue. The Scientific Committee welcomed this and looked forward to receiving the results.

5.36 The Scientific Committee welcomed the interaction that was taking place between the two Working Groups.

MANAGEMENT UNDER CONDITIONS OF UNCERTAINTY ABOUT STOCK SIZE AND SUSTAINABLE YIELD

6.1 WG-FSA reviewed a report of a FAO/Government of Sweden technical consultation on the precautionary approach to fisheries management held at Lysekil in Sweden. The consultation highlighted the nature of precaution in fisheries management, clarified the concept of ‘reversal of the burden of proof’ in relation to fisheries management and provided specific guidelines for management, research, technology development and transfer, and species introduction. A summary of the report is set out in Annex 5, paragraphs 10.2 to 10.8.

6.2 The Scientific Committee noted that CCAMLR had acted as a pioneer for many of the approaches outlined in the Lysekil meeting. CCAMLR has already implemented, or was in the process of developing, many of the recommendations of the Lysekil meeting. These recommendations represent the latest thinking on what a precautionary approach entails. It considered, however, that some progress could still be made within CCAMLR in the prospective evaluation of management procedures and their likely outcomes under conditions of uncertainty. There was much still to be done and the Scientific Committee considered it important that CCAMLR continue to work at the forefront of world development of precautionary approaches to fisheries management. Working Groups were encouraged to take account of the recommendations of the Lysekil report in their work.

6.3 The Scientific Committee noted the significant advance made in this year’s assessment of *D. eleginoides* in Subarea 48.3 through the use of a stochastic stock projection method (Annex 5, paragraphs 5.56 to 5.72). This has allowed uncertainty in the estimates of recruitment, intrinsic variability in recruitment and uncertainty in other demographic parameters to be taken into account in the calculation of total allowable removals. If uncertainty were ignored, the traditional $F_{0.1}$ criterion gives a yield of 12 400 tonnes, which entails a high risk of over-exploitation. Taking uncertainty and recruitment variability into account, however, reduces the yield estimate to 4 000 tonnes and controls

the risk of over-exploitation. The use of the stochastic projection method should mean that reductions in uncertainty would be expected to lead to increases in allowable catch (see Annex 5, paragraph 5.70). The Scientific Committee noted that additional sources of uncertainty with the *D. eleginoides* fishery are those related to straddling stock issues and the need to ensure that there are adequate means for the exchange of information between CCAMLR and agencies managing adjacent areas (Annex 5, paragraphs 10.10 to 10.14).

6.4 The Scientific Committee reiterated that a long-term management plan for the *C. gunnari* fishery in Subarea 48.3 is required that takes into account uncertainty arising from sporadic mortality (see also paragraph 4.66). The Scientific Committee noted, however, that WG-FSA has as yet been unable to devote sufficient time to this work.

6.5 WG-EMM has also made progress in management under uncertainty. The approach, begun this year, of strategic modelling for the development and evaluation of ecosystem assessments provides one of the necessary foundations for the quantification of the effects of uncertainty on management advice. The strategic modelling approach will eventually allow for the integration of harvesting and predator-prey-environment models (Annex 4, paragraphs 7.35 to 7.106).

6.6 The Scientific Committee reiterated the need to consider the interaction between science and management, noting that policy decisions must give rise to the formulation of management objectives. Given management objectives, the Scientific Committee can advise the Commission on the likelihood of achieving them.

6.7 The Scientific Committee noted that CCAMLR has well developed policies and conservation measures for new and exploratory fisheries. However, there are no clear policies or measures to deal with cases where fisheries have been closed but are under consideration for re-opening. Although conservation measures have specified the requirement for a survey before resuming fishing in some fisheries, other steps are not well defined. Such steps could include, for example, the presence of scientific observers during the resumption of the fishery, the subsequent re-assessment of the fishery by WG-FSA and the criteria it would apply in advising on whether the stocks are sufficiently recovered. The Scientific Committee also recognised that a key element once a fishery is re-opened is the need for a plan for obtaining adequate information for further monitoring and assessment. The Scientific Committee agreed that this topic should be the subject of future discussions, and invited Members to submit papers on it.

SCIENTIFIC RESEARCH EXEMPTION

7.1 The Scientific Committee had been asked by the Commission to review the appropriateness of the 50-tonne krill catch limit, set as a scientific research exemption, specified in Conservation Measure 64/XII (CCAMLR-XII, paragraph 6.10). The Scientific Committee was unable to offer advice on this limit at its last meeting and called for Members using commercial types of trawl to submit information on the levels of catches which could be taken in research cruises, to be reviewed at WG-EMM-95 (SC-CAMLR-XIII, paragraph 11.2).

7.2 No information on this subject was available to WG-EMM, and consequently the Scientific Committee was unable to provide any further advice on the appropriateness of the limit for krill. It reiterated its call for information and requested WG-EMM to again consider the matter in the light of information available.

7.3 Last year, some members of WG-FSA had suggested that the period of six months required for advance notification of intended survey activity, where the expected catch was greater than 50 tonnes, was overly restrictive (SC-CAMLR-XIII, paragraph 11.4). WG-FSA considered this matter (Annex 5, paragraph 7.3) and concluded that the provision was appropriate in that it provides for sufficient opportunity for review of proposals by Working Groups and the Scientific Committee.

7.4 The Scientific Committee stated that its understanding of Conservation Measure 64/XII, paragraph 3(a), was that the review process would be complete either at the end of the two-month review period, should no request for review be lodged, or at the end of full review by the Scientific Committee and its Working Groups, should a request be lodged. The research survey could proceed immediately after the review process was complete. It requested that the Commission confirm that its understanding is correct.

NEW AND EXPLORATORY FISHERIES

New Fishery in Divisions 58.4.3 and 58.5.2

8.1 Australia submitted a proposal for a new fishery in Divisions 58.4.3 and 58.5.2 for the 1995/96 seasons (CCAMLR-XIV/8). The proposal was for a single trawler to undertake an exploratory cruise in Division 58.5.2 (Heard Island) to explore deeper water than has hitherto been investigated by Australian research cruises, and in Division 58.4.3 (Elan and Banzare Banks), for which there are very few records of fishing or research. WG-FSA considered this proposal in depth (Annex 5, paragraphs 5.1 to 5.7).

8.2 The Scientific Committee congratulated Australia on the thoroughness of its proposal.

Advice to the Commission

8.3 The Scientific Committee endorsed WG-FSA's advice on this proposal (Annex 5, paragraphs 5.4 to 5.7) and recommended the following TACs for these fisheries (Table 4).

Table 4: Recommended TACs for the new fisheries proposed by Australia in Divisions 58.5.2 and 58.4.3.

Area	Species	TAC
Division 58.5.2 (new exploratory deep-water fishery)	<i>D. eleginoides</i>	No additional TAC: catches to be part of the 297 tonnes currently set by Conservation Measure 78/XIII
	<i>C. gunnari</i>	No additional TAC: catches to be part of the 311 tonnes currently set by Conservation Measure 78/XIII
	<i>L. squamifrons</i> , <i>N. rossii</i> , <i>C. rhinoceratus</i> and <i>Bathyraja</i> spp.	By-catch limitation of 5% of the catch in any haul
	Other species	50 tonnes each species
Division 58.4.3 Elan and Banzare Banks	<i>D. eleginoides</i> and <i>D. mawsoni</i>	200 tonnes combined catch
	Other species	50 tonnes each species

8.4 Bearing in mind that previous research surveys in Division 58.5.2 found a low biomass of *L. squamifrons*, *N. rossii*, *Channichthys rhinoceratus* and *Bathyraja* spp., and that there is no TAC or prohibition on directed fishing for these species in this division, the Scientific Committee recommended that a by-catch limitation should be considered along the lines of Conservation Measure 84/XIII, paragraph 7. The relevant part of Conservation Measure 84/XIII, paragraph 7, with recommended insertions, reads:

‘If, in the course of the directed fishery [for *D. eleginoides* or *D. mawsoni*], the by-catch of any one haul of any of the species [*Lepidonotothen squamifrons*, *Notothenia rossii*, *Channichthys rhinoceratus* and *Bathyraja* spp] exceeds 5%, the fishing vessel shall move to another fishing ground ...’

8.5 The Scientific Committee also recommended that in order to maximise the use to which information from the exploratory cruises could be put, fishing should take place over as large a

geographical and bathymetric range as possible. In particular, areas where concentrations of fish are found should not be the only areas that are fished.

8.6 The Scientific Committee endorsed Australia's proposal to place a scientific observer on board and ensure that the vessel operated a vessel monitoring system (VMS).

New Fishery in Subarea 58.7

8.7 Dr Miller informed the Scientific Committee of South Africa's intention to initiate a new longline fishery for *D. eleginoides* within South Africa's EEZ, on the high seas adjacent to this EEZ and within the CCAMLR Convention Area in the EEZ around the Prince Edward Islands (part of Subarea 58.7).

8.8 At present, full details on the proposed fishery are unclear. In the spirit of Conservation Measure 31/X, however, South Africa will aim to limit fishing effort and will submit haul-by-haul data to the Commission from the fishery from both outside and inside the Convention Area in the recognised CCAMLR formats. Permit conditions will also require that the provisions of Conservation Measure 29/XIII (minimisation of seabird incidental mortality during longline fishing) be adhered to, namely that scientific observers should be carried on the vessels concerned and that all vessels should be fitted with satellite-linked vessel monitoring systems.

8.9 The Scientific Committee noted South Africa's notification and looked forward to further information in due course, especially with respect to anticipated catch levels and limitation of actual levels of fishing effort. It also noted that no information on potential stock of *D. eleginoides* exists for the proposed fishing areas and therefore strongly supported South Africa's future submission of relevant data to the CCAMLR database.

CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION

Scientific Observation in the 1995 Season

9.1 The Scientific Committee recalled that it was a requirement of Conservation Measure 80/XIII that an international scientific observer be aboard each vessel fishing for *D. eleginoides* in Subarea 48.3. CCAMLR had received reports of 18 scientific observations in this fishery (from Argentina, Chile, Spain, Ukraine and Russia) which WG-FSA had used extensively in its work (Annex 5, paragraph 3.12). In addition, CCAMLR received reports of observations on board two krill trawlers,

one under the CCAMLR Scheme of International Scientific Observation (from the US) and two under a national program (Ukraine) (SC-CAMLR-XIV/BG/10, 20 and 22). The Scientific Committee most sincerely thanked all scientific observers for their considerable efforts in the 1994/95 season, and congratulated them on the quality of the data and reports arising from their work.

9.2 Experience has shown that the CCAMLR Scheme of International Scientific Observation often is the only means to:

- obtain verifiable data from fisheries in the Convention Area;
- obtain information to better understand the conduct of particular fisheries; and
- educate crews of vessels in the use of measures mitigating the incidental mortality of seabirds.

9.3 In this regard, the Scientific Committee recalled its earlier discussions on the value of scientific observer data, given in paragraphs 3.36 to 3.38, particularly noting the increases in data quality and quantity that had been possible on those vessels using two scientific observers.

9.4 The 100% scientific observer coverage, and the observer data from the *D. eleginoides* fishery available to the Scientific Committee this year, had made it possible to conduct the first reliable assessments of *D. eleginoides* and the first systematic analyses of incidental mortality of seabirds. Information collected by scientific observers is crucial for future assessments and management of finfish fisheries in the Convention Area.

9.5 Therefore, the Scientific Committee recommended that it is essential to continue 100% coverage in the *D. eleginoides* fishery. This principle, which is also applied to the crab fishery, should be extended to other finfish fisheries.

9.6 The Scientific Committee has made considerable progress with increasing the efficiency of the scientific observer system, based on experience from the previous seasons, by:

- developing a system for the preparation of observer summary reports (Annex 5, Appendix H);
- defining priority tasks for scientific observers (Annex 5, paragraph 8.79);
- developing a logbook for ease of data collection and submission (Annex 5, paragraph 11.13); and

- further revising the *Scientific Observer Manual* (see below).

9.7 The Scientific Committee recommended that the Commission endorse each of the above initiatives.

9.8 In order to make maximum use of the data, however, and thus give full justice to the scientific observers' considerable efforts in collecting this information, observer data need to be processed and presented in such a way as to enable working groups to make full use of them in assessments. The large volume of data submitted by the scientific observers is likely to increase in the future. These need to be checked, coded, validated and summarised - often in a comparatively short time - in order to make efficient use of them in assessment work. The Data Management Group of the Secretariat is under-staffed to carry out this task. Therefore, the Scientific Committee strongly recommended the employment of a data analyst to undertake this work.

9.9 Similar fisheries for *D. eleginoides* occur in the waters adjacent to the Convention Area, and fishing vessels may fish both in the Convention Area and outside. Species subject to incidental mortality also occur both inside and outside the Convention Area. Information from these fisheries outside the CCAMLR area is very important for the assessment of CCAMLR *D. eleginoides* fisheries. Therefore,

- the Scientific Committee suggested that the Commission should draw to the attention of Members fishing in areas outside the Convention Area the benefits a high degree of scientific observer coverage can bring in terms of data quality for assessing the impact of fishing on *D. eleginoides* and seabirds caught incidentally in these fisheries; and
- in order for CCAMLR to gain access to information from observer programs in areas adjacent to the Convention Area, consideration should be given to ensuring a free flow of information between *D. eleginoides* longline fishery observer programs operating inside and outside the Convention Area. This should include provision of CCAMLR information to bodies responsible for management of fisheries outside the Convention Area, where appropriate.

9.10 The Scientific Committee reiterated its advice from last year (SC-CAMLR-XIII, paragraphs 13.10 to 13.14) in relation to the presence of two scientific observers on board, the responsibilities of crews hosting an observer, the fate of samples collected on board, and the submission of data to CCAMLR and access to these data (SC-CAMLR-XIII, paragraphs 13.10 to 13.14).

9.11 It was agreed that in future, scientific observers would be asked to submit to the Secretariat all observer data, and a summary report using the format given in Annex 5 (Appendix H), and could submit an additional report at their discretion. Since a large number of summary reports is expected, the reports would not be copied and distributed to working groups or the Scientific Committee as working or background papers. Instead, an index of the contents of all scientific observer reports will be maintained by the Secretariat for distribution to all working groups and the Scientific Committee, and the summary reports themselves would be made available for reference.

9.12 It was emphasised that all data and all reports would be available to any Member, working group, the Scientific Committee or Commission at any time for consultation under the Rules for Access and Use of CCAMLR Data, and that the intention of this decision was to avoid unnecessary duplication of reports rather than to restrict access or scientific analysis.

Revision of the *Scientific Observers Manual*

9.13 A draft *Scientific Observers Manual* was prepared by the Secretariat as SC-CAMLR-XIV/6. The Scientific Committee endorsed all the changes to this draft suggested by WG-EMM (Annex 4, paragraph 3.15) and WG-FSA (Annex 5, paragraphs 8.75, 8.76 and 8.79). It suggested further changes based on observations by Ukraine (SC-CAMLR-XIV/BG/31).

9.14 The Scientific Committee recommended that the amended *Scientific Observers Manual* should be published in loose-leaf form in 1996.

CCAMLR DATA MANAGEMENT

Interaction with Other Organisations

10.1 At its last meeting, the Scientific Committee requested that the Secretariat lodge information on planned research cruises, being compiled annually by CCAMLR, on an electronic bulletin board being developed by SCAR (SC-CAMLR-XIII, paragraph 14.11). The Data Manager reported that no request for this information had yet been received. The Scientific Committee agreed that the Secretariat should provide the information to SCAR when the bulletin board is developed.

10.2 The Data Manager reported in SC-CAMLR-XIV/BG/5 that SCAR had decided that the host of its Antarctic Master Directory (AMD) would be the International Centre for Antarctic Information and Research (ICAIR) (New Zealand). Appropriate formats for submitting directory information to

the AMD would be developed over the next year. The Scientific Committee reiterated its request (SC-CAMLR-XIII, paragraph 14.14) that when the AMD became operational, information about CCAMLR data holdings should be lodged with it. The CCAMLR rules of access to data would be clearly stated with this information.

10.3 The usefulness of exchanges of information about data holdings with other institutions concerned with Antarctic Data Management was recognised. In particular, the increasing value of CCAMLR's long-term data sets both to the Scientific Committee and the international scientific community was noted (Annex 4, paragraph 9.17). The Scientific Committee recommended that the Secretariat continue to develop contacts with other international and national data centres, such as the National Snow and Ice Data Center (NSIDC) (Colorado, USA), ICAIR and the Chilean national centres described in SC-CAMLR-XIV/BG/33, especially with regard to developing a World Wide Web site (WWW) (see paragraph 10.5) and exchanging information on data holdings.

10.4 The Data Manager reported that progress was being made with acquiring data from the IWC (SC-CAMLR-XIII, paragraph 14.23). A full report on this work will be presented at the 1996 meeting of the Scientific Committee.

World Wide Web

10.5 The Secretariat's proposal for the development of a CCAMLR WWW site, requested by the Scientific Committee last year (SC-CAMLR-XIII, paragraph 14.31), was presented in SC-CAMLR-XIV/5. The Scientific Committee agreed that a web site should be developed at the Secretariat in stages, along the lines indicated in the proposal. The following process should apply:

- (i) install, develop and test a web site containing textual information in 1996. A home page, the text of the Convention, the CCAMLR newsletter and WG-EMM newsletter should be mounted;
- (ii) monitor the traffic on the web site and provide a report to SC-CAMLR-XV; and
- (iii) the Scientific Committee will review progress and consider further developments of the web site at its 1996 meeting, including the question of access to public domain data sets through the web.

10.6 It was emphasised that although this scheme includes a component of monitoring usage, such monitoring would not necessarily indicate the level of usage that might be expected for later developments of the web server, such as access to public domain data sets.

Data Management Workload

10.7 Paper SC-CAMLR-XIV/BG/5 provided information that the amount of data processed by the Secretariat had increased three-fold in 1995. It also indicated that new requirements for data reporting, both of historic and future data (Annex 4, section 8; Annex 5, paragraph 11.2) would mean that the amount of data that had to be processed by the Secretariat was likely to increase over the next few years. These increases were greater than those predicted in 1993 (CCAMLR-XII/8) for which the Commission had provided additional funding (CCAMLR-XII, Annex 4, paragraph 5).

10.8 The Scientific Committee considered that the role of Secretariat Data Management had changed since the 1980s from a limited data processing function to an organisation from which the Scientific Committee had three primary requirements:

- (i) data management functions (data acquisition, database maintenance);
- (ii) coordination of Scientific Committee protocols for data acquisition and analysis, including model validation; and
- (iii) routine and investigative data analysis.

10.9 The workload associated with all three requirements of the Scientific Committee is currently increasing. Much of this increased workload is a consequence of initiatives of both the Scientific Committee and the Commission towards management under uncertainty and the development of an ecosystem approach. Both these developments require very high quality data and complex statistical analyses that are heavily dependent upon computing power.

10.10 In this regard, the Scientific Committee endorsed the recommendation of WG-FSA that the Secretariat purchase a fast workstation and analysis software (Annex 5, paragraph 11.5).

10.11 The Scientific Committee emphasised that it could not function without a high quality Data Management/Analysis Section within the Secretariat. It directed the Data Manager to keep the resource requirements of the Data Management/Analysis Section under review and to provide advice on funding requirements as necessary.

Ukrainian Historical Data

10.12 Paper SC-CAMLR-XIV/BG/15 described a large volume of historical oceanographic environmental and ichthyological data covering a 20-year period which is currently held on paper records at YugNIRO (Ukraine). These data might be of considerable assistance to the Scientific Committee. To increase their accessibility, these data are being transferred to magnetic media. The Scientific Committee was pleased that Ukraine was undertaking this task, and encouraged other Members to assist Ukraine.

COOPERATION WITH OTHER ORGANISATIONS

11.1 In 1993 the Scientific Committee requested a document detailing the scope of cooperation CCAMLR has with organisations with interests in Antarctic issues. This document was presented as SC-CAMLR-XIV/BG/4. The Scientific Committee thanked Dr Sabourenkov for completing this useful work, which for the first time documents the complexity of CCAMLR's interaction with other organisations, and drew it to the Commission's attention.

IUCN

11.2 The IUCN Observer (Mr A. Graham) noted that the IUCN General Assembly in 1994 had adopted a resolution commending CCAMLR's approach to resource management.

11.3 IUCN regards the incidental mortality of birds and mammals as a result of fishing operations as a matter of grave concern to the wider community. An example of this concern is given by the Australian Government which has listed the Macquarie Island subspecies of the wandering albatross as threatened under national legislation and longline fishing as a threatening process requiring mitigation. The IUCN urged CCAMLR to consider setting by-catch limits for affected species which would allow fisheries to be closed if incidental mortality could not be reduced to acceptable levels and strategies to achieve zero targets could not be devised.

11.4 Finally, the IUCN urged Scientific Committee Members to assist with the implementation of a number of international agreements: the Convention on Biological Diversity; the Convention on Migratory Species (the Bonn Convention); the Convention on International Trade in Endangered

Species (CITES); and the new UNCLOS Agreement⁶. The Scientific Committee delegates were urged to recommend to their governments that the last agreement be ratified as soon as possible.

FAO

11.5 The Observer from FAO (Dr R. Shotton) informed the Scientific Committee that FAO considered CCAMLR to be a leading example of the practical implementation of a precautionary approach in fisheries management, which was discussed at a meeting in Lysekil (Sweden) in June 1995 (paragraphs 6.1 and 6.2; Annex 5, section 10). Nevertheless, he noted that while uncertainty was currently being taken into account by CCAMLR in its management approaches, other aspects of a precautionary approach such as determination of attitude to risk and future discounting were not yet being addressed. Associated with these concepts is the need to assist decision makers in articulating coherent objectives, a difficult and technical activity in multi-objective situations where conflicting goals are sought to be achieved.

11.6 The Scientific Committee was reminded that FAO had played a large part in drafting the UNCLOS Agreement which was now open for ratification.

11.7 FAO is interested in a joint case-study with CCAMLR on the management of fisheries, and will approach CCAMLR soon with a formal proposal for that study.

11.8 Finally, Dr Shotton drew the attention of the Scientific Committee to a forthcoming FAO-sponsored publication on Euphausiid fisheries, which is being authored by Drs S. Nicol (Australia) and Y. Endo (Japan). Delegates were notified that the authors might be contacting relevant scientists with requests for information in the near future.

SCAR

11.9 The SCAR Observer to the Scientific Committee (Dr Miller) informed the Scientific Committee that various SCAR groups will meet in conjunction with the XXIVth meeting of SCAR in Cambridge during late July-early August 1996. Meetings of groups of interest to the Scientific Committee will include the Steering Committee for CS-EASIZ (coastal shelf sector of the ecology of the Antarctic sea-ice zone), the SCAR Group of Specialists on Southern Ocean Ecology, the SCAR

⁶ Draft agreement for the implementation of the provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the conservation and management of straddling fish stocks and highly migratory fish stocks.

Group of Specialists on Seals, the SCAR Bird Biology Subcommittee and the Working Group on Biology.

11.10 Dr Miller also noted that the Scientific Committee's interaction with SCAR was increasing. In this regard, the Scientific Committee agreed that in order to improve the flow of information between CCAMLR and SCAR's Group of Specialists on Environmental Affairs and Conservation (GOSEAC), Dr E. Fanta (Brazil) should serve as a liaison officer between the Scientific Committee and GOSEAC. The Scientific Committee noted that it had already considered cooperation with SCAR under other agenda items, namely the APIS Program, (paragraphs 3.64 to 3.67), for which Dr Boyd would act as liaison, and various items on data management (paragraphs 10.1 and 10.2) for which the Data Manager would act as liaison.

11.11 Dr M. Fukuchi (CCAMLR Observer to CS-EASIZ) reported that SCAR's CS-EASIZ Program is now under way and has been incorporated into GLOCHANT (SCAR's major initiative related to Global Change in the Antarctic). There will be close coordination between CS-EASIZ and GLOCHANT. In this connection, a new program ASPECT (Antarctic Sea-Ice Processes, Ecosystems and Climate) has now been prepared, and a joint EASIZ-GLOCHANT meeting was held at the National Institute of Polar Research (NIPR), Tokyo, in March 1995.

11.12 The first meeting of the CS-EASIZ Steering Committee was held at BAS (British Antarctic Survey), Cambridge, UK, 25 August 1995, and was very successful. CS-EASIZ fieldwork will commence with a cruise by RV *Polarstern* in the 1995/96 season. The first edition of the EASIZ newsletter and a brochure describing the CS-EASIZ Program will appear later this year and will be forwarded to CCAMLR.

SCOR

11.13 The Observer from SCOR, Dr Everson, introduced the SCOR initiative JGOFS and the SCOR Working Group 86 (Ecology of Sea Ice). Both have components dealing with ecology and production in the ice zone which are of interest to WG-EMM. Of greater significance is SO-GLOBEC which is a program covering many of the components of Southern Ocean ecology that are of interest to WG-EMM. The approaches taken by GLOBEC are likely to cover a greater species diversity than those currently included in CEMP. Dr Everson submitted documentation on each of these programs to the Secretariat and encouraged Members who might wish to extend collaboration on these programs to make contact through the SCOR Secretariat.

IWC

11.14 The Observer from IWC (Mr J. Bannister) drew attention to a number of items arising out of matters raised last year on behalf of the IWC Scientific Committee by Dr Reilly. The IWC's interest in these issues was also reported to the Scientific Committee by the CCAMLR Observer to the SC-IWC, Dr de la Mare, in SC-CAMLR-XIV/BG/34.

11.15 The IWC Steering Group on Research Related to the Conservation of Large Baleen Whales in the Southern Ocean held a meeting in Japan in March 1995. Dr Everson represented CCAMLR, as a krill specialist, and the Scientific Committee noted that his report on the meeting had been presented to WG-EMM (WG-EMM-95/31). As a result of that meeting, and of deliberations by the IWC Scientific Committee at its annual meeting in Dublin in May, a four-week cruise to study blue whales is to take place off Australia, between Fremantle and Hobart and down to 45°S, in December/January 1995/96, supported jointly by Japan and IWC. The major aim is to provide scientifically-based criteria for distinguishing 'true' from 'pygmy' blue whales in the field which will allow more accurate estimates of 'true' blue whale numbers on future surveys. Passive acoustics, photo-identification, photogrammetry and tissue biopsy will be employed. Secondary target species will be southern right whales and humpback whales.

11.16 A symposium/workshop on the effects of climate change on cetaceans is to be held in Hawaii at the end of March 1996, and its provisional agenda has already been circulated to some Scientific Committee Members for comment. It was confirmed that Dr Marín would represent the Scientific Committee at the meeting, and the proposal of WG-EMM was endorsed that CCAMLR scientists could contribute on two topics:

- (i) biological changes in the marine environment which may affect the distribution and availability of krill; and
- (ii) CCAMLR approach to strategic modelling - a tool to develop management advice in the context of a changing environment (Annex 4, paragraph 9.14).

11.17 It was agreed that Dr de la Mare and Mr Ichii should prepare a paper for presentation at the workshop outlining the CCAMLR approach to those topics (Annex 4, paragraph 9.15).

11.18 Dr de la Mare informed the Scientific Committee that a copy of the IWC's report on the effects of chemical pollutants on cetaceans had been forwarded to the Secretariat.

11.19 Last year the Scientific Committee discussed the possibility of adding a whale sightings survey component to cruises in studies in CCAMLR ISRs (SC-CAMLR-XIII, paragraph 14.24). The Scientific Committee agreed that this topic was still of importance, and should be included in the agenda of the next meeting of WG-EMM.

11.20 In order to progress with this subject, the Scientific Committee invited the IWC to provide a document for evaluation at WG-EMM outlining the minimum effort required to carry out statistically reliable whale observations on platforms of opportunity in the Antarctic, and the availability of trained observers for this work.

11.21 A related concern is the effect of active acoustics (used in surveying krill) on whale behaviour and the influence this might have on the results from, or design of, combined sightings and acoustic surveys. The Scientific Committee requested the IWC for any technical advice on this matter.

11.22 The Scientific Committee noted that priority in the IWC's comprehensive assessment of southern hemisphere baleen whales was being given to humpback whales. Several stocks, including those wintering off the east and west coasts of Australia and the east coast of South Africa, were showing strong signs of recovery. The 'Australian' populations were both increasing at 10% per year, and numbers were up to around 2 000 and 4 000 on the east and west coasts respectively. A revision of estimates for southern hemisphere 'true' blue whales gave much the same figure as reported last year, i.e. around 500 animals, with a CV of 0.36. Detailed information on the most recent southern hemisphere whale estimates is to be sought formally from IWC (paragraph 3.70).

11.23 In response to the Scientific Committee's request for advice from IWC on cetacean-fisheries interactions (SC-CAMLR-XIII, paragraphs 9.42 and 9.43) Dr R. Gambell (Secretary to the IWC), wrote to the Executive Secretary including a paper on 'Developments on Issues Relating to the Incidental Catches of Cetaceans since 1992 and the UNCED Conference' (*Rep. Int. Whal. Commn* (Special Issue 15), 1994: 609-613). The Scientific Committee welcomed this information. However it noted that interactions between cetaceans and fisheries continue to be reported by scientific observers in the CCAMLR area (see for example Annex 5, paragraph 3.13) and agreed that information on this matter should continue to be exchanged with the IWC.

CWP (Coordinated Working Party on Fishery Statistics)

11.24 CCAMLR-XIV/7 reported on the Sixteenth Meeting of the CWP (Madrid, Spain, March 1995). The primary business of this meeting was the reconsideration of new statutes and rules of procedure

for the CWP. The report recommended that CCAMLR endorse the new statutes and become a member of the new CWP.

11.25 The Scientific Committee endorsed this suggestion and recommended that the Secretariat continue to participate in meetings of the CWP.

NAFO and ICES

11.26 Dr Øritsland presented a report on the NAFO/ICES symposium on the role of marine mammals in the ecosystem (SC-CAMLR-XIV/BG/28). Of interest to CCAMLR were addresses on 'Environmental, spatial and temporal influences on life history', 'Foraging strategies and energetic considerations' and 'Theoretical considerations on the role of apex predators in multispecies models'. While these topics were of general interest to CCAMLR, there was only one address under, 'Marine mammal - fisheries interactions', by the prodigious Prof. Butterworth, which discussed Antarctic situations and CCAMLR's ecosystem approach to management.

11.27 Dr Everson participated in the ICES Symposium on Fisheries Acoustics held at Aberdeen, 12 to 16 June 1995. He and several participants subsequently participated in the WG-EMM meeting in Siena, Italy, contributing to the Working Group's discussions on acoustic estimation of krill. Dr Everson also drew the Scientific Committee's attention to activities taking place within two ICES Working Groups. The ICES Fisheries Acoustics Science and Technology Working Group is currently preparing a cooperative research report on acoustic target strength and the ICES Fishing Technology and Fish Behaviour Working Group has a Study Group on Unaccounted Mortality and a Subgroup on Selectivity Methods; copies of these reports had been sent to the Secretariat.

Future Cooperation

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

- Canadian Krill Fisheries Workshop, November 1995, Vancouver, Canada - Dr Agnew (Data Manager);
- SCAR-COMNAP Second Environment Workshop, March 1996, Texas, USA - Dr Agnew (Data Manager);

- IWC Workshop on Effects of Climate Change on Cetaceans, March 1996, Oahu, Hawaii, USA - Dr Marín;
- IWC Scientific Committee Meeting, June 1996, Aberdeen, UK - Dr Kock (Chairman, Scientific Committee);
- XXIV SCAR meetings, August 1996, Cambridge, UK - Dr Croxall (birds), Dr Miller (GOSSOE) and Dr J. Bengtson (USA) (seals);
- APIS, August 1996, Cambridge, UK - Dr Boyd;
- CS-EASIZ, August 1996, Cambridge, UK - Dr Fukuchi;
- IOC First Southern Ocean Forum, September 1996, Bremerhaven, Germany - Dr Kock (Chairman, Scientific Committee);
- Third International Penguin Conference, September 1996, Cape Town, South Africa - Dr Kerry;
- CCSBT ERS⁷ Group - Australia.

Proposals for ASMAs and ASPAs Submitted for Consideration
by Antarctic Treaty Consultative Parties

11.29 The proposal by Brazil and Poland (CCAMLR-XIV/BG/27) did not arrive in time for the Scientific Committee to give it full consideration, and as a consequence this matter was referred to the Commission.

PUBLICATIONS

12.1 The publication *CCAMLR Science* is currently in the second year of its three-year trial period. Paper CCAMLR-XIV/BG/4 reported that the number of subscribers to the journal is steadily increasing and that the second volume will be available in the course of CCAMLR-XIV.

⁷ Commission for the Conservation of Southern Bluefin Tuna Ecosystem and Related Species

12.2 Copies of Volume 1 have been sent to four journals for independent review. Only *Marine Mammal Science* has so far responded, commenting very favourably on the quality of the content, editing and presentation.

12.3 The Scientific Committee expressed its appreciation to the Secretariat, and in particular to Dr Sabourenkov (Editor), Ms G. Naylor, Mrs R. Marazas, Ms G. von Bertouch and Mr B. Scruton (technical editors) for the extremely high standard of all aspects of the publication.

12.4 The Scientific Committee endorsed the recommendations of the Working Groups regarding the publication of: revisions of the *CEMP Standard Methods* (Annex 4, paragraph 5.14); logbooks for observers (Annex 5, section 12); a revision of the first volume of the extra *Statistical Bulletin* (Annex 5, section 12); the booklet 'Catching fish not birds: a guide to improving longline fishing efficiency' (Annex 5, paragraph 8.22); and a new version of the *Scientific Observers Manual*.

ACTIVITIES OF THE SCIENTIFIC COMMITTEE IN THE INTERSESSIONAL PERIOD

13.1 An offer was made by Norway to host WG-EMM in 1996, and the Subgroup on Standard Monitoring Methods meeting. This was gratefully received by the Scientific Committee.

13.2 WG-EMM will meet in Bergen, Norway, from 12 to 22 August 1996, and will be convened by Dr Everson.

13.3 The Subgroup on Monitoring Methods will also meet in Bergen, from 8 to 10 August 1996, convened by Dr Kerry. The Subgroup on Statistics will meet from 8 to 10 May 1996 in Cambridge, UK, convened by Dr Agnew.

13.4 Preliminary task lists for both the Subgroup on Statistics and the Subgroup on Monitoring Methods are given in SC-CAMLR-XIV/BG/7. The Scientific Committee endorsed these task lists. The proposed timetable for intersessional work for the methods subgroup prior to its Bergen meeting was amended to:

November 1995 to March 1996	All new text to be collected, circulated to experts as appropriate and edited into methods format by Convener and the Secretariat.
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April 1996

Circulate all new method texts to Members and SCAR groups (as required by Annex 4, paragraph 5.53), requesting comments by the end of the SCAR Biology meeting (2 August 1996). Further completely new method texts should be solicited from Members and SCAR.

13.5 Participants at WG-EMM were further invited to attend a workshop on geostatistics, acoustics and survey design, to be convened by Dr K. Foote in Bergen after WG-EMM, from 26 to 28 August, 1996.

13.6 WG-FSA will meet from 7 to 16 October 1996 in Hobart, Australia and will be convened by Dr de la Mare.

13.7 The Scientific Committee recalled the extremely valuable work done by Dr Kim over the last three years in coordinating information about research around the Antarctic Peninsula. This work had culminated in a very productive workshop in Hamburg, Germany in 1995 (Annex 4, Appendix D). The Scientific Committee recommended that such coordination work, which has benefits for both individual Member research programs and the Scientific Committee's work, should continue, and welcomed Dr Kim's offer to continue to act as coordinator for this work (Annex 4, paragraph 9.8).

BUDGET FOR 1996 AND FORECAST BUDGET FOR 1997

14.1 The Scientific Committee noted a request from SCAF that it should attach priorities to the various items of its budget, and should bear in mind SCAF's desire for zero real growth. The Scientific Committee considered its budget in the light of this request.

14.2 However, given the increasing volume of work required of the Scientific Committee to provide the best scientific advice to the Commission, the Scientific Committee felt it was unrealistic to expect, within a goal of zero real growth in the CCAMLR budget as a whole, that the budget of the Scientific Committee should necessarily remain stable.

14.3 The Scientific Committee reminded the Commission that, in fact, the Scientific Committee budget was currently only 7.5% of the total CCAMLR budget, and that this percentage has been stable or even slightly declining since 1989 (Annex 6, Figure 1).

14.4 Furthermore, the Scientific Committee noted that in 1996 the meetings of WG-EMM and WG-FSA comprise 83% of the total budget; it was unable to prioritise between these two meetings without explicit advice from the Commission.

14.5 The budget and explanatory notes are attached as Annex 6. For 1996 provision is made for meetings of WG-EMM and WG-FSA, the Subgroup on Monitoring Methods and the Subgroup on Statistics. Provision is also made, under the projection for 1997, for a contribution from CCAMLR to the Euphausid Biology Symposium (paragraph 4.24) and the publication of the 'Guide to Understanding CCAMLR's Approach to Management'.

14.6 In respect of the Secretariat Travel item, the Scientific Committee explored the possibility of cost saving by holding the meeting of WG-EMM in Hobart. It reiterated its advice of earlier years, however, that there are immeasurable benefits to CCAMLR in raising both its scientific and political profile within the host country. The work of the Scientific Committee has been considerably enhanced by participation of scientists at these meetings who would otherwise be unable to attend. There was also considerable benefit to Members hosting the meeting, in that they did not have to pay for travel of their scientists, and in general, Members often did not have to pay as much as they would should the meetings take place in Hobart. Finally, if costs were to be reduced at such meetings the Scientific Committee requested that the Commission consider whether there was a need for the Executive Secretary to attend working group meetings, given that the Secretariat's function at these meetings is to provide technical support.

14.7 A number of additional items were recommended by the Scientific Committee for inclusion in the Commission's budget. These were, in priority order, the employment of an Observer Data Analyst, the purchase of a fast workstation, the publication of scientific observer logbooks, the publication of a revised edition of the *Statistical Bulletin* and the installation of a WWW site at the Secretariat. Detailed explanation and costing for these items is given in Annex 6.

14.8 The Scientific Committee noted its difficulty in establishing priorities, e.g. between its working groups and between the first three items listed in paragraph 14.7. It considered that both working groups and all three items were essentially of equal importance to its work. Should any element not be fully funded, the work of the Scientific Committee would be directly impacted and the quality of its advice would suffer. The Scientific Committee, however, welcomed attempts by the Commission to prioritise items within the budget of CCAMLR as a whole.

14.9 It was pointed out that the path which the Scientific Committee has been following, especially in regard to the development of management under uncertainty, the ecosystem approach, and the use

of scientific observers, had been determined by initiatives of the Commission. It is these new approaches which require additional resources.

14.10 The Scientific Committee also drew the attention of the Commission to the great benefit it derives from the large amount of work currently being performed by individual scientists on behalf of CCAMLR, which would be very costly if obtained through consultancy.

ADVICE TO SCOI AND SCAF

15.1 Advice to SCOI and SCAF is given under Agenda Items 9 and 14.

ELECTION OF VICE-CHAIRMEN OF THE SCIENTIFIC COMMITTEE

16.1 In accordance with Rule 8 of the Rules of Procedure of the Scientific Committee there was an election of two Vice-Chairmen. Prof. C. Moreno (Chile) nominated Dr S. Kim (Republic of Korea) and Dr M. Naganobu (Japan) nominated Prof. B. Fernholm (Sweden) as Vice-Chairmen. In making the nominations, Prof. Moreno and Dr Naganobu referred to the considerable experience of Dr Kim and Prof. Fernholm in Antarctic marine research, their long association with CCAMLR and dedication to the work of the Scientific Committee. The nominations of Dr Kim and Prof. Fernholm were seconded by Drs Everson and de la Mare respectively.

16.2 Dr Kim and Prof. Fernholm were unanimously elected as Vice Chairmen of the Scientific Committee for the period from the end of the Fourteenth Meeting until the end of the Scientific Committee meeting in 1997.

NEXT MEETING

17.1 The next meeting of the Scientific Committee will take place in Hobart, Australia, from 21 to 25 October 1996.

OTHER BUSINESS

18.1 There was no other business.

ADOPTION OF THE REPORT

19.1 The report of the Fourteenth Meeting of the Scientific Committee was adopted.

CLOSE OF THE MEETING

20.1 In closing the meeting, Dr Kock thanked participants for their hard work, not only during the meeting, but during the intersessional period. He also expressed his appreciation to the Rapporteurs, Secretariat, Interpreters and sound system operators for their support and assistance.

20.2 On behalf of the Scientific Committee, Dr Miller expressed a sincere vote of thanks to the Chairman, Dr Kock, for his expert guidance through a vast amount of work.

20.3 Dr Kock then closed the meeting.

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LIST OF PARTICIPANTS

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OF THE SCIENTIFIC COMMITTEE**

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OF THE SCIENTIFIC COMMITTEE**

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**REPORT OF THE WORKING GROUP ON
ECOSYSTEM MONITORING AND MANAGEMENT**

(Siena, Italy, 24 July to 3 August 1995)

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REPORT OF THE WORKING GROUP ON ECOSYSTEM MONITORING AND MANAGEMENT

(Siena, Italy, 24 July to 3 August 1995)

INTRODUCTION

Opening of the Meeting

1.1 The meeting of the Working Group on Ecosystem Monitoring and Management (WG-EMM) was held at the University of Siena, Italy from 24 July to 3 August 1995.

1.2 Prof. Piero Tosi, Chancellor of the University of Siena, opened the meeting and welcomed participants to Siena. On behalf of the Working Group the Convener, Dr I. Everson (UK), thanked Prof. Tosi and Prof. Silvano Focardi for the invitation to hold the meeting in Siena and for the substantial work which had been performed in pre-meeting arrangements.

1.3 The Convener expressed his satisfaction that 16 Members were represented by 43 participants, and that evidence of a high level of interest in the work of WG-EMM was shown by the submission of 90 papers, the largest number ever submitted to a CCAMLR Working Group. The list of participants is given in Appendix A and the list of papers in Appendix B.

1.4 He welcomed representation and the provision of information on CEMP-related programs from New Zealand for the first time. The Working Group regretted the continuing failure of France and Germany to send scientists and data from their active CEMP-related research programs on dependent species.

Adoption of the Agenda

1.5 The Provisional Agenda was introduced and discussed. A number of changes were made to the order of subitems within Item 5, and a new item 'Interactions Between Environmental Variables and Harvested/Dependent Species' included. A number of subitems were added to Item 6. The Agenda, as amended, was adopted (Appendix C).

AIMS AND OBJECTIVES

Historical Perspective of CCAMLR Ecosystem Monitoring

2.1 The Convener introduced WG-EMM-95/30 which presented an overview of the objectives and progress of ecosystem monitoring by CCAMLR. He reminded the meeting that the Scientific Committee's initiation of work towards an ecosystem approach to management arose directly out of Article II of the CCAMLR Convention which can be summarised as harvesting of individual species should be set at a level that does not adversely affect the target species, depleted populations should be allowed to rebuild and harvesting should not adversely affect dependent species.

2.2 The Working Group recognised that from the outset the Scientific Committee had agreed that the complexity of the Antarctic ecosystem was such that attempts should not be made to manage the ecosystem as a whole. Rather, management should be directed at a number of well-defined ecosystem components. It also recognised that a primary aim of all studies within the framework of ecosystem monitoring and management must be the provision of advice regarding harvested species.

2.3 WG-EMM-95/30 detailed the considerable progress that has been made in understanding both harvested and dependent species, their interactions, the nature of harvesting and the influences of environment on the Antarctic ecosystem. A substantial time series of information has been collected by the Working Groups on Krill (WG-Krill) and CEMP (WG-CEMP) since this work began in the mid-1980s. It has resulted in a highly improved understanding of ecosystem components although, with a few exceptions, these have generally been investigated in isolation from other components. In 1991, the Scientific Committee considered that enough detail was known about the individual components to enable the initiation of a process of integrating this information into an ecosystem management approach, and held the first joint meeting of WG-Krill and WG-CEMP in Viña del Mar, Chile in August 1992 to do this. The process culminated with the establishment of WG-EMM in 1994.

2.4 The Working Group agreed that many of the topics identified at the first joint meeting (SC-CAMLR-XI, Annex 7) as being critical to a management-oriented understanding of the key components of the Antarctic ecosystem were still important, and many had only been partially addressed since that meeting. It agreed to consider these further at the present meeting (see paragraphs below).

Objectives of WG-EMM

2.5 The Working Group considered that it was appropriate, at this first meeting of WG-EMM, to review its objectives in terms of ecosystem assessment.

2.6 The terms of reference for the Working Group were set out in SC-CAMLR-XIII, paragraphs 7.41 to 7.43. The Working Group agreed that a useful synthesis of these terms of reference was:

- (i) to provide advice on an ecosystem assessment combining information from dependent and harvested species and the environment; and
- (ii) to use this assessment to provide advice on management.

2.7 Such an approach requires consideration of a fundamental question.

(Q1) What constitutes an 'ecosystem assessment'?

2.8 In order to understand how to approach this primary question the Working Group agreed that it might be considered as a series of secondary questions:

- (Q2) (i) What are the elements of an ecosystem assessment?
- (ii) How do we make the assessment?
- (iii) How do we improve the assessment?
- (iv) How do we use the results from the assessment in formulating management advice?

2.9 The Working Group also agreed that in order to address these secondary questions a strategic model or plan would be required.

2.10 However, it was recognised that until the strategic plan was developed and answers to secondary questions obtained, it would be necessary to agree about the mechanism by which management advice would continue to be provided to the Scientific Committee.

2.11 As a first step towards answering question Q1, a schematic diagram of the Antarctic ecosystem was drawn up (Figure 1), which relates to how ecosystem assessment had been defined at previous meetings.

What is an Ecosystem Assessment?

2.12 At the second joint meeting of WG-Krill and WG-CEMP (Cape Town, South Africa, 1994), the Convener of WG-CEMP provided a description of what WG-CEMP understood its tasks to be in relation to ecosystem assessment. These were to determine annually the magnitude, direction and significance of trends in each of the predator populations being monitored; to evaluate annually these data by species, site and region; to consider conclusions in the light of relevant information on prey and the environment; and to formulate appropriate advice to the Scientific Committee (SC-CAMLR-XIII, Annex 7, paragraph 5.1).

2.13 The Working Group agreed that although reference to a dependent species-oriented assessment in the above paragraph had been appropriate for WG-CEMP, the emphasis on harvested species should be increased so as to reflect the broader needs of WG-EMM. Accordingly, the Working Group agreed that an ecosystem assessment consists of:

- Part 1: an analysis of the status of key biotic components of the ecosystem; and
- Part 2: a prediction of the likely consequences of alternative management actions for the future status of these components.

2.14 The Working Group considered the definition of 'status' (as in paragraph 2.13) that is used in single-species fishery assessments, and how this definition might be applied to ecosystem assessment.

2.15 In terms of ecosystem assessment, 'status' would need to include not only the points necessary for a single-species assessment, which are:

- current abundance and productivity of the harvested species, with abundance related to some level prior to the onset of exploitation; and
- if possible, the relationships (links) between these quantities and the state of the environment;

but also points related to dependent species which may be summarised as:

- current abundance of dependent species (usually expressed as breeding population size or an index thereof) in relation to previous values, where possible in conjunction with data on current and recent adult survival and recruitment rates.

2.16 Although it was recognised that in many instances the data would not allow the provision of precise management advice, it was understood that management actions considered under Part 2 (paragraph 2.13) would include the concept of a precautionary approach in the absence of certainty; a principle already applied in CCAMLR management regimes.

2.17 An evaluation of the status of biotic components in an ecosystem assessment will depend upon an adequate understanding of the components and links in Figure 1. Further, a successful predictive ability will require a good understanding of current and past ecosystem dynamics and how they are likely to change in the future. The Working Group agreed that an important adjunct to the ecosystem assessment process would be a continual review of the information required to understand the system sufficiently to make effective assessments. This review would include reappraisal of, *inter alia*, the taxa considered as key species within the dependent and harvested components, spatial and temporal aspects, and the most appropriate parameters to measure.

2.18 In the past, the method employed by WG-CEMP to describe the status of various component species, together with associated environmental parameters, was to use a set of site-based tables (SC-CAMLR-XIII, Annex 6, Table 2). The Working Group acknowledged that even though WG-CEMP had been unable to construct these tables with quantitative data as it had intended (SC-CAMLR-XII, Annex 6, paragraph 6.37), the tables had still provided an extremely valuable qualitative assessment of current status. It was agreed that the general form of these tables should be retained and that the new presentation should aim to increase the ability to investigate species and subarea-based trends.

2.19 It was recognised, however, that the parameters given in the tables provided information about different components of the system over different spatio-temporal scales. No single parameter could provide a complete description of the status of the ecosystem. The objective of Part 1 of an effective assessment (paragraph 2.13) would therefore be to examine how such information could be integrated into a form most appropriate for reliable execution of Part 2 of that paragraph.

2.20 Currently, some 14 parameters for dependent species and four environmental parameters are assessed and reviewed annually by CCAMLR, based on the data in the CEMP database. A number of time series of parameter values could also be developed from information on harvested species. Figure 2 shows how these and other parameters could provide information on the components and links of Figure 1.

2.21 The development of a framework for the evaluation of ecosystem status was considered to be fundamental to the aims of the Working Group. It was recognised that estimation of sets of parameters to fully describe the various components and links of the system may well be limited by

current data availability and the difficulty of collecting the data which might be specified in the future. (As an example, reliable time series of dependent species survival rates are rare and difficult to obtain.) Nevertheless, work should be continued on ascertaining what might be achievable with more limited data.

Organisation of the Meeting

2.22 The Working Group examined its agenda with reference to Figure 1 and was able to identify agenda items addressing either one component or one or more links between components. It agreed that, in general terms, items which addressed the evaluation of a component were often technical and could be discussed in partial isolation from other components. They were, therefore, assigned to subgroups for detailed discussion.

2.23 Items which addressed links and strategic modelling/planning should not generally be addressed in isolation. These are best discussed by the whole Working Group, using both the reports of the subgroups and other information where necessary. However, it was recognised that some topics related to the linkage of components do, in part, require detailed technical consideration by subgroups prior to consideration by the full Working Group.

2.24 Responsibility for the organisation and compilation of the Working Group's report was, as far as possible, spread through the Working Group's membership to ensure an even distribution of workload and in the interests of a more efficient consideration of specific items.

2.25 The Convener reminded the Working Group that the first joint meeting had identified a number of items which it considered should be studied further to advance work on ecosystem monitoring and management (SC-CAMLR-XI, Annex 8, paragraphs 1 to 13). Although some had been addressed since 1992, topics 1 to 5 of the Report of the First Joint Meeting of WG-Krill and WG-CEMP (SC-CAMLR-XI, Annex 8) were considered to be still pertinent to the work of the group at this time. Topics 9 and 10 (CEMP experimental approach, feedback mechanisms for management advice) were considered to be questions at the level of the strategic model (i.e., they are investigations of the performance of the model, not of its components) and therefore require substantial development of the strategic model before they can be adequately addressed. The Working Group assigned topics 1 to 5 to the components or links of Figure 1:

- 1: Krill escapement: Fishery/dependent species link (fishery component operating through the impact on harvested species).

- 2: Functional relationships between krill and predators: Dependent species/harvested species link.
- 3: Krill biomass versus availability: Environment/harvested species link.
- 4: Refining functional relationships: Dependent species/harvested species/environment link.
- 5: Considering predator demands in subarea allocation of catch limits: Dependent species/harvested species/fisheries links.

2.26 The report was prepared by Dr D. Agnew (Secretariat), Drs I. Boyd and J. Croxall (UK), Dr W. de la Mare (Australia), Dr P. Fedoulov (Russia), Prof. B. Fernholm (Sweden), Dr R. Hewitt (USA), Mr T. Ichii (Japan), Dr K. Kerry (Australia), Dr G. Kirkwood (UK), Dr K.-H. Kock (Germany), Dr F. Mehlum (Norway), Dr D. Miller (South Africa), Dr E. Murphy (UK), Dr S. Nicol (Australia), Dr P. Penhale (USA), Dr E. Sabourenkov (Secretariat), Dr W. Trivelpiece (USA) and Dr J. Watkins (UK).

All members of the Working Group contributed to the various appendices. The Convener expressed his appreciation to Working Group members for their contributions.

DATA

Krill Catches in 1994/95

3.1 In the 1994/95 season krill catches in the Convention Area were reported by three Members: Japan (60 304 tonnes), Poland (6 287 tonnes) and Ukraine (51 325 tonnes). Chile and Russia, both of whom fished for krill in previous seasons, reported no krill fishing activities in 1994/95. All catch reports were submitted on a monthly basis as required.

3.2 The total reported catch of krill was 117 916 tonnes. This represents an increase in comparison to catches of 88 776 tonnes in 1993/94 and 83 818 tonnes in 1992/93. Catches reported by Japan and Poland were of the same order as previous seasons. The increase was due to an increase in the catch reported by Ukraine from 8 708 tonnes in 1993/94 to 51 325 tonnes in 1994/95.

3.3 The Working Group noted that no plans for expanding krill fishing were reported by Ukraine at the Commission meeting in 1994.

3.4 All catches reported by Ukraine were taken in Area 48 between January and June 1995, with catches being roughly equally distributed between Subareas 48.1, 48.2 and 48.3.

3.5 The greater part, 4 510 tonnes, of the krill catch reported by Poland was made in Subarea 48.2. Additional catches were reported from Subareas 48.1 and 48.3.

3.6 Japanese catches were mainly taken in Subareas 48.1, 48.2 and 48.3. During the season, the area of operation moved from Subarea 48.1 (South Shetlands) to 48.2 (South Orkneys) and then to 48.3 (South Georgia) in advance of the northward movement of the ice-edge.

3.7 A catch of 1 264 tonnes of krill was reported by Japan in Division 58.4.1 (Wilkes Land, Indian Ocean sector) in January/February 1995.

3.8 The Japanese krill fishery in Subarea 48.1 was concentrated to the north of Livingston Island. Most catches were taken further offshore than in previous seasons. This was because in January/February 1995, krill concentrations were found to be more abundant over the slope than on the shelf itself.

3.9 The Working Group reiterates the importance of continuing a dialogue with fishing nations in order to understand trends in krill fishing and the distribution of catches over the Convention Area (CCAMLR-XII, paragraph 4.5; SC-CAMLR-XIII, paragraph 5.8).

3.10 The Working Group recalled that in previous years it had received reports of krill catches in an area immediately west of Subareas 48.2 and 48.3, FAO Statistical Area 41 (i.e., a catch of 2 506 tonnes by Poland in 1993, and a catch by Russia in 1991/92 (Sushin and Myskov, 1992¹)). It was agreed that for WG-EMM to consider fully the krill component of its ecosystem assessment, continuing information on krill caught outside the Convention Area is most important.

3.11 Last year the Secretariat received from FAO a STATLANT A report that 71 tonnes of krill had been taken in 1993/94 from the Convention Area by a non-Member country, Latvia. Following a request from the Commission, the Secretariat wrote to the Government of Latvia with a request for information about fishing activities of Latvia in the Convention Area. No response has been received as yet.

¹ Sushin, V.A. and A.S. Myskov. 1992. Location and intensity of the Soviet krill fishery in the Elephant Island area (South Shetland Islands), 1988/89. In: *Selected Scientific Papers, 1992 (SC-CAMLR-SSP/9)*. CCAMLR, Hobart, Australia: 305-335.

Scheme of International Scientific Observation

3.12 The first scientific observation program on board a commercial krill fishing trawler under the CCAMLR Scheme of International Scientific Observation was undertaken in 1995. Through a bilateral agreement between the US and Japan, an international scientific observer was placed on board the Japanese trawler, *Chiyo Maru No. 2*, fishing for krill in Division 58.4.1 (Wilkes Land) from 28 January to 22 February 1995 (SC-CAMLR-XIV/BG/10).

3.13 The Working Group noted with satisfaction the large volume of information on catch, effort, and biological data collected from krill catch samples obtained by the observer during fishing operations of the vessel.

3.14 Mr Ichii noted that in addition to the time spent searching for krill swarms, the time between sets of the trawl recorded by the observer was close to the time required to process the krill caught in previous hauls.

3.15 The pilot edition of the *Scientific Observers Manual* (1993) was used for planning the observation program and recording data. Based on experience from using the manual and, in particular, the data forms, the observer suggested that some data forms could be modified to make them easier to use in the field. The Working Group asked the Science Officer to take these suggestions into account in preparing the revised edition of the manual to be submitted for consideration by the Scientific Committee at the forthcoming meeting in 1995.

3.16 The Working Group agreed that the observer's report had provided useful information. It strongly urged Members to implement observation schemes along the lines of the Japanese/US arrangement and in accordance with CCAMLR's Scheme of International Scientific Observation.

3.17 Krill caught by the Japanese vessel fishing in Division 58.4.1 were mostly immature or juvenile specimens and were in all feeding states. There was no evidence that fishing strategy was altered due to the feeding intensity of the krill caught (SC-CAMLR-XIV/BG/10). These observations were explained by Mr T. Kato (Japan) who pointed out that the fishing vessel was not concentrating on catching high quality krill but was aiming to catch a large quantity of krill quickly.

3.18 The Working Group noted that in the past the Scientific Committee had requested information related to the assessment of the mortality of krill passing through trawl meshes during

fishing operation (SC-CAMLR-XII, paragraph 2.25). The Working Group recalled that in 1993² Dr Yu. Kadilnikov (Russia) had submitted a paper describing a model to test the effects of mesh characteristics on the passage of krill through trawl nets. No further developments have been reported. The Working Group reiterated the Commission's call for information on this topic. It also again urged Dr Kadilnikov to submit the computer code for his model in order for the model to be verified and tested.

Consideration of Commercial Harvesting Strategy

3.19 Fine-scale catch data from 1973/74 to 1993/94 from the Convention Area submitted by Japan from their commercial fishery and augmented by research/experimental fine-scale data from the Soviet Union revealed historical fishing patterns (WG-EMM-95/6).

3.20 In Area 48, krill fishing has consistently been restricted to very localised areas off the South Shetland Islands, the South Orkneys and South Georgia.

3.21 In Area 58, krill fishing has occurred over a much wider area, reflecting the exploratory nature of the fishery in this region in earlier years. Krill harvesting in Area 58 has, in certain years, occurred in waters adjacent to known predator colonies (WG-EMM-95/6).

3.22 Seasonal movements of fishing activity in Area 48 during 1994/95 followed a pattern exhibited in previous years: from the South Shetlands early in summer, to the South Orkneys later in summer and to South Georgia in autumn and winter. This pattern is largely driven by ice conditions (WG-EMM-95/7).

3.23 The single Japanese vessel fishing in Division 58.4.1 during 1994/95 headed south from New Zealand and moved westward along the shelf break until good fishable concentrations were encountered at around 100°E.

3.24 Krill were reported to be scarce in Division 58.4.1 during 1994/95 and those caught were small (mean size: 37.7 mm) (SC-CAMLR-XIV/BG/10) compared to those caught in Area 48 (mean lengths: 40 to 46 mm) (WG-EMM-95/51).

² Kadilnikov, Yu.V. 1993. Peak mortality of krill, fished with midwater trawls and feasible criteria of krill trawls ecological safety. Document *WG-Krill-93/34*. CCAMLR, Hobart, Australia.

Biology and Ecology of Harvested and Dependent Species of Particular Relevance to Fisheries Management and CEMP

3.25 A number of papers relevant to this agenda item were tabled.

3.26 Paper WG-EMM-95/54 discussed the distribution of salps at South Shetland Islands in 1990/91 in relation to krill. Krill were found mainly in coastal areas with salps being encountered in greater abundance in oceanic areas offshore. Salp predation of small krill in addition to competition for food between salps and young krill were considered in respect to the relatively low abundance of krill at stations where salps were abundant. The Working Group noted that the effect of predation by salps on small krill may be reduced by delayed krill spawning when salps are abundant.

3.27 Laboratory observations of krill feeding on salps (WG-EMM-95/57) suggest an ecological relationship between krill and salps, indirectly through salps via the microbial loop to krill and directly through feeding by krill on salps.

3.28 The Working Group agreed that although salps may be an important ecosystem component at various times, information on their biology and ecology is still limited. It concluded that there did not appear to be a need to incorporate salps into the Working Group's ecosystem assessments at this time, but urged members to continue investigating the role of salps in the Antarctic marine ecosystem.

HARVESTED SPECIES

4.1 A subgroup was formed to review information and papers presented under Agenda Item 4. The aim was to highlight areas where new information was available that was of specific relevance to Agenda Item 7. Only this latter information is presented in Section 4.

Methods for Estimating Distribution, Standing Stock, Recruitment and Production of Harvested Species

4.2 Thirteen papers were available for discussion under Agenda Item 4(i). The main subject areas covered by the submitted papers were:

- acoustic survey design;
- quantification of errors;

- use of multifrequency techniques for the discrimination of target types; and
- problems identified with echosounder systems.

Survey Design

4.3 Papers WG-EMM-95/34, 38, 43, 71 and 76 related to the topic of survey design. An introduction and overview of some of the issues concerning design and analysis of surveys was provided by Dr K. Foote (Norway).

4.4 Acoustic survey data may be analysed in two basic ways: classic random sampling techniques utilising mean and variance to describe the density distribution of biomass; or geostatistical techniques utilising spatial properties of the data to derive a mean and an estimation of variance. In the absence of spatial structure the estimation of variance will ideally be the same as the sampling variance. It was pointed out that discussion of these points is also to be found in the report of the Workshop on Estimation of Variance in Marine Acoustic Surveys (WG-EMM-95/38).

4.5 With regard to survey design, three general points were raised in the overview by Dr Foote. Firstly, stratification of survey transects may allow an increase in efficiency if there is prior knowledge about the distribution of the species being surveyed. Secondly, in the absence of any knowledge of structure, uniformity of transect spacing will provide maximum information about any large-scale structure. Thirdly, a two-tiered design where a preliminary survey is used to locate areas for stratification of effort during a second survey phase is also effective.

4.6 With regard to potential design for a survey of Area 48 (see also paragraphs 4.59 to 4.67; WG-EMM-95/71), it was accepted that a stratified survey design was the most appropriate one available. It was agreed that in the absence of information about the distribution of krill in the oceanic regions, uniform transect spacings would be the most appropriate.

4.7 The Working Group agreed that previous survey information should be used to define strata within the survey area and that the mean and variance from these surveys could be used to assess the amount of sampling effort required (see WG-EMM-95/71). Any additional information on spatial structure could be used to refine the estimation of effort required.

4.8 The Working Group recommended that further papers on survey design of Area 48 should be prepared during the intersessional period and discussed at the next meeting of WG-EMM.

4.9 A design for an acoustic survey in Division 58.4.1 was tabled (WG-EMM-95/43). While the paper was not considered in detail this year, it was noted that the design was submitted to the last meeting of WG-Krill where it met with favourable review.

Quantification of Errors

4.10 Quantification of errors associated with acoustic surveys (WG-EMM-95/72 and 73) requires consideration of two broad categories of sources of variance and bias:

- those arising from the use of transect sampling (random sampling error); and
- those arising from the application of acoustic methods (measurement error, which contains elements of both systematic and random error).

4.11 Paper WG-EMM-95/76 considered random sampling error in a comparison of geostatistical and random sample survey analyses. The paper described the analysis of three surveys and highlighted problems inherent in the analysis of an extremely aggregated species such as Antarctic krill. The Working Group recognised that there is a large amount of information available outside WG-EMM on the use of random sample and geostatistical approaches to analyse survey data but at present there is no consensus on which approach may produce more efficient estimators³ of abundance and variance. The Working Group recognised that at this stage there was no need to re-analyse the data used to provide the current estimates of biomass for the management model using geostatistical techniques.

4.12 Measurement error in acoustic surveys of Antarctic krill was considered in WG-EMM-95/72. Systematic and random errors may arise from system calibration, target strength (TS) estimation, diurnal vertical migration and target identification. These components of uncertainty may be different for each survey and as large as (or larger than) sampling error.

Multifrequency Techniques

4.13 Multifrequency acoustic techniques can be used to classify target types under certain conditions, and papers concerned with hardware design (WG-EMM-95/8 and 9) and surveys utilising such techniques were submitted (WG-EMM-95/58, 72, 75 and 87). The Working Group recognised the

³ A more efficient estimator is one which leads to estimates whose differences from the unknown true value of the quantity of interest are likely to be smaller.

importance of developing such techniques further, and recommended that for future surveys at least two frequencies should be used as an aid in interpreting measurements of volume backscattering.

Echosounder Problems

4.14 Two papers (WG-EMM-95/37 and 73) gave details of some physical and technical problems that have been identified with echosounder systems and may bias biomass estimates. WG-EMM-95/37 described the problems associated with the recognition of single targets in the *in situ* estimations of target strength. WG-EMM-95/73 highlighted some technical problems with a commonly used echosounder. It was emphasised that these problems would not have affected biomass estimates used to calculate the current precautionary catch limits.

Analysis and Results of Studies on Distribution, Standing Stock, Recruitment and Production of Harvested Species

Distribution

4.15 Papers WG-EMM-95/4, 5, 19, 23, 49, 58, 67, 70, 72 and 87 were tabled and important new information was identified as follows.

4.16 The possibility of using predator behaviour to provide information on prey distribution was pursued (WG-EMM-95/23). The behaviour of fur seals at South Georgia suggested that there was overall clumping of prey at the fine-scale level but there was a more even spacing of prey patches at the mesoscale level. The study showed how predator behaviour can provide valuable information on the functional relationship between prey dispersion and predator performance. It also gave some indication of the spatial scales at which studies of predator/prey interactions should be undertaken.

4.17 In general, the scales assumed for the spacing of swarms and patches agreed with those scales identified from acoustic measurements of interswarm distance. Such differences as observed might also arise from assumptions underlying the observational methods (e.g., the extrapolation from the chord length of a swarm detected on a transect to the true size of the swarm in three dimensions). To correspond to the scale of the swarm, the sampling interval in such acoustic studies needs to be around 10 to 15 m.

4.18 A variogram of biomass estimates (g.m^{-2}) from a survey also contains information on spatial structure. This provides an alternative method of analysis of spatial scale which does not require any identification of swarms.

4.19 Some studies (e.g., WG-EMM-95/87) have indicated that predators do not always exploit the highest densities of prey concentration in an area. At present little is known about the methods that predators use to search for krill. However, an understanding of such behaviour requires surveys of krill distribution concurrent with detailed tracking and observation studies of predators. Both sets of studies must be undertaken at the same horizontal and vertical scale. The use of large research vessels was often inappropriate for such studies. The Working Group felt that novel approaches and techniques utilising, for instance, Remotely Operated Vehicles (ROVs) or echosounders mounted on small launches need to be investigated.

4.20 The collection of spatial information from acoustic survey and predator data may assist in deriving a composite index of krill abundance which takes account of distribution and abundance of krill at small scales.

4.21 Paper WG-EMM-95/23 suggested that in years when little krill was available to predators the character of swarms within patches, rather than the overall number of swarms, may change. Such an observation could be investigated through examination of acoustic data at a scale that resolves individual swarms.

4.22 The Working Group concluded that fine-scale studies of krill and predator distribution were important in understanding spatial structure that could be used in the design of surveys at a local scale as well as in the study of predator/prey interactions.

4.23 The presence of a substantial amount of myctophid fish was observed using midwater trawling nets and acoustics beyond the Elephant Island shelf in the 1994/95 season (WG-EMM-95/87). Data from acoustic surveys were used to describe a scattering layer found between 150 and 200 m depth in the day, shallower at night, which may be attributed to these fish (WG-EMM-95/58).

4.24 The importance of the width at the northern boundary of the coastal water mass to consideration of krill flux was recognised. This factor influences the current speed and volume transport in the coastal areas to the north of Elephant Island where krill tend to be abundant (WG-EMM-95/58). When the front existed further south close to Elephant Island, the coastal water mass was relatively narrow and the current speed high, and vice versa. Buoy-tracking observations (WG-EMM-95/49) confirm earlier observations presented at the Workshop on Evaluating Krill Flux Factors (WS-Flux) (SC-CAMLR-XIII, Annex 7, Appendix D) suggesting the existence of a mechanism (oceanic

currents) for krill transport from the South Shetland Islands to the South Orkneys and to South Georgia.

4.25 The findings in these papers and of WS-Flux emphasised the need for further consideration of krill flux. It is clear that the amount of krill in an area at any one time will be a function of the standing stock size and the flux. Thus, the fact that krill in a single area are less abundant in one year than another may not be sufficient to conclude that the krill stock size has also decreased. Similarly, differences in krill densities in adjacent areas do not necessarily imply different stock abundances.

4.26 In light of the above, the Working Group encouraged further research on krill flux and other issues associated with the spatial distribution of krill.

Standing Stock

4.27 Papers WG-EMM-95/15, 74 and 75 were tabled and important new information was identified as follows.

4.28 Acoustic surveys indicated that krill density at South Georgia and the South Orkney Islands was extremely low (1.7 and 10.7 g.m⁻² respectively) in the 1993/94 season, compared with previously published FIBEX density estimates (59.7 and 82.8 g.m⁻² respectively, WG-EMM-95/75). However, Dr Fedoulov noted that a strong seasonal pattern was apparent in CPUEs of the Russian krill fishing fleet between 1974 and 1990 which suggest seasonal variations in the abundance of krill around South Georgia (WG-EMM-95/69). He emphasised the necessity to describe exactly when in the season density estimates have been made. In response it was noted that there was additional evidence of low krill abundance from the breeding success of land-based predators and prey switching by mackerel icefish, which normally feed on krill. Furthermore, krill abundance was lower in the South Shetland Islands in the 1993/94 season.

4.29 The possibility of a decline in krill abundance from the 1977-83 period (higher mean density with a large range) to the 1985-94 period (lower mean density with a smaller range) was suggested for the Antarctic Peninsula region, based on the 16-year span of net sampling data (WG-EMM-95/15). This matter is discussed further in paragraph 4.43.

Recruitment

4.30 Papers WG-EMM-95/15, 18, 55 and 58 were tabled and important new information was identified as follows.

4.31 In WG-EMM-95/15 it is suggested that recruitment success of krill is related to sea-ice conditions during the preceding winter season, the timing of krill spawning, and the occurrence of dense salp concentrations. The importance of this information for ecosystem assessment and fisheries operations was recognised. Recent poor recruitment from spawning in 1991/92 and 1993/94 seasons was noted, together with probable good recruitment success from spawning in the 1994/95 season.

4.32 Krill size composition in the Bellingshausen Sea (Subarea 88.3), which was one of the lesser-studied regions of the Southern Ocean, was found to be similar to the krill stock composition in the South Shetland region (Subarea 48.1) in the 1993/94 season (WG-EMM-95/18). This finding suggests that the actual krill size composition and the recruitment of krill are similar over a wider spatial scale than just within Subarea 48.1.

Interannual and Within-Season Variability in Distribution, Standing Stock, Recruitment and Production of Harvested Species

4.33 Seven documents were tabled and discussed (WG-EMM-95/15, 18, 23, 53, 55, 58 and 69).

4.34 Paper WG-EMM-95/58 suggested an interannual difference in the timing of peaks of seasonal abundance and in the timing of spawning activity. Peaks of abundance, maturation and spawning in the 1994/95 season occurred earlier than generally observed in the Elephant Island area.

4.35 CPUE data from the Russian krill fishing fleet for the period 1974 to 1990 were used to demonstrate seasonal and interannual variability of krill abundance in Subarea 48.3 (WG-EMM-95/69). Maxima occurred in March, followed by a decline until October. The interannual variation of CPUE was high. As an example, zero CPUEs in both 1978 and 1984 were followed by high CPUEs in 1979 and 1985.

4.36 Large year-to-year variability in krill recruitment around Elephant Island was revealed (WG-EMM-95/15).

4.37 It was noted that in all those papers, attempts were made to seek correlation between krill biological indices and environmental parameters. The results of this were similar in the above-mentioned papers: relationships were indicated between recruitment, krill size indices and sea-ice conditions.

4.38 Paper WG-EMM-95/53 demonstrated the relationship between sea-level air pressure gradients in Drake Passage and krill recruitment variability. Years of high and low pressure differences coincided with the years of good and poor krill recruitment respectively.

Precautionary Catch Limits

Consideration of the Use of the FIBEX Survey for Calculation of B_0

4.39 At last year's meeting, WG-Krill calculated a revised precautionary catch limit of 4.1 million tonnes for krill in Area 48. At the following Scientific Committee meeting, two basic views were expressed. One basic view was that the revised precautionary catch limit of 4.1 million tonnes should replace the existing value of 1.5 million tonnes. An alternative view expressed by some Members was that there was no need to revise the overall precautionary catch limit of 1.5 million tonnes. The Members holding the latter view considered that the catch limit calculated by WG-Krill used an estimate of krill biomass based on data (SC-CAMLR-XIII, paragraph 5.40):

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

4.40 The Working Group discussed these two concerns. The calculations of precautionary yield do not assume that the estimate of biomass from a survey has a pre-specified relationship to the median unexploited biomass of the stock. By using information on the variability in recruitment and an estimate of the variance of the krill biomass estimate, the krill model produces statistical distributions of the biomass of krill in the absence of exploitation, and as affected by various levels of exploitation.

4.41 These statistical distributions include all of the possible relationships between the estimated biomass and the true median unexploited biomass that are consistent with the recruitment variability incorporated in the model, as well as with uncertainty in the abundance estimate and demographic parameters. Thus, if the assumptions of the model are not substantially violated, the possibility that the biomass was high in the survey year is taken into account in calculating the precautionary catch limit. One of the assumptions of the model used to date is that the statistical distribution of krill

biomass in the absence of exploitation is independent of time. Therefore, as long as this assumption is not violated, it does not matter that the abundance estimate is from data collected in 1981.

Consideration of Recruitment Data for Area 48

4.42 If a reliable time series of estimates of proportional krill recruitment were available, it could be used in the krill model to condition the statistical distribution of unexploited biomass, and thus improve the calculation of the precautionary catch limit.

4.43 Paper WG-EMM-95/15 presented a time series of R_i recruitment estimates⁴ for a portion of Subarea 48.1 from reasonably comparable net haul surveys conducted in most years from 1977 to 1994. In principle, these data could be used to condition the statistical distribution of the unexploited biomass used in the calculation of the precautionary catch limit. The R_i estimates in WG-EMM-95/15 were not always consistent with related estimates obtained by WG-Krill (SC-CAMLR-XIII, Annex 5, Appendix F). However, the estimates from WG-Krill used data from outside the region analysed in WG-EMM-95/15. The estimates in WG-EMM-95/15 also gave a substantially lower value of average recruitment proportion than was obtained by WG-Krill using all of the available data from the Antarctic at large. However, the estimates in WG-EMM-95/15 were not calculated using the maximum likelihood estimation method used by WG-Krill (de la Mare, 1994⁵). In addition, the calculations involved the exclusion of some observations which the authors had classified as outliers. The Working Group agreed that to be used for input to the krill model, the estimates would need to be recalculated using the maximum likelihood method using the data set including the outliers, for both R_1 and R_2 . These recalculations could not be carried out within the time available at the meeting.

4.44 The other difference between the WG-Krill recruitment estimates and those reported in WG-EMM-95/15 lay in the geographical region over which the data had been pooled. The key issue in deciding on the extent of pooling is whether the pooled data will provide a representative sample of the length frequency distributions of the underlying population. This is an issue that must be resolved, not just for this data set, but also for others, such as the extensive length frequency data from predator diet samples.

4.45 Specification of the appropriate degree of pooling in the net haul data was assigned to a subgroup. The results of its deliberations are taken up under Agenda Item 7(vii) (paragraphs 7.107 to 7.118).

⁴ The R_i recruitment rate is the proportion of animals of age i in the population in that year.

⁵ de la Mare, W.K. 1994. Estimating krill recruitment and its variability. *CCAMLR Science*, Vol. 1: 55-69.

4.46 The hypothesis that recruitment is correlated with the extent of ice cover in the previous year could lead to serial correlation in recruitment if there are trends or cycles in ice cover over time. The krill yield model can be modified to allow for the inclusion of serial correlation in recruitment. The possibility of such serial correlation in existing recruitment data should be investigated.

4.47 At its last meeting, WG-Krill had identified further investigations to be carried out in examining the sensitivity of the krill yield model to possible correlation between natural mortality (M) and von Bertalanffy growth rate (κ). This work has not yet been completed.

4.48 Summarising the preceding discussions, the Working Group indicated that the following areas needed further work.

- Both an index of abundance based on net sampling and a time series of recruitments suggest that 1981 (the year in which B_0 was estimated) may have been a year of high abundance (WG-EMM-95/15).

Using the time series of proportional recruitments in the model may allow the recalculation of the distribution of unexploited biomass so that this possibility is reflected more explicitly. Commercial length frequency data should be examined to provide qualitative confirmation of any variations in recruitment. Population trajectories obtained from the krill model using the recruitment index can be compared with the net sampling abundance index.

- Recruitments may exhibit serial correlation.

Time series of recruitments should be analysed for serial correlation.

4.49 The Working Group developed a plan (Appendix D) for completing the analyses in time for its next meeting. A steering group convened by Dr Agnew and consisting of Prof. D. Butterworth (South Africa), Drs de la Mare, Hewitt, V. Loeb (USA) and V. Siegel (Germany) would correspond to complete the required analyses.

4.50 The Working Group agreed to consider revision of the precautionary catch limits as results of these studies become available.

Consideration of Uncertainty in the Variance of B_0

4.51 Paper WG-EMM-95/72 suggested that the variance in the B_0 estimate may have been underestimated because of uncertainty arising in the use of the acoustic gear (paragraph 4.10), and it was suggested that the possibility of any further improvements to the variance estimate of the 1981 survey result should be investigated.

4.52 In relation to possible improvements of the variance estimates for the 1981 survey, concern was expressed that these data had already been subjected to extensive analysis and it was unclear whether high priority should be given to yet further re-analysis.

4.53 The Working Group agreed that the effects of additional uncertainty arising from the random component of measurement errors associated with the use of acoustic gear (paragraph 4.12) could be examined via sensitivity tests carried out at this meeting, using increased values of survey coefficients of variation in the krill yield model.

4.54 Based on the estimates of the additional variability for surveys conducted in the Elephant Island area as cited in WG-EMM-95/72 (additional random error with CV around 23%), runs of the krill yield model with survey CVs increased from the current 30% to 40% were undertaken. Results for a CV of 50% were also computed.

4.55 The results of the runs of the krill yield model are shown in Table 1. The run $\sigma_s = 0.4$ yields the following results, according to the decision rules developed by WG-Krill: (i) γ_1 (the probability that spawning biomass falls below 20% of its pristine level, after 20 years, should not exceed 10%) = 0.140; (ii) γ_2 (median spawning biomass should not fall below 75% of its pristine level after 20 years) = 0.116; and (iii) γ (choose the lower of γ_1 and γ_2) = 0.116.

4.56 In summary, γ_1 was sensitive to the increased survey estimate CV, but γ_2 was not. The final value of γ to be used in determining the precautionary catch limit under the three decision rules currently being used for krill was the lower of the two values that were indicated by the two spawning stock biomass criteria. As it was the median spawning stock biomass criterion (γ_2) that led to the lower value of γ , it followed that the precautionary catch limits from the krill yield model were insensitive to the increased levels of survey estimate CV within the likely range.

4.57 The Working Group agreed that in view of these findings, it was not necessary to attempt re-analysis of the FIBEX data aimed at improving the variance estimate of B_0 .

Subdivision of Precautionary Limit

4.58 Given the agreement to consider the revision of the precautionary catch limit calculations for Area 48 at its next meeting, the Working Group was unable to offer further advice on subdivision of the precautionary limit to statistical subareas until the possible revision of the area limit has been considered.

Future Work

4.59 Concerns were raised during discussions under Agenda Item 4(iv) (paragraphs 4.39 to 4.57) concerning the continued use of the FIBEX survey data as an estimate of B_0 in the krill yield model. Although one specific concern about survey variance had been addressed in paragraph 4.6, the Working Group discussed a number of other concerns and examined whether it would be desirable and feasible to conduct a new krill biomass survey of Area 48.

4.60 The Working Group agreed that the question of whether there should be a new biomass survey in Area 48 could be broken down into two related questions: (i) is there a need for a new survey; and (ii) what resources would be necessary to carry out such a survey? Issues regarding survey design were acknowledged to affect the second question and have been addressed in paragraphs 4.3 to 4.9.

4.61 There was agreement that a new hydroacoustic survey of Area 48 would be desirable. The main arguments in favour of a new survey were:

- there were technological and methodological problems associated with the collection and analysis of the FIBEX data;
- there was inadequate survey coverage in Subarea 48.3 during FIBEX;
- there is biotic and abiotic evidence to suggest that there have been changes in the environment of the South Atlantic since the FIBEX survey;
- technology and survey design have advanced substantially since FIBEX; and
- a new survey could be designed specifically with the krill yield model in mind.

4.62 Two papers considered the question of required resources: WG-EMM-95/71, which described a time budget for a survey of Area 48 and WG-EMM-95/43, which described a time budget for the survey of Division 58.4.1 planned for the 1995/96 season.

4.63 Paper WG-EMM-95/71 set out a stratified random design having four strata: the South Shetlands area, the South Orkneys area, the South Georgia area and one stratum in the oceanic area not contained in the other areas. The strata were selected on the basis of historical patterns of krill fishing, differentiating between island and oceanic areas, and on strata derived from the FIBEX data.

4.64 FIBEX and AMLR data were used to determine the ship-time required to survey the area at expected levels of CV. Precision improves as survey effort is increased, but gains for effort levels exceeding three ship-months are small. The paper concluded that a single research vessel can achieve reasonable precision ($CV < 0.25$) by expending one to two months of survey effort.

4.65 In contrast, the FIBEX survey in Area 48 took some 12 months of ship-time.

4.66 Paper WG-EMM-95/43 indicated that the collection of oceanographic data in Division 58.4.1 would add 43% to the ship-time required for the acoustic and associated net sampling survey.

4.67 The Working Group concluded that a new survey of krill in Area 48 could be achieved with a moderate expenditure of ship-time, and therefore encouraged the development of plans for a survey in Area 48.

DEPENDENT SPECIES

Review of Members' Activities

5.1 Members' CEMP-related activities are summarised in SC-CAMLR-XIV/BG/2 Rev. 1. Participants at the present meeting provided brief reports on their recent and current activities as part of CEMP (Appendix E).

Sites

5.2 Members were asked to report on the initiation of CEMP research at new sites and on changes in CEMP research at existing sites.

5.3 Dr E. Franchi (Italy) reported that a joint Italian/Australian biological research program on Adélie penguins began at Edmonson Point, Ross Sea region, during the 1993/94 season (WG-EMM-95/47). Members noted the importance of the initiation of this research.

5.4 Dr P. Wilson (New Zealand) reported on New Zealand research activities in the Ross Sea which are closely related to CEMP goals. Monitoring of the size of some of the southernmost Adélie penguin breeding colonies on Ross Island has been carried out regularly since the 1960s, and for all other colonies in the Ross Sea since 1981.

5.5 Dr Mehlum reported that Norway plans to establish a CEMP site and initiate research on chinstrap penguins, macaroni penguins and fur seals at Bouvet Island during the 1996/97 season. Possible logistic cooperation with South Africa is hoped to improve access to the site.

5.6 Dr Agnew introduced a report from the Norwegian Foundation for Nature Research (NINA) to the Scientific Committee which summarised recent work on Antarctic petrels at Svarthamaren, Dronning Maud Land. The NINA group enquired if it was possible to register the location as a CEMP site.

5.7 The Working Group noted that the work undertaken by the NINA group represented by far the most detailed study yet undertaken on the population dynamics and foraging performance (including body condition) of this species, which is one of those originally selected as a priority for CEMP.

5.8 The Working Group indicated that it would be very happy to accept Svarthamaren as a CEMP monitoring site if so proposed by Norway. It noted that a doctoral thesis on the work, referring to most of the published and in-press papers arising from research at this site, is held in the Secretariat library. It was suggested that the NINA group might consider what data from their study would be suitable for submission to CEMP, in the light of the draft methods proposed in paragraph 5.41.

5.9 Dr Kerry reported that data will be collected on CEMP parameters for Adélie penguins near Casey Station during the 1995/96 season only. This program, as well as a joint French/Australian program at Dumont d'Urville Station, is being conducted in association with a krill survey being conducted by Australia and will provide initial data on predator/prey relationships.

5.10 Dr R. Holt (USA) regretfully reported that the US would be closing the Seal Island CEMP site due to safety considerations. Limited research may be conducted during the 1995/96 season. Other sites will be considered during the next year with the intent of establishing a new site for US research on predator/prey relationships the year after.

5.11 A report on South African research activities indicated that various CEMP methods continued to be utilised in studies of gentoo and rockhopper penguins at Marion Island. Furthermore, the land and marine zones of the Prince Edward Islands (Marion and Prince Edward Islands) are in the process of being proclaimed as a Special Nature Reserve under South African law. This development will heighten the islands' conservation status and will require the continued collection of data likely to be of interest to CEMP.

5.12 It was recommended that other Members conducting research on CEMP indicator species should contribute appropriate data to CCAMLR and in particular to the CEMP database.

5.13 There was no information on the status of the management plan for the Antarctic Specially Managed Area (ASMA) at Admiralty Bay, King George Island. The plan, submitted by Brazil and Poland, had been referred to CCAMLR-XIII, which provided suggestions for consideration.

CEMP Standard Methods

Existing Standard Methods

5.14 Translations of revisions to the standard methods are almost completed and documents will be distributed to Members in the near future. Small changes arising from discussions at this meeting will be incorporated.

5.15 The standard methods were reviewed briefly. Comments were made on procedures only as noted below.

5.16 Method A1 - adult weight on arrival at breeding colony. For Procedure A it was noted that it was not always possible to obtain weight data at the time of first arrival of the birds to breed. Since the weights of birds arriving later are often less than those of the first arrivals, the results are biased. It was suggested that a potential additional procedure under this method would involve either relating weights to a fixed point in the breeding chronology (e.g., egg laying) and/or involve weighing at this time. Dr Trivelpiece indicated that he had collected data on interannual variation in Adélie penguin weights at egg laying and offered to analyse his results, as a potential alternative means of examining variability in early-season condition among Adélies. The results of his analysis will be submitted for inspection by the Working Group at next year's meeting.

5.17 Method A5 - duration of foraging trip. Paper WG-EMM-95/46 suggested that there may be consistent gender differences in foraging trip duration, feeding localities and diet of breeding Adélie penguins at Béchervaise Island, Prydz Bay and Edmonson Point, Ross Sea region. Female penguins tended to make longer foraging trips than males, ranged greater distances more frequently, and consumed larger quantities of krill, especially when their chicks were small. Males tended instead to make shorter journeys to closer foraging grounds during the guard period and fed more extensively on fish throughout chick rearing.

5.18 It was noted that information collected using Method A5 would be advantageously presented in five-day periods and, if possible, related to the mean or median dates of laying and creching and to the sex of the parent bird being studied. This would require modification to the data submission form so that Members could report data in the appropriate way.

5.19 To address this topic it was decided that a subgroup chaired by Dr Kerry and including Drs Agnew, Boyd, Trivelpiece and G. Kooyman (USA) should work intersessionally. The Working Group should present for consideration by a Subgroup on Monitoring Methods and/or next year's meeting of WG-EMM suggestions for improvements to (i) monitoring protocols; (ii) data submission requirements; and (iii) presentation of the data.

5.20 Method A6 - breeding success. It is not necessary to count adults as part of Index A6c and reference to this was deleted from the text of the standard method. It was noted that Procedure C does not reflect breeding success. Instead it records chick fledging success, i.e. chicks fledged per chicks hatched. It was agreed that this information may still be useful and should continue to be reported.

5.21 Method A8 - chick diet. Paper WG-EMM-95/32 provided a detailed method for obtaining stomach samples from penguins by gastric lavage. The Working Group thanked Dr J. Clarke (Australia) for preparing this paper which had been requested by WG-CEMP (SC-CAMLR-XIII, Annex 6, paragraph 4.30).

5.22 The Working Group agreed that the text on gastric lavage of penguins should, with minor modifications, replace the existing text in the standard method under General Procedures - Procedure A, paragraph 3. It noted, however, that although the technique was in common use, several important elements of the technique had been subjected to little if any critical examination. This is especially the case where physiological effects (e.g., of cold versus warm water and/or fresh versus salt water) are involved. Members were therefore requested to report their experiences of using the present technique and also to assess the effects of different methodologies, particularly by using experimental techniques.

5.23 The Working Group noted that there had been two Australian studies on the effects of gastric lavage on the survival of Adélie penguin chicks (Robertson, 1994⁶; Clarke et al., 1994⁷). No evidence was found which showed that the collection of stomach samples once only during chick rearing from one member of a pair of adult Adélie penguins adversely affected the survival or weight at fledging of their chicks. Studies were not conducted on the effects of the collection of more than one sample from the same bird in a season. These findings support the accepted view that gastric lavage is currently the most humane method of procuring samples from Adélie penguins.

5.24 Paper WG-EMM-95/32 suggested that the present method of preparing stomach samples for analysis might not consistently exclude excess water before determining the wet weight of the sample or its components. The Working Group noted the problem and encouraged Members using consistent techniques to specify these in a report to the next meeting so that appropriate advice could be incorporated into the method.

5.25 Paper WG-EMM-95/32 noted that the contents of the first lavage from birds (compared with the remainder of the stomach contents) contained a high proportion of neritic organisms which suggested that these had been obtained opportunistically by birds on their return to the colony from a foraging trip. The paper therefore cautioned against the use of the historical published information for Prydz Bay where the food from a bird was reported from only one lavage without checking if the stomach had been emptied. As a general point the paper suggested that CEMP consider modifying method A8 to report the contents of the first and subsequent lavages separately.

5.26 The Working Group noted that the CEMP methods currently specify the use of lavage until the stomach is empty. The topic of subdividing the stomach sample prior to analysis would require further discussion and should be referred to a Subgroup on Monitoring Methods.

5.27 Paper WG-EMM-95/32 raised the question of whether birds with empty stomachs should be considered when reporting data on diet. Given the observation that in 1994/95 known breeding birds were returning to Béchervaise Island with empty stomachs (WG-EMM-95/33), it was agreed that such birds should be recorded in the comments field on the data reporting sheet. How such data should be incorporated into the calculation of indices should be considered by a Subgroup on Monitoring Methods. The further point raised by the paper that stomach samples should be reported only for known breeding birds with chicks should also be considered. Dr Wilson noted

⁶ Robertson, G. 1994. Effects of water-offloading techniques on Adélie penguins. *Journal of Field Ornithology*, 65(3): 376-380.

⁷ Clarke, J. and K. Kerry. 1994. The effects of monitoring procedures on Adélie penguins. *CCAMLR Science*, Vol. 1: 155-164.

that sampling birds after they were actually observed to return to their chick was the only way to ensure this, but that it was time consuming and not always logistically possible.

Sexing Adélie Penguins

5.28 Details of a method for sexing birds by timing of incubation are provided in Appendix 2.3 of *CEMP Standard Methods*. This method was developed at Béchervaise Island. In WG-EMM-95/45 evidence was presented from Prydz Bay and the Ross Sea region which suggests that this method may be applicable to Adélie penguins at other sites.

New/Potential CEMP Methods

At-sea Behaviour

5.29 At its 1994 meeting, WG-CEMP began the process of developing indices of predator foraging performance based on at-sea behaviour for inclusion in the monitoring program (SC-CAMLR-XIII, Annex 6, paragraphs 4.15 to 4.23). In the intersessional period, draft standard methods of attachment of instruments to penguins (WG-EMM-95/65) and for the measurement of at-sea behaviour (WG-EMM-95/36) were produced by Drs Trivelpiece and Boyd respectively.

5.30 The Working Group approved the general scope and content of these drafts. It noted that the attachment methods text needed critical review by seal biologists and suggested that the draft could also be reviewed by the SCAR Group of Specialists on Seals and the SCAR Bird Biology Subcommittee at their meetings in July 1996. The text on measurement of at-sea behaviour might need modifying once more specific proposals for indices to monitor at-sea behaviour were developed at a proposed workshop (SC-CAMLR-XIII, paragraph 6.20).

5.31 This workshop was scheduled to be held in 1996. However, Dr Boyd, the Convener of the ad hoc subgroup charged with organising the workshop, reported that because the other members of the subgroup had been unable to attend the meeting planned during WG-EMM, no progress had been made with the plans for the workshop, the choice of venue and the terms of reference (beyond those already formulated in SC-CAMLR-XIII, Annex 6, paragraph 4.22).

5.32 The Working Group regretted that progress had not been made on this important topic. In the circumstances it saw little option but to recommend postponing the meeting until 1997, requesting the Scientific Committee to carry forward the appropriate financial provision from the 1996 to the

1997 budget. Dr Boyd was asked to investigate potential venues for the meeting as a matter of priority, to review the terms of reference as appropriate and to consult, via the CCAMLR Secretariat, with potential participants as soon as possible.

Crabeater Seals

5.33 Crabeater seals have been regarded as of primary importance for CEMP since its inception in 1985. However, despite field research on crabeater seals in recent years, no proposals for standard methods (and thereby for the provision of data to CEMP) have been made.

5.34 Therefore, the Working Group welcomed the report (SC-CAMLR-XIV/BG/11) of the SCAR Antarctic Pack Ice Seals (APIS) research project, arising from a planning workshop in Seattle USA, partly funded by CCAMLR. Dr Boyd, a member of the SCAR Group of Specialists on Seals which had planned the project, stated that over the next five years the APIS program aims to promote studies on the status of Antarctic pack-ice seal populations and the role they play in the Antarctic marine ecosystem. By encouraging scientists from various nations and scientific disciplines to share resources, to collaborate on multidisciplinary projects and to identify and utilise centres of specialised analytical expertise, the APIS program seeks to build a cooperative, multinational science program.

5.35 Although concern was expressed that the report of the recent APIS workshop (SC-CAMLR-XIV/BG/11) had little explicit reference to CCAMLR's interest in relevant data on crabeater seals, it was recognised that in previous APIS documents (e.g., SC-CAMLR-XIII/8), explicit reference had been made to the needs of CCAMLR.

5.36 Dr Boyd also noted that it was implicit that aspects of the program will assist substantially in the provision to CCAMLR of advice on the status of Antarctic seals. In addition, APIS intends to produce a number of recommended standard methods for studies which are likely to be applied across research platforms within the Antarctic. The Working Group encouraged the development of these methods and asked that, where appropriate, consideration be given to the development of standard methods which were also of direct relevance to CCAMLR.

5.37 Members should be encouraged to support this important program. The Working Group considered that careful consideration ought be given by APIS to the collection and analysis of data relevant to the aims of CCAMLR in general and of CEMP in particular.

Antarctic Fur Seals

5.38 It was noted above that demographic data for Antarctic fur seals at South Georgia collected by consistent⁸ methods from 1984 to 1994 had been submitted by the UK to CCAMLR (WG-EMM-95/26). In order to assist other Members collect, analyse and summarise similar data, it was important that the methodologies in WG-EMM-95/26 be developed in the form of a standard method. Drs Boyd and Croxall offered to undertake this task.

5.39 In addition, the provision in WG-EMM-95/28 and 29 of extensive data on the diet of Antarctic fur seals at South Georgia indicates that it should be possible to develop standard methods for dietary studies of this species. Drs Boyd and Croxall offered to do this task.

5.40 For some time WG-CEMP had been requesting investigation of potential methods of incorporating condition indices into monitoring studies. Dr Boyd presented WG-EMM-95/21, which compared the use of body mass, body mass corrected for length and bioelectrical impedance measurements for assessing body condition (in terms of total body water and total body lipid determined by hydrogen isotope dilution) in adult female Antarctic fur seals. Bioelectrical impedance gave the poorest correlations, whereas body mass alone gave the best ones.

Petrels

5.41 Dr Mehlum introduced WG-EMM-95/86, which described draft standard methods for fulmarine petrels. The draft was a first step in describing standard methods for population size, breeding success and annual survival and recruitment in the Antarctic petrel. The Working Group welcomed this effort and asked that the draft be circulated to relevant experts for comments and passed to a Subgroup on Monitoring Methods for consideration at a future meeting.

5.42 Lic. R. Casaux (Argentina) summarised WG-EMM-95/85, which presents data on the diet (obtained by lavage) of cape petrels at Laurie Island, South Orkney Islands. *Euphausia superba* was the predominant prey species in the samples; uropod, exopodite and telson length were used to estimate body length. The Working Group suggested that this technique and the statistical relationships presented (see also Nicol, 1993⁹) should be included in a draft of standard methods for studying the diet of fulmarine petrels and might be relevant to diet studies of other predator species.

⁸ Consistent refers to the use of the same method throughout the collection of a time series of data where the method may differ from a CEMP standard method or relate to a CEMP parameter for which standard methods have not yet been developed.

⁹ Nicol, S. 1993. A comparison of Antarctic petrel (*Thalassoica antarctica*) diets with net samples of Antarctic krill (*Euphausia superba*) taken from the Prydz Bay region. *Polar Biology*, 13: 399-403.

Lic. Casaux agreed to prepare a draft of methods for analysis of petrel diet samples for discussion at the next meeting of WG-EMM and/or a Subgroup on Monitoring Methods.

5.43 Dr Agnew reported that, following the tabling last year of WG-CEMP-94/24 (SC-CAMLR-XIII, Annex 6, paragraph 4.13), Dr J.A. van Franeker (Netherlands) had provided the Secretariat with a copy of his computer program for use in sex-discriminant analysis of seabirds.

Gastric Lavage

5.44 The Working Group noted that recent communication with Dr A. Veit (University of Washington, USA) indicated that he was prepared to provide text relating to the use of lavage for obtaining stomach samples from albatrosses and petrels. The Secretariat was asked to continue the dialogue with a view to having a method available for consideration at the next meeting of WG-EMM.

5.45 Discussion of the use of this gastric lavage technique on penguins is included in paragraphs 5.21 to 5.27.

Diseases and Pollutants

5.46 Last year Drs Kerry and Clarke were asked to prepare procedures for the collection of diagnostic samples if and when an outbreak of disease or a parasitic infestation is observed in a seabird colony (see SC-CAMLR-XIII, paragraph 6.18).

5.47 In response to this request, Dr Kerry presented WG-EMM-95/44 which outlines methods for the collection and preservation of samples in the field for later examination and analysis by veterinary pathologists.

5.48 The Working Group welcomed these instructions and recommended that they be circulated to Members for use in the interim pending a more detailed examination by appropriate specialists in Member countries. The Working Group agreed that comments should be forwarded to Dr Kerry who would prepare a revised document for consideration by a methods subgroup and/or at the next meeting of WG-EMM.

5.49 The Working Group endorsed the recommendation that scientists conducting field studies should consult with veterinary pathologists before going into the field to ensure that, if needed, urgent analysis of samples is possible and that any special sampling requirements of the laboratory can be accommodated. The recommended list of equipment to have on hand in the field was noted.

5.50 WG-CEMP (SC-CAMLR-XIII, Annex 6, paragraph 4.42) had noted that, in the event of an outbreak of disease or increased infestation, there may be interest in whether any contaminant or pollutant contributed to the outbreak and suggested that consultation with Prof. Focardi be undertaken to ensure sample collection procedures for disease include those necessary for post hoc testing for contaminants.

5.51 Dr Franchi, in collaboration with Prof. Focardi, presented details of such collection methods. It was agreed that a revised version of these instructions be appended to WG-EMM-95/44 and circulated for comment as suggested in paragraph 5.53 below.

Conclusions

5.52 In considering these methods, the Working Group agreed that research involving their use has progressed to the point where a detailed revision of all methods should be considered. This review would determine whether they are yielding the precise information required by WG-EMM and whether their usefulness could be improved by modification or by the development of new methods.

5.53 The Working Group therefore suggested that a Subgroup on Monitoring Methods be established to:

- (i) circulate the existing proposals for changes to current methods and proposals for new ones, to all Members and to the SCAR Group of Specialists on Seals and Bird Biology Subcommittee for comment and suggestions for improvement;
- (ii) invite all Members and the SCAR Group of Specialists on Seals and Bird Biology Subcommittee to suggest new methods (with accompanying documentation wherever possible) relevant to CEMP objectives;
- (iii) arrange a meeting to review the responses to (i) and (ii) above; and
- (iv) consider developing plans for a comprehensive review of methods.

Indices

Data Submission Review

5.54 Seven Members have so far submitted data to the CEMP database (WG-EMM-95/12 Rev. 1). Argentina submitted data from 1988 to 1990. Additional data from Argentina for the 1993/94 and 1994/95 seasons were delivered to this meeting by courier.

5.55 Australia submits data annually for Béchervaise Island and sporadically for Magnetic Island.

5.56 Brazil submitted data from 1990 to 1992 from Elephant Island but the predator program is in abeyance.

5.57 Chile has submitted data on pup growth from Cape Shirreff for 1993/94 and 1994/95, the latter conforming to the standard method, as stated in WG-EMM-95/77.

5.58 The UK has now completed submission of all historical data (except on diet) on penguins from Bird Island. Annual data submission continues for Bird Island and Signy Island. The tabling of WG-EMM-95/26, which describes the demography of fur seals at South Georgia and provides full quantitative data on birth, mortality and recruitment rates of pups and pregnancy and survival rates of adult females, effectively constitutes submission of these demographic data to CEMP. The methodological details in the paper will need some modifications in order to serve as the text of a standard method (see paragraph 5.38).

5.59 Italy has submitted data for 1995 from the new site at Edmonson Point, Ross Sea. The new activity being conducted there was warmly welcomed by the Working Group, as was the valuable addition to the database, as there has not been any earlier data submitted from this region.

5.60 The continuing absence of Japanese data on Adélie penguin population size for the Syowa station area was noted. Dr M. Naganobu (Japan) offered to make enquiries with colleagues in Japan.

5.61 The USA has submitted data from Anvers Island from 1990 to 1995 and Seal Island from 1988 to 1995. Some data for Seal Island are missing from the database for 1995 because technical difficulties have delayed the submission. Dietary data (A8) are also missing from 1992 and 1993 as they are still being processed. The USA was strongly encouraged to submit historical data from Anvers Island and particularly all the relevant long-term data on numerous penguin parameters from the monitoring site at Admiralty Bay, King George Island.

5.62 Penguin data collected by New Zealand in the Ross Sea following CEMP methods were described by Dr Wilson. Submission of these data to the CCAMLR database was strongly recommended by the Working Group which, together with the new Italian data, would be a valuable addition from a part of the Antarctic continent for which there are no CEMP data.

5.63 The Working Group looked forward to the CCAMLR database receiving data from the planned Norwegian research program at Bouvet Island and, if possible, from the recent studies at Svarthamaren.

5.64 The Working Group requested that data from the South African research program at Marion Island on gentoo penguins (a CEMP indicator species), collected using CEMP Standard Methods, be submitted to the CCAMLR database. This represents an extension to the existing scope of CEMP (because gentoo penguins at Marion Island do not depend primarily on prey species on the current list of those selected by CEMP). Data from rockhopper penguins at Marion Island are not eligible for submission at present because this species is not currently a selected CEMP indicator species.

Data Analysis and Presentation

5.65 It was recalled that in 1994 WG-CEMP encountered a number of problems in the interpretation and presentation of the CEMP indices, which prevented WG-CEMP from making the transition from a qualitative to a quantitative assessment of indices and trends (SC-CAMLR-XIII, Annex 6, paragraphs 5.6, 5.7 and 7.7). It was recommended that the Subgroup on Statistics meet intersessionally to:

- (i) confirm that appropriate analytic and statistical methods were being used; and
- (ii) improve the presentation of the indices.

Several Members of the subgroup met in Cambridge, UK, in January to consider these problems.

5.66 Dr Agnew presented the report from the meeting of the Subgroup on Statistics (WG-EMM-95/10). New software (using Microsoft Access) had been developed to make the graphical presentations (WG-EMM-95/12 Rev. 1 and 14 Rev. 1) more easily understood. The new data compilation included three parts:

- (i) an introduction and summary of all indices by site and species (WG-EMM-95/12 Rev. 1);

- (ii) tables of results with associated statistics and indications of statistically significant differences between years for all parameters within sites (WG-EMM-95/13 Rev. 1); and
- (iii) figures of indices depicting trends at sites between years (WG-EMM-95/14 Rev. 1).

5.67 It was noted that the graphs should be studied in conjunction with the tables of results, as the scales used in the presentations may tend to imply statistically significant differences where none exist, and vice versa. The Working Group wished to convey their thanks and appreciation to Dr Agnew for his considerable efforts in improving the analyses and presentations in WG-EMM-95/12 Rev. 1 and 14 Rev. 1.

5.68 The Working Group reviewed the predator data and indices for further technical comments relating to analysis and presentation.

5.69 Index A1 - penguin weight at arrival. A suggested improvement would be the production of a frequency distribution, which could be done easily with the new software.

5.70 Index A3 - penguin breeding population size. Two colonies, TO14 and TO16 from Palmer Station (USA), are no longer counted because they are too large to count accurately. They should be deleted from the database.

5.71 Dr Agnew observed that there were instances where colonies being monitored year to year split or coalesced and when this occurred they were given new identification names or codes without the Secretariat being advised. Dr Agnew stressed the importance of reporting population numbers for the same group of penguins each year. Members reporting data were therefore requested to note any changes to the colony structure and names and, where necessary, illustrate such changes with a map or diagram.

5.72 Index A5 - penguin foraging trip duration. The separation of data into brood and creche stage was discussed. It was agreed that this was appropriate and that some of the apparent inter- and intra-annual variation in the data for Adélie penguin relates to different foraging strategies. It was noted that a frequency distribution presentation of the data would be useful for the analysis of this index but would require data to be submitted appropriately.

5.73 Index A8 - chick diet. There were no technical comments on the data analysis and presentations of A8; however, there was a paper submitted (WG-EMM-95/32) with suggested changes to the methods which had been discussed earlier (see paragraphs 5.21 and 5.22).

5.74 Index C1 - fur seal cow foraging trip duration. The graphical presentation of data from Bird Island was mistakenly based on the data from Seal Island; this was corrected during the meeting.

5.75 Index F2 - sea-ice percentage cover. The new methods of presentation were very helpful for examining patterns in these data.

5.76 There were no technical comments offered for indices not addressed in the above section (e.g., A2, A4, A7, B1 and C2).

Data Interpretation - Ecosystem Assessment

5.77 Tables 2 and 3 were passed out to members who were asked to update their respective data submission summaries and add the 1994/95 data on status and trends to the interannual summaries of parameters at sites. The interpretation of the 1994/95 data was then undertaken.

5.78 Dr Trivelpiece noted that all penguin data for the Antarctic Peninsula area (Subareas 48.1, 48.2 and 48.3) in the 1994/95 season indicated better breeding success but decreased populations compared with 1993/94. In contrast, data from Béchervaise Island in the Prydz Bay region indicated catastrophic breeding results.

5.79 Dr Kerry reported that at Béchervaise Island and the islands within a 5-km radius, all penguin chicks died within three weeks of hatching. Evidence suggested that starvation was the major cause. Foraging trip durations were longer than previous years and birds foraged further afield, up to 170 km (compared with 110 km), and returned with little or no krill. The spatial extent of the absence of krill is not known, but may be limited. Birds at colonies 57 km to the west and 169 km to the east appeared normal for the corresponding stage of the breeding cycle. Full details are provided in WG-EMM-95/33.

5.80 Dr Kerry noted that there was some evidence during spring that emperor penguin chicks at the Auster Colony also may have been affected by a lack of krill. This colony, is located approximately 65 km to the east of Béchervaise Island. At Taylor Colony, approximately 50 km to the west of Béchervaise, healthy chicks were observed when visited in mid-January. It was concluded that the absence of krill was localised to the north and east of Béchervaise Island and that this affected also the presumably krill-dependent prey of emperor penguins.

5.81 Dr Boyd noted that at Bird Island, South Georgia, the 1994/95 season seems to have been characterised by normal krill availability. The reduction of the breeding population of gentoo

penguins and Antarctic fur seals at Bird Island, in spite of good indices for reproductive success, probably reflected that breeding success had been exceptionally low in the preceding year. The reduction in the macaroni penguin population (which had sustained average breeding performance in 1993/94 despite having to switch its diet from krill to *Themisto*) also probably reflected the unusual conditions at South Georgia in 1993/94.

5.82 The pattern at Signy, of 1994/95 breeding populations of Adélie and chinstrap penguins significantly reduced from recent levels, may also reflect low food availability (WG-EMM-95/75) and rather poor reproductive performance in 1993/94. Additionally or alternatively, these fluctuations at Signy may reflect the effects of variation in prey availability mediated through ice conditions in the Antarctic Peninsula area (WG-EMM-95/15, 63 and 64).

5.83 Dr Croxall explained that the substantial reduction in the number of black-browed albatrosses breeding at the study site in 1994/95 was due to very late and heavy snow fall preventing the breeding population from nesting. The importance of linking this kind of information to the data appearing in the CCAMLR database was emphasised. The information should be noted both at the time of submission of the data and at the appropriate meeting where the data are discussed.

5.84 Dr Boyd noted that fur seal pup growth indices indicate faster growth at Seal Island than at Bird Island, a matter which merits further investigation. A possible explanation may be that due to the small size of the colony at Seal Island, the same pups are weighed more frequently there. However, Dr Croxall recalled that in the 1970s the Bird Island data values were higher than in more recent years, so that other explanations, perhaps relating to ecological effects of population size, may be involved.

5.85 Dr Trivelpiece noted that the Adélie penguin data from Palmer Station reflected a pattern consistent across all Antarctic Peninsula area sites: good breeding success but reduced population size. Krill size classes (large) and foraging trip durations (long) show significant correlation with ice patterns and krill habitat preferences (WG-EMM-95/64). Dr Holt noted that the overall trend described for the other Antarctic Peninsula sites was evident at Seal Island.

5.86 Dr Franchi reviewed the new Italian data from Edmonson Point that, for the first time, included a complete set of parameters; therefore no trend analysis was possible. The Working Group looked forward to the possibility of following trends in this new area. She also informed the Working Group that ecotoxicological and disease studies were undertaken at the site. The studies are expected to continue for a minimum of three years.

Dependent Species Links with Harvested Species and the Environment

The Overlap Between the Fishery and Foraging by Dependent Species

5.87 The importance of continued investigation and analysis of the nature and significance of overlap between the location of krill fisheries and the foraging areas (and food requirements) of krill-dependent predator species during their breeding season was re-emphasised in SC-CAMLR-XIII, paragraphs 7.8 to 7.16. This interaction is currently assessed during the critical period-distance (CPD), which is currently taken to be a range of 100 km from breeding sites over the period December to March.

5.88 The Data Manager had, as requested, continued to calculate overlap between the location of krill fishing and the predator CPD. The summary of the results of analysis of the 1994 data, together with previous assessments, was presented in WG-EMM-95/41. This paper was presented in a new style and format, consistent with those for the CEMP predator indices. The Working Group thanked the Data Manager for his work and for the much improved presentation.

5.89 It was noted that where the percentage of total catch reported by fine-scale data was less than 50%, these data have not been included in the analysis presented in WG-EMM-95/41. In general, however, more than 75% of the catch was reported at fine scale. Furthermore, considerable historical data had been provided this year by Japan. The Working Group thanked Japan for its great efforts to provide so much valuable data. For the first time results for Division 58.4.2 were included. A similar presentation for Division 58.4.1 was not included because details of the penguin colonies in this area were unavailable at the time.

5.90 The overall picture in Subarea 48.1 was of a progressive reduction in the percentage catch within the CPD from 90 to 100% in the late 1980s to 60 to 70% in recent years, with a reduction in the total catch in the CPD in 1993 and 1994. In Subarea 48.2 there is no clear pattern, but the catch in 1993 and 1994 was much reduced compared with previous years and the percentage of catch in the CPD was less than 20% (compared to 40 to 50% in the previous two years). For Subarea 48.3, catches and overlap in the CPD were very low because the main krill fishery takes place in the winter. In Division 58.4.2 (Prydz Bay region), catches were small but the percentage of catch in the CPD in recent years was high (60 to 80%).

5.91 Mr Ichii explained that one reason for some of the recent reduction in the fishery/dependent species overlap within the CPD in Subareas 48.1 and 48.2 was that more fishing was conducted outside the critical period for predators. This was because of logistic constraints on the timing of the

fishery imposed by the need for the vessels involved also to fish in areas adjacent to the Convention Area.

5.92 It was recollected, however, that the existing CPD concept was only one of a suite of potential critical periods for predators. There are clear indications that the March to May period may be equally critical for the survival of fledgling penguins in some regions, and also suggestions that winter (June to September) may be an important time for the survival of adult seals and penguins.

5.93 Mr Ichii pointed out that no account is taken of the size and distribution of colonies in the calculations of the CPD. He also suggested that the CPD ought to be weighted by the distance of the fishery from colonies of different sizes (WG-Joint-94/8 and 17).

5.94 However, it was noted that these issues may be of importance only if there is no flux of krill in the areas under consideration (see SC-CAMLR-XIII, Annex 7, paragraph 4.3).

5.95 Dr Kerry noted that Adélie penguins at Béchervaise Island regularly forage during the entire breeding season between 100 and 120 km from the coast, and that during the past season they had foraged up to 170 km from the coast (WG-EMM-95/46). He suggested, therefore, that the critical distance should be extended to at least 125 km for Division 58.4.2.

5.96 It was agreed that both the concept and the detail of the CPD needs to be critically re-examined in the light of new data on the foraging ranges of predators, fishing grounds and the times of year at which predators are particularly vulnerable. Such a discussion should be a high priority at the next meeting of WG-EMM.

5.97 The Data Manager reported that in 1995 there had been a substantial increase in the catch of krill by Ukraine in Subareas 48.1, 48.2 and 48.3 (see paragraph 3.2). In view of this, it was thought advisable to review the overlap between fisheries and dependent species as soon as possible, and the Data Manager was asked to provide relevant information for this year's meeting of the Scientific Committee.

5.98 As a contribution to the continuing research aimed at assessing potential overlap between predators and the krill fishery in the vicinity of Seal Island, Mr Ichii introduced WG-EMM-95/87. This described the results of assessments of krill and fish abundance (from acoustic surveys) in relation to the foraging journeys of chinstrap penguins and Antarctic fur seals tracked by VHF radio (and satellite tags) during the incubation and early offspring rearing periods. Krill densities were higher over the shelf areas and lower in offshore areas where fish (principally myctophids) were at high density and available at night within the depth foraging range of penguins and fur seals. The individual predators

actually tracked, however, travelled to areas well offshore during incubation/early pup rearing (December) and also offshore, albeit closer to Seal Island, in January. The propensity for chinstrap penguins and Antarctic fur seals to travel to offshore areas might reflect that:

- (i) krill were present at shallower depths throughout the day, and therefore more easily detected and caught;
- (ii) krill tended to be larger in size; or
- (iii) myctophids were available to predators at night.

The availability of myctophids was regarded as the key element determining the foraging strategy of predators which incorporated an overnight period into their foraging trip (i.e., all fur seals and some chinstrap penguins).

5.99 The Japanese and US scientists were congratulated for undertaking such a complex, intensive and productive research project. However, it was noted that the key role of myctophids in the foraging strategies of chinstrap penguins and fur seals was, at this stage, simply inferred from data on prey abundance and predator location (and these from very small numbers of individuals) and unsubstantiated by any data on predator diets. Furthermore, existing data on the diet of chinstrap penguins from Seal Island indicate that fish have only comprised more than 1% by mass of the diet in one year (1994: 9%) of the five years for which data are available (WG-EMM-95/13 Rev. 1). All published dietary data for chinstrap penguins from the South Shetland and South Orkney Islands indicate that krill is their main prey (more than 90% by mass); thus, even if myctophids were important in the diet of chinstraps at Seal Island in January 1995, this could, at present, be regarded as a local effect only. Analogies were drawn with the situation at South Georgia from which macaroni penguins and Antarctic fur seals regularly travel through inshore krill concentrations (exploited by species such as gentoo penguin) to shelf-slope and offshore areas (where myctophids are abundant) to feed almost exclusively on krill. Caution was urged in drawing conclusions from the data presented in WG-EMM-95/87, at least until quantitative dietary data from the tracked predators and for the chinstrap penguin and Antarctic fur seal populations at Seal Island in January 1995 are available.

Subarea and Local Consumption

5.100 A key element in the assessment of krill fishery/dependent species interactions is knowledge of the food requirements of predators. WG-CEMP had undertaken considerable work in developing

appropriate energy budget models for the main predator groups (phocid seals, fur seals, penguins) and providing estimates of energy and/or krill consumption for some or all of these groups in appropriate areas (SC-CAMLR-XIII, Annex 6, paragraphs 6.3 to 6.6).

5.101 It was also noted that a current proposal relating to potential precautionary measures (e.g., WG-EMM-95/17) is based on estimation of the food requirements of predators. It was recommended, therefore, that a comprehensive compilation of data regarding diets, energy budgets and foraging ranges/areas of top predators in the Convention Area be maintained and updated annually, together with appropriate information on analogous modelling exercises for other ecosystems. Members were requested to make such information available to WG-EMM.

5.102 Paper WG-EMM-95/22 reported new data on activity-specific energetics of gentoo penguins, and WG-EMM-95/28 and 29 provide new quantitative data on summer and winter diet of Antarctic fur seals at South Georgia. Dr Boyd stated that he was currently developing a generic pinniped energy budget model and would be considering the sensitivity of its results to values of demographic variables. Dr Trivelpiece reported that a modelling exercise (WG-EMM-95/66) aimed at developing an energetic model for Adélie penguins, as part of a larger ice/krill/dependent species model, is planned. Papers WG-EMM-95/46 and 87 contained valuable data on foraging ranges of penguins and fur seals.

5.103 Data on actual foraging areas covered by Antarctic fur seals and chinstrap penguins from Seal Island, obtained from shipboard radio telemetry and satellite tracking, are summarised in WG-EMM-95/87 (see also paragraphs 5.98 and 5.99).

Relationships Between Dependent Species and Other Ecosystem Components

Modelling Functional Relationships

5.104 The background to this topic is reviewed in SC-CAMLR-XIII, Annex 7, paragraphs 4.19 to 4.30. At that meeting, specific problems had been highlighted about interpretation of the data used in the models. This resulted in the clarification of several issues relating mainly to whether survival data for predators had been interpreted correctly. The joint meeting had encouraged further development of the models in the light of this new information.

5.105 The Working Group considered WG-EMM-95/39 and 42 which described progress with the development of modelling functional relationships between indices of predator recruitment/survival and krill abundance. Initially, only those aspects relevant to the predator data were discussed.

5.106 In WG-EMM-95/39, substantial progress was reported towards achieving a realistic result from the model for the black-browed albatross. Allowing different juvenile and adult survival rates in the model had led to a substantial improvement in realism. The current model assumes that the population is stable, although this is not the case, as noted in WG-CEMP-94/44, and does not explicitly incorporate data on laying rate.

5.107 Specific steps to be taken in extending the model for black-browed albatross are detailed in Appendix F(a). The most important of these are to re-estimate parameters to reflect the observed decline in the population over the 1976 to 1989 period, rather than to assume that the population is stable, and to incorporate laying rate data within the calculation of fecundity rate.

5.108 Further modelling of Antarctic fur seal functional relationships incorporating the full set of data on survival rates had been less successful because of an additional problem with the data (WG-EMM-95/39). A rate of population increase of +3.4% per annum was the maximum that could be achieved by the model even though there was evidence of an actual increase of +10% per annum. However, it was pointed out that:

- (i) there are wide confidence limits on the current annual estimates of both adult female survival and pregnancy rates;
- (ii) survival rate will be underestimated by the current methods of measurement in Antarctic fur seals. This is because estimated adult emigration (currently assumed to be negligible) and correction for tag loss rate will be, if anything, on the low side. Further, age-dependent mortality factors are likely to have affected the survival rate of the study population more than that of the South Georgia population as a whole; and
- (iii) the rate of increase in the study population (though not in the whole South Georgia population) has decreased throughout the study period (it is currently stable). The study population from which these data are derived is not a closed population and it is not known how representative it is of the whole South Georgia population of Antarctic fur seals. In these circumstances, the current fit given by the model may be much better than the authors of WG-EMM-95/39 thought. Further discussions may now be required to determine the best way to proceed.

5.109 Specific steps for further developing the model for the Antarctic fur seal are listed in Appendix F(b). Because tag-recapture estimates of adult survival rate are biased downwards when used to represent the population as a whole, an additional parameter is to be introduced into the

model to adjust these estimates so that the model population is able to achieve the growth rate of some 10% per annum observed in the recent past for the overall population.

5.110 For Adélie penguins (WG-EMM-95/42), a model had been developed which allows for lower adult survival rates in the year of first breeding and the possibility that breeding may be deferred one year if conditions are poor. However, the fit of the model to a time series of annual estimates of breeding population size was unable to reproduce as much interannual variability as the data suggest. As a further development of this model, variable annual adult survival could be incorporated instead of using a fixed value as at present. It was also pointed out that there is interannual variation in sub-adult survival and this may have to be incorporated in the model.

5.111 The planned modifications to the Adélie penguin model of WG-EMM-95/42 are described in Appendix F(c). These include allowance for first breeding to occur over a wider range of ages and for annual variation in the first year survival rate.

5.112 Implementation of the steps outlined in Appendix F(a) and F(b) should allow final calculations for the present form of the krill/dependent species model to be presented at the 1996 meeting of WG-EMM for two species, the black-browed albatross and the Antarctic fur seal. The Adélie penguin modelling exercise is more complex and may therefore require a further iteration at the 1996 meeting before results of possible relevance to management recommendations from this approach become available for this species.

5.113 The Working Group endorsed the future work described above. It noted that this work should at present be confined to the three species mentioned, but encouraged extension of the approach to other species and sites as possible and appropriate. Extension of the approach would depend on the availability of appropriate demographic data and it is important that these contain estimates of the measurement error associated with the empirical estimates of the population parameters.

Krill Selectivity by Predators

5.114 At the 1994 joint meeting, calculations involving the length distributions of krill in predator diet data had been requested because the results of the krill yield estimation model were particularly sensitive to the age-dependence in krill natural mortality (SC-CAMLR-XIII, Annex 7, paragraphs 4.34 and 4.35). In response to this, sets of krill length frequency distributions from minke whale, crabeater and Antarctic fur seal, Adélie, chinstrap, gentoo and macaroni penguin and white-chinned

petrel stomach samples had been sent to Prof. Butterworth and Miss R. Thomson (South Africa) for them to attempt to assess the effects of this age dependence.

5.115 The results of an illustrative analysis, using data on minke whales from Mr Ichii, crabeater seals from Dr J. Bengtson (USA), Adélie penguins (Lishman, 1985¹⁰) and white-chinned petrels (Croxall et al., 1995¹¹), are summarised in WG-EMM-95/40. Prof. Butterworth pointed out that most of the krill lengths in the data sets supplied showed that predators were taking a low proportion of krill from age classes <3 years. Since the krill yield model is more sensitive to mortality in the early age classes of krill, which these sets suggest to be poorly represented in the diet of the predators, he questioned whether continuing with this approach was worthwhile. However, questions were raised about the selection of those data sets examined in WG-EMM-95/40. The meeting felt there was evidence from several of the submitted data sets and various other studies (e.g., WG-EMM-95/28, 29 and 64) that krill of <3 years of age (<44 mm) were taken regularly by predators consuming large quantities of krill.

5.116 If krill natural mortality is to be inferred from the length distribution of krill consumed by predators, then further requirements would include: (i) representative data on the length frequencies of krill taken by all major krill predators; and (ii) estimates of the proportion of the total consumption of krill by each species. The Working Group agreed that: (i) for most major predators diet and/or scat samples provide representative data on the length frequency of krill they eat; and (ii) adequate estimates of proportionate krill consumption could be provided. However, concern was expressed about how easy it would be to obtain fully representative length frequency distributions, because of the effects of different spatio-temporal scales of sampling.

5.117 The Working Group noted that concern about the sensitivity of the krill yield model results to age dependence in krill natural mortality had been based on calculations for which natural mortality was changed for krill of ages 0, 1 and 2. However, subsequent practice has been to base estimates of krill recruitment variability and natural mortality on krill length frequency data for age 2 and above only. This means that the yield model results become independent of values assumed for krill natural mortality for ages 0 and 1. Given the difficulties of developing predator dietary data into the form necessary to attempt to estimate age dependence in krill natural mortality, the Working Group agreed that the sensitivity of the krill yield model results to this dependence should be re-examined for ages 2 and above only, prior to possible further analysis of the dietary data.

¹⁰ Lishman, G.S. 1985. The food and feeding ecology of Adélie and chinstrap penguins at Signy Island, South Orkney Islands. *Journal of Zoology, London*, 205: 245-263.

¹¹ Croxall, J.P., A.J. Hall, H.J. Hill, A.W. North and P.G. Rodhouse. 1995. The food and feeding ecology of white-chinned petrel *Procellaria aequinoctialis* at South Georgia. *Journal of Zoology, London*, 237.

5.118 In preparation for further work on this topic it will be important to assess biases in krill length frequency data derived from predators. Members able to compare krill length frequency data from net hauls with data derived from predator diet samples taken at times and places similar to the times and places of net hauls were asked to make such information available to the next meeting of WG-EMM.

Other Approaches

5.119 Dr Trivelpiece presented an analysis of the relationship between Adélie penguin fledgling survival (1981 to 1991 cohorts), population changes (1977 to present) and pack-ice cycles (WG-EMM-95/63). The analyses revealed that cohort survival was independent of ice cycles; however, the relatively constant survival rates from 1981 to 1986 (mean 22%, range 20 to 24%) declined significantly to a mean of 10% (range 5 to 14%) for the 1987 to 1991 cohorts. Lagging two years behind this change in cohort survival, the Adélie population at Admiralty Bay declined from approximately 10 000 to 5 000 breeding pairs. Furthermore, analysis of krill length frequency from Adélie diet samples (1974 to present; WG-EMM-95/64) and pack-ice cycles (WG-EMM-95/62) revealed a consistent pattern of relationship between krill length frequencies and pack-ice cycles. These papers suggest that the reduction in the frequency of winters with extensive pack-ice has resulted in a decrease in krill recruitment, and hence biomass, in the region, which in turn has led to changes in the survival, recruitment and population size of Adélie penguins.

5.120 The Working Group recognised the significance of this work and the importance of testing the conclusions and hypotheses therein. Analysis of additional time series of data on krill length frequencies from predators in appropriate areas and of other relevant demographic data for penguins (especially data on chinstrap penguin survival and recruitment rates from Seal Island) was strongly recommended.

5.121 Methods are also being developed to examine indices of variability in the spatial structure of krill swarms from data on the foraging time budgets of Antarctic fur seals (WG-EMM-95/23). This paper concluded that, during 1990/91 at South Georgia, when fur seals seemed to have reduced food availability, there appeared to be no reduction in the frequency at which seals encounter krill swarms but the quality of those swarms as foraging patches for fur seals may have been reduced.

5.122 While welcoming this development, Mr Ichii asked if there were concurrent acoustic data to provide an independent test of the ideas expressed in the paper. Unfortunately there were no such data. Mr Ichii noted that, from his recent experience in work around Seal Island, fur seals appeared to swim continuously through krill swarms rather than feeding on a single swarm for a long period of

time, as suggested by Dr Boyd's analysis. In response, Dr Boyd suggested that, because of the small spatio-temporal scales (0.18-0.27 km and 1.3-1.36 km) involved in fur seal feeding, it would be difficult to infer, by casual observation, the precise behaviour of fur seals engaged in travelling and foraging and that one could easily have the impression that animals were travelling continuously.

5.123 Paper WG-EMM-95/75 reported some data from 1993/94 on comparisons of acoustic estimates of the abundance of krill and other zooplankton in the South Georgia and Signy Island areas, which were consistent with available data on predator reproductive performance. Interpretation of these relationships would have been improved by dietary data from penguins at Signy and more detailed data on non-krill zooplankton distribution and abundance at South Georgia, but this could not have been foreseen as a desirable objective at the time the acoustic study was planned.

5.124 It was emphasised that it was important to collect data on distribution and abundance of predators and prey from similar times and places. Data on the population structure of prey from predators as well as on prey populations directly, should also be collected in a similar manner.

Ecosystem Assessment

5.125 The data requirements to develop strategic models for ecosystem assessment were reviewed. For dependent species the only sources of integrated data on population size, adult survival rate, reproductive rate and recruitment are:

- Subarea 48.3 - Antarctic fur seal (South Georgia)
Black-browed albatross (South Georgia)
- Subarea 48.1 - Adélie and gentoo penguin (King George Island)
- Subarea 48.1 - Adélie penguin (Palmer)
- Division 58.4.2 - Adélie penguin (Béchervaise)

Historical data covering all the above variables are available for Adélie penguins at Cape Crozier and crabeater seals in Subarea 48.1.

5.126 A variety of studies are providing regular or annual time series of data on some or all of: diet (including prey population structure), foraging range and foraging performance and these are listed in Table 4.

Research Relating to Non-krill Harvestable Resources (Scope of CEMP)

5.127 The background to this item is set out in Annex 6 of SC-CAMLR-XIII, paragraphs 9.1 to 9.8, and SC-CAMLR-XIII, paragraphs 6.34 to 6.40.

5.128 In response to the Scientific Committee's request for relevant information and proposals for monitoring and related research initiatives the meeting considered the implications of papers tabled this year and information considered in previous years.

5.129 In the past, these contributions have mainly related to: (i) a need within CEMP to know if CCAMLR intends to undertake monitoring and/or coordinated directed research (e.g., including on dependent species) on *Pleuragramma antarcticum*; (ii) the potential for coordinating the collection, analysis and interpretation of data on interactions between certain fish-eating (and possibly even squid-eating) species and their prey. The main fish-based dependent species/harvested species interactions discussed at the present meeting related to blue-eyed shag, king penguin and Antarctic fur seal.

5.130 Lic. Casaux presented a review of recent Argentinian research investigating in detail the consumption (in terms of number and biomass) of coastal fish species by blue-eyed shags in Subareas 48.1 and 48.2 (WG-EMM-95/78, 79, 81, 82 and 83). The fish species represented in the diet agreed, even in relative importance, with those sampled by means of conventional fishing gear (gill/trammel nets) and included harvested and harvestable species. He also presented a draft of a methodological proposal for monitoring changes in coastal fish populations by analysis of pellets (WG-EMM-95/84). This method could be a very effective means of detecting both short- and long-term variations in fish populations, which should have considerable interest for CCAMLR.

5.131 The Working Group welcomed these developments and noted that the fish consumed by blue-eyed shags include juveniles of species (such as *Notothenia rossii*) which have been harvested in the past and whose current status in Subareas 48.1 and 48.2, where there is currently no commercial fishing, is of much interest to CCAMLR.

5.132 It was noted, however, that it may be important to try to clarify: (i) the sizes/ages of commercially exploitable fish species eaten by shags; and (ii) any biases inherent in the use of shags as sampling agents for these size categories of the fish population.

5.133 For king penguins at South Georgia, WG-EMM-95/27 provides detailed quantitative dietary data for three consecutive summers demonstrating that, like king penguins at all sub-Antarctic islands so far studied, they depend almost exclusively on a diet of myctophids.

5.134 Dietary work on this species, in conjunction with the use of satellite tracking, time-depth recorders (TDRs) and other instruments is already providing much information on the dynamics of interactions between king penguins and their prey (Jouventin et al., 1994¹²). Many of these data could be of relevance to CCAMLR in terms of obtaining information on aspects such as relative abundance and distribution within and between years of a group of fishes which has been subjected to considerable harvesting in some subareas and for which relatively few biological data from the fishery are currently available.

5.135 Papers WG-EMM-95/28 and 29 include the first full quantitative data on the composition (by numbers and biomass) of the fish diet of Antarctic fur seals. In breeding females in three consecutive summers at South Georgia the fish element of the diet was small and mainly comprised ice fish and notothenioids early in the pup-rearing season (December/January) and myctophids later on (February/March). In contrast, the winter diet of male fur seals in two consecutive years at South Georgia contained substantially more fish, mainly consisting of *Champscephalus gunnari*. The size of the fur seal population and the estimated potential consumption of *C. gunnari* is such that this predation may have a significant influence on the dynamics of the South Georgia stock of *C. gunnari* - which is of considerable interest to CCAMLR as an extensively harvested resource.

5.136 The Working Group suggested that it was becoming increasingly important for CCAMLR to consider fish-based dependent species/harvested species interactions in its deliberations and to consider appropriate mechanisms for coordinating studies and evaluating results.

ENVIRONMENT

General Environmental Analyses

6.1 A number of papers reported on directed studies aimed at understanding particular physical environmental processes or characterising variability.

6.2 Paper WG-EMM-95/16 considered water mass distributions in the Elephant Island area utilising a Conductivity Temperature and Depth probe (CTD) survey. The frontal variability of the

¹² Jouventin, P., D. Capdeville, F. Cuenot-Chaillet and C. Boiteau. 1994. Exploitation of pelagic resources by a non-flying seabird: satellite tracking of the king penguin throughout the breeding cycle. *Marine Ecology Progress Series*, 106: 11-19.

region was highlighted and the Working Group recommended the compilation and analysis of available historical data sets.

6.3 This point was further developed in WG-EMM-95/67 where historical data have been analysed to generate a regional description of the oceanographic regime in the Antarctic Peninsula area allowing consideration of the variability. The importance of Circumpolar Deep Water (CDW) in influencing the production systems of the area was emphasised.

6.4 The value of such a review of historical data was clear and the Working Group considered that the issues of access to such data and the facilitation of analyses should be reviewed.

6.5 Papers WG-EMM-95/61, 62 and 80 report on the analyses of long-term, large-scale climate and sea-ice data sets. These papers emphasise the strong links between the ice, ocean and atmospheric systems. They also highlight that there are important regional differences in the operation of the physical systems as well as strong inter-regional connections. Interannual variability was considered and possible trends or patterns examined. Understanding of the underlying physical processes involved remains incomplete.

6.6 The ecological importance of such variability was recognised and this theme was developed extensively in WG-EMM-95/62. The paper emphasises that the ice/ecosystem link was highly variable in the Antarctic Peninsula region and that the high interannual variability was not spatially consistent in the area.

6.7 One paper (WG-EMM-95/52) developed on aspects discussed at WS-Flux (SC-CAMLR-XIII, Annex 5, Appendix D) last year and reported on the development of a coupled physical-biological numerical model of the Southern Ocean ecosystem. The paper reported on a three-dimensional regional model of the King George Island/Livingston Island area.

Prey-based Analyses of Environmental Data

6.8 Papers WG-EMM-95/4, 19 and 49 reported on aspects of current flow influence on krill distribution, building on information obtained at WS-Flux last year.

6.9 General concepts of krill flux were discussed in WG-EMM-95/19 which emphasised the importance of krill biology when considering the generation of krill distributions using current systems. Paper WG-EMM-95/4 reported on a restricted-area study of short-term changes in the distribution of krill in relation to current flows.

6.10 Paper WG-EMM-95/49 reported on an extensive multidisciplinary study of environment and krill distribution. Aspects of current flows and krill flux were examined using drifting buoys tracked by the ARGOS satellite system. The data emphasised that the South Shetlands area was one of high retention. Transfer of buoys released from the South Shetland area across the Scotia Sea occurred although the tracks followed were highly variable. The time-scale for transfer to the South Georgia vicinity was of the order of 150 to 200 days.

6.11 The execution of a multidisciplinary cruise considering krill flux, reported in paper WG-EMM-95/50, used a wide range of environmental logging systems including CTD, Expendable Bathythermography (XBT), Acoustic Doppler Current Profile (ADCP) and Remotely Operated Vehicle (ROV).

6.12 A number of studies considered interannual variation in krill recruitment. Paper WG-EMM-95/15 used data on ice concentration, duration and other ice indices. Links to surface water temperatures were also considered.

6.13 The Working Group noted the value of such studies and, realising the long-term planning required in developing such studies, emphasised the continued need for such data as highlighted by WS-Flux.

6.14 The correlation between climate and krill recruitment was examined in WG-EMM-95/53. This paper investigated sea-level pressure data as an indication of atmospheric system behaviour. The effect on krill recruitment was considered to operate through links between the atmospheric-ice and ocean systems.

6.15 Krill recruitment and ice cover was also considered in WG-EMM-95/55 which used the extensive Japanese fishery data set for the South Shetland region and linked this to sea-ice extent.

6.16 Aspects of ice/ocean/recruitment relationships were analysed in WG-EMM-95/69 using data from the central Scotia Sea. This paper considered links between CPUE from the Russian fishery data and atmospheric, oceanographic (sea surface temperature (SST)) and sea-ice variables. Links between the physical variables were examined in detail.

6.17 Paper WG-EMM-95/58 reports on the results of a workshop on the temporal changes in the Antarctic Peninsula region. This brought together a range of extensive data sets on both biotic and abiotic components of the ecosystem. The recommendations of the workshop emphasise the importance of good oceanographic data for addressing the question of mesoscale distribution of

prey. Data utilised included CTD, nutrient distributions and chlorophyll *a* concentrations. The importance of variability in water mass distributions was emphasised. One transect with five stations on 55°W was occupied six times from early December 1994 to late February 1995 north of Elephant Island. One of the important findings is the north-south movement of the oceanic frontal zone varying about 15 n miles, which might influence the krill flux and distribution. Nutrient depletion was found as the season progressed, probably associated with phytoplankton species succession.

6.18 Paper WG-EMM-95/18 reported on a specific study on the distribution and biological characteristics of krill in the Bellingshausen Sea. These data were discussed in relation to other ecosystem components.

6.19 Paper WG-EMM-95/54 reports on a multidisciplinary study which included analysis of salp and chlorophyll *a* distributions and concentrations in relation to water mass effects.

6.20 An investigation of spatial distributions of krill CPUE (WG-EMM-95/51) emphasised the importance of bathymetry.

6.21 A study from an area outside the CCAMLR region on euphausiid species in Japanese waters (WG-EMM-95/48) was reported. Distributions were linked to current system fluctuations and oceanographic regimes.

Integrated Ecosystem Analyses of Environmental Data

6.22 A number of papers reported on mesoscale studies of predator/prey interactions.

6.23 Paper WG-EMM-95/87 considered penguin foraging and included hydrographic observations. The need for bathymetric data was emphasised.

6.24 Paper WG-EMM-95/60 reported on the AMLR program and emphasises the multidisciplinary nature of the cruises. The paper highlights the effort required to carry out detailed ecosystem analyses of mesoscale variability.

6.25 A proposal for a fully integrated oceanographic/biological program was described in WG-EMM-95/43.

6.26 A number of papers discussed the interannual variability of various aspects of predator biology in relation to environmental variation.

6.27 The effect of environmental variation on pregnancy rates of fur seals in relation to time of year and food availability was discussed in WG-EMM-95/24.

6.28 Papers WG-EMM-95/28 and 29 considered the diet of fur seals and emphasised the potential importance of interannual variability in the pelagic system.

6.29 Paper WG-EMM-95/33 reported on penguin deaths in the vicinity of Mawson and emphasised the need for understanding environmental variation.

6.30 Links between penguin recruitment and environmental variation were examined in paper WG-EMM-95/63. Penguin recruitment was linked to ice-extent data and interannual variability in krill recruitment. Further aspects of this study were developed in WG-EMM-95/64 and 66.

6.31 Paper WG-EMM-95/31 reported on a meeting which considered large baleen whales in the Southern Ocean. Various ecosystem interactions were considered at the meeting and large-scale surveys suggested.

6.32 Paper WG-EMM-95/66 proposes a modelling study developing coupled biological-physical models of the krill/penguin/ice/ocean system as a method for developing understanding of ecosystem operation.

Data Reports

6.33 Papers WG-EMM-95/11 to 14 report the CEMP and other data sets compiled by the Secretariat. Physical data include a range of sea-ice indices for a range of locations.

Consideration of Future Environmental Data Requirements

6.34 Paper WG-EMM-95/20 highlights general aspects of environmental monitoring programs in the Antarctic and aspects of data management.

6.35 The Working Group emphasised that the studies considered here cover a wide range of topics and scales. It considered that carefully focused questions were required to clarify what types of environmental data and analyses were needed to meet the objectives of WG-EMM.

6.36 A proposal for the development of standard transects was discussed. It was noted that various nations were developing standard transects. The Working Group was also reminded that programs such as the World Ocean Circulation Experiment (WOCE) were already undertaking such studies. Links to such programs would need to be considered once the questions on environmental data were clarified.

6.37 The Working Group was reminded that an earlier meeting of WG-CEMP had generated a table identifying the environmental data requirements of that group (SC-CAMLR-V, Annex 6, Table 6). The Working Group recognised that many of the subjects shown in the table had undergone important developments since 1986 and noted that a more detailed scheme had been proposed by Dr Fedoulov.

6.38 A general table was produced which incorporated the information in SC-CAMLR-V, Annex 6, Table 6 and Dr Fedoulov's suggestion (Table 5). It shows some of the measurable variables and methods for the study of oceanic, ice, atmospheric and terrestrial features at different scales. The table can be used to identify the variables and methods available.

6.39 The Working Group recognised that the items set out in Table 5 require elaboration, particularly in respect of defining the spatial and temporal scales over which the various environmental processes operate. Dr S. Kim (Republic of Korea) noted in particular that no clear distinction is made between the physical and biotic components of the environment. For example, a detailed breakdown of the ocean processes affecting prey, such as primary productivity, might be considered for inclusion in the table.

Sea-ice

6.40 The Working Group noted that CCAMLR has long recognised the importance of seasonal sea-ice dynamics in the Antarctic marine ecosystem. In particular, information has been sought on the physical and biological properties of sea-ice as these affect key ecosystem components at different times and in different areas.

6.41 Papers tabled at the meeting reported on recent developments in studies aimed at understanding the effects of sea-ice on various biota and the differential responses of such biota to ice dynamics. In this connection, it was recognised that the effects of sea-ice depend on both its character and extent and the rate at which these change through time.

6.42 Developments of particular significance identified by WG-EMM include linkage of sea-ice conditions to krill recruitment (WG-EMM-95/15, 18 and 55), spatial and temporal variability in sea-ice as a function of long-term seasonal climatic changes (WG-EMM-95/61, 62 and 80) and possible effects of sea-ice on predator population dynamics and diet (WG-EMM-95/63 and 64).

6.43 It was noted that the Antarctic Peninsula region is one which shows very large interannual variability and that there has been a strong cyclical signal over some decades. The region also shows an annual cycle characterised by a five-month advance and a seven-month retreat of pack-ice which is the opposite of other regions (WG-EMM-95/52).

6.44 The Working Group agreed that a clear distinction needs to be made between the direct effects and indirect effects arising from variability in sea-ice extent, character and dynamics. Such effects are summarised in the last column of Table 5.

6.45 For example, sea-ice impacts predators directly via habitat availability and indirectly via prey availability.

6.46 For prey, sea-ice affects the over-winter survival of larval krill and affects adult maturation and growth rates. Ice may also provide a refuge for krill as well as a site for seeding the water column with food in early summer.

6.47 In the case of the fishery, the presence of ice directly affects fishing operations with consequent effects on krill and its dependent species.

6.48 The Working Group agreed that in order to facilitate formulation of specific hypotheses on the potential effects of sea-ice on components of the Antarctic marine ecosystem in key areas and to identify the data necessary to test such hypotheses, a small task group should work by correspondence during the forthcoming intersessional period.

6.49 The task group, convened by Dr Miller and consisting of Drs Agnew, Croxall, Holt, Naganobu, Siegel and Trivelpiece, will:

- summarise previous discussions and data requests by CCAMLR on sea-ice and related matters. To a large extent this task will be carried out by the Secretariat;
- identify key hypotheses and areas of research aimed at improving current understanding of the physical and ecological effects of sea-ice in the Antarctic marine ecosystem;

- liaise with other programs focused on sea-ice studies (e.g., EASIZ of SCAR), the cataloguing of currently available data and identification of future data requirements;
- identify key sea-ice properties and processes, including the data necessary to characterise the variability and seasonability of such properties and processes; and
- report to WG-EMM's next meeting on the above.

6.50 The Working Group was reminded of the importance of other oceanographic and atmospheric variables and possible inter-relationships. The Working Group noted that care must be taken in the interpretation of short time-series and in investigating correlations with other variables. The need for carefully focused questions was again emphasised.

ECOSYSTEM ASSESSMENT

By-catch of Fish in the Krill Fishery

7.1 Two papers reported on the by-catch of fish in the krill fishery. One (WG-EMM-95/56) assessed the by-catch in the Japanese krill fishery off the South Shetland Islands (Subarea 48.1) from 30 January to 18 February 1995, the other (SC-CAMLR-XIV/BG/10) the occurrence of fish in commercial krill catches taken by a Japanese trawler off Wilkes Land (Division 58.4.1) from 19 January to 2 March 1995.

7.2 A detailed examination of these papers was prepared for submission to the Working Group on Fish Stock Assessment (WG-FSA).

7.3 The Working Group welcomed the two investigations and encouraged continuation of such studies. However, it noted that the two studies provided only limited information on spatial, seasonal and diurnal differences in fish by-catch. The data were not presented in the standardised manner (i.e., in numbers/weight per tonne/hour) which makes possible comparison between studies, as requested during previous meetings (e.g., SC-CAMLR-XII, Annex 5, paragraphs 7.1 to 7.5; SC-CAMLR-XIII, Annex 4, paragraphs 5.6 and 5.10) and in the *Scientific Observers Manual*. Dr S. Kawaguchi (Japan) informed the Working Group that there is evidence from the study presented in WG-EMM-95/56 that the level of by-catch of mesopelagic fish is higher during the night. The possibility that WG-FSA could provide additional information on periods and areas at which early life stages of fish are at risk from the krill fishery was considered to be remote at present, given the limited

information on patterns of spatial, seasonal and diurnal distribution and abundance of larval and juvenile fish.

7.4 The Working Group reiterated requests from previous years by the Scientific Committee and its Working Groups and encouraged Members to conduct more extensive studies on this matter to cover spatial, seasonal and diurnal differences in the occurrence of fish in krill catches to assess when fish are most vulnerable to the krill fishery. It also stated that appropriate statistical procedures be applied to the analysis of such data. Results should be presented in a standardised manner as agreed by the Scientific Committee to facilitate assessment by the Working Groups.

Interactions Amongst Harvested Species, Dependent Species and the Environment

7.5 When reviewing new tabled information on interactions between harvested species and dependent species, and between both of these and the environment, it was clear to the Working Group that the three were inextricably linked. Accordingly, discussions on Agenda Subitems 7(ii) and 7(iv) were combined. The relevant material is in Sections 4, 5 and 6 of this report. To avoid excessive duplication, only a brief summary is given of material already described in those sections, along with appropriate references.

7.6 An initial review of the available material indicated that there was new information available to this meeting on a number of interactions. Discussion on these is grouped under corresponding headings.

Links Between Sea-ice, Krill Abundance and Penguin Breeding Success and Abundance (see paragraphs 5.78, 5.85, 5.119 and 5.120)

7.7 Papers WG-EMM-95/62, 63 and 64 presented analyses that suggested that the reduction in the frequency of winters with extensive pack-ice has resulted in a decrease in krill recruitment and thus biomass in the region. This, in turn, has led to changes in the survival, recruitment and population size of Adélie penguins. All penguin data in the Antarctic Peninsula region indicate that there was better breeding success but decreased breeding population size in the 1994/95 season compared with the 1993/94 season.

7.8 In relation to the latter point, Mr Ichii commented that it was more likely that breeding success was directly related to krill availability at breeding time than was breeding population size. Dr Croxall agreed, stating that breeding population size was likely to integrate krill availability over winter and, in terms of penguin recruitment, probably over several years.

7.9 The Working Group agreed that this work was of particular significance, and it recalled its recommendation (paragraph 5.120) that appropriate additional time series of krill length frequencies from predator stomachs be analysed, along with other relevant demographic data from penguins. On the basis of this work, it should be possible to both make and test predictions based on the hypotheses proposed for environment/harvested species/dependent species interactions.

Penguin Chick Starvation at Béchervaise Island
Linked to Local Food Shortage
(see paragraphs 5.79 and 5.80)

7.10 At Béchervaise Island and surrounding islands, all penguin chicks had died soon after hatching, with evidence suggesting that starvation was the principal cause (see WG-EMM-95/33). Longer foraging trips were also recorded, with birds returning with little or no food. The extent of food scarcity appeared to be limited, since birds at colonies between 50 and 150 km to the west appeared not to be affected.

7.11 It was noted that this major apparent interaction between krill availability and fledgling survival occurred despite there having been no krill fishing in the region over the last five years. That there can be such extreme variations in local krill availability and subsequent effects on dependent species in the absence of fishing has important implications for the interpretation of any apparent effects in areas where there has been fishing activity.

Krill Flux and Other Determinants of Local Krill Abundance
(see paragraphs 4.24 and 4.25)

7.12 Paper WG-EMM-95/58 presented evidence demonstrating the importance of frontal zones to the krill flux process in the coastal areas to the north of Elephant Island. Oceanic currents seem also to be implicated in the transport of krill from the South Shetlands to the South Orkneys and South Georgia.

7.13 Dr Trivelpiece noted that comparisons of krill length frequency distributions in penguin diet samples from Palmer Station (Bellingshausen Sea) and Admiralty Bay (South Shetland Islands) indicated the krill populations of these two regions had different age structures within years (WG-EMM-95/64). The comparisons suggest only slow interchange between the Bellingshausen Sea and the South Shetland Island krill populations. Dr Everson noted that the movement of krill is not necessarily directly along the Antarctic Peninsula; there may be some areas within which they are retained. These differences were linked to a one-year time lag in pack-ice cycles between the areas.

7.14 Dr Naganobu queried whether DNA analyses might be used to determine whether krill concentrations in different areas came from the same stocks. Several members commented that in other bodies (e.g., the IWC), considerable progress had been made in studying stock structure and migration using these techniques.

7.15 Dr Nicol commented that DNA techniques had been tried previously with krill, but DNA samples proved very difficult to extract. Given the rapid advances in this field, he agreed that it may be worthwhile trying again.

Patterns of Breeding Success and Breeding Population Size at Bird Island
and Signy Island Linked to Krill and Different Environmental Factors
(see paragraphs 4.28, 5.81 and 5.82)

7.16 The 1994/95 season at Bird Island appeared to be one of normal krill availability, corresponding to indices of good reproductive success in gentoo and macaroni penguins and Antarctic fur seals. This contrasts with the 1993/94 season, characterised by very poor krill availability and corresponding reproductive success. The reduced breeding population size of gentoo penguins and Antarctic fur seals at Bird Island in 1994/95 was attributed to events connected with the low reproductive success in 1993/94. Similar, but less pronounced, patterns have been observed at Signy Island, but this might also involve a more direct effect of variation in prey availability influenced by sea-ice conditions in the Antarctic Peninsula region (i.e., a stronger sea-ice-prey link than at Bird Island).

7.17 The hypotheses suggested for Signy and Bird Islands are very important for three reasons. They suggest (i) that the effects on predators can carry over from one year to the next; (ii) that at different sites there can be different functional relationships; (iii) that there can be time lags in the prey response to the environment. All three of these points suggest that interactions between the environment, harvested and dependent species can be very complex, and can occur with different time lags.

7.18 It was noted that there was additional evidence, arising from the low proportion of krill in the diet of icefish, that the 1993/94 season at South Georgia was a very poor one (Kock et al., 1994¹³).

7.19 One difficulty in interpreting the linkage between breeding success, breeding population size and krill availability was that the latest season for which predator data are available and that for which estimates of krill abundance are available are different. This is a problem for a number of subareas.

Low Albatross Breeding Population Size Linked to Snowfall
(see paragraph 5.83)

7.20 The numbers of black-browed albatross breeding at South Georgia in 1994/95 was reduced due to a late and heavy snowfall preventing nesting.

7.21 Several members commented that this provided a striking example of a strong environment/dependent species link having a major effect on a dependent species in an area where fishing was taking place. Had for some reason the environmental event not been noticed, the reduced population size could well have been attributed, at least in part, to fishing.

7.22 Dr de la Mare commented that several of the examples of linkages described above emphasise the high degree of variability intrinsic in the system, even in the absence of fishing, and especially at the local scale. The examples also highlighted the potential complexity of the various interactions and the probable presence of time lags in responses. This highlights the need, where possible, to be able to calculate predator-based indices so that they really do reflect the effects of changes in the abundance and availability of krill.

New Models Relevant to Harvested Species/Dependent Species Interactions
(see paragraphs 5.104 to 5.118)

7.23 Three papers were presented that developed new models relevant to the interactions between dependent species and harvested species. Paper WG-EMM-95/39 modelled functional relationships between krill and black-browed albatrosses and Antarctic fur seals. Paper WG-EMM-

¹³ Kock, K.-H., I. Everson, L. Allcock, G. Parkes, U. Harm, C. Goss, H. Daly, Z. Cielniaszek and J. Szlakowski. 1994. The diet composition and feeding intensity of mackerel icefish (*Champsocephalus gunnari*) at South Georgia in January/February 1994. Document WG-FSA-94/15. CCAMLR, Hobart, Australia.

95/42 undertook a similar task for Adélie penguins, while WG-EMM-95/40 addressed the issue of age-dependent mortality in krill by analysing krill length frequencies from predator stomach samples.

7.24 The principles of, and requirements for further work on, the models developed in these papers were discussed in detail under Agenda Subitem 5(v) (paragraphs 5.87 to 5.126) and no further comment will be given here.

Krill Fishery/Dependent Species Interactions

7.25 The Data Manager has provided further data on the overlap between the location of krill fishing and predator CPD. These are given in WG-EMM-95/41. The CPD is taken to be a distance of 100 km from the breeding site over the principal breeding period December to March. These results are discussed under paragraphs 5.88 to 5.91.

7.26 It was recognised that the CPD would be species-dependent, and several members commented that it may be useful to review this matter (paragraph 7.96). Even ignoring species-dependent effects, differing views were expressed as to whether application of the concept of CPD under- or overestimates the extent of overlap between predators and krill fishing (see also paragraphs 5.92 to 5.94).

7.27 In any case, there remains a major problem in that the relationship between overall krill abundance within the CPD and the actual krill availability to predators in that region is complex. There are still few data on this. It is very important that more empirical studies are undertaken.

7.28 Research has continued on assessing the potential overlap between predators and the fishery in the vicinity of Seal Island (WG-EMM-95/87). It was found that krill were in higher densities over the shelf areas than in offshore areas, where acoustic surveys showed that fish (mainly myctophids) were at high density and available at night within predator foraging ranges. See paragraphs 5.98 and 5.99 for further discussion.

7.29 Mr Ichii commented that the results of this research called into question the standard assumption that there is a tight relationship between krill and predators. It may well be that predators will switch prey species from krill to myctophids when the density of krill is low. If so, then low krill abundance does not necessarily lead to deleterious effects on predators.

7.30 Dr Croxall responded by noting that this assumption is based on many years of dietary data. Furthermore:

- (i) paper WG-EMM-95/87 contains no data on diets of predators, so consumption of myctophids, let alone prey-switching, is purely inferential;
- (ii) the extensive series of published and CEMP data on the diet of chinstrap penguins in Subareas 48.1 and 48.2 have never recorded myctophids at more than 10% by mass of diet;
- (iii) changes in predator diet in years of low krill availability are, however, documented to occur in some predators at South Georgia (gentoo penguins take more icefish and *Notothenia* species, macaroni penguins more *Themisto*) but not in others (e.g., Antarctic fur seal, black-browed albatross). None of the prey-switching of these krill-dependent predator species involves myctophids - and this in a subarea where most myctophid fishing in the Convention Area has taken place; and
- (iv) more work on predator diet in Subareas 48.1 and 48.2 is to be encouraged because substantial time series of quantitative data are needed to demonstrate the extent to which predators depend on krill.

7.31 In response to a question concerning acoustic discrimination of fish and krill targets, the importance of using multifrequency acoustic methods was emphasised. While it is possible to reliably distinguish krill and myctophid targets during the day (when they are well separated in their depth ranges), this becomes difficult at night even using such techniques.

7.32 Paper WG-EMM-95/23 reports studies of the variability of the spatial structure of krill swarms using data from foraging time budgets of fur seals (see also paragraphs 5.121 and 5.122). The main assumption in this work is that the predator foraging behaviour reflects the spatial structure of the prey. The results suggest that seals forage at the scale of individual krill swarms and also at the scale of groups of swarms (aggregations). The methods in WG-EMM-95/23 may be useful for studying and interpreting functional relationships between predators and krill, and between krill abundance and availability to predators.

7.33 Dr Miller agreed that this study had important implications for how spatial information might be used to obtain a proper index of availability, and for the scale at which predator/prey studies should be conducted in the field.

7.34 Mr Ichii observed that the paper seemed to make the assumption that the principal prey species was krill, even in a poor krill year, and he referred to information from Seal Island reported in WG-EMM-95/87. In response, Dr Boyd commented that at South Georgia, concurrent diet studies had been undertaken and these had shown that the principal species in the diet was indeed krill, even in the poor krill year, as reported in WG-EMM-95/28. This emphasised, in his view, how essential it was to undertake simultaneous studies of diet and at-sea feeding ecology and behaviour.

Approaches to Integration of Harvested Species/Dependent Species/Environment Interactions into Management Advice

7.35 This subitem was discussed under three main headings: strategic modelling; accounting for land-based predators when setting precautionary catch limits; and ecosystem assessment.

Strategic Modelling

7.36 Figure 1 gives a schematic diagram of the components and linkages that together make up the processes involved in ecosystem monitoring and management in the Antarctic. The primary components of the exploited ecosystem are the environment, harvested species, dependent species and the fisheries. The system as a whole is completed by a link between these components and management approaches. The ecosystem assessment is conducted using information on the non-management components and linkages between them.

7.37 As indicated in Section 2, a vital tool in evaluating the procedures involved in an ecosystem assessment and in any system of providing management advice is strategic modelling. The strategic model incorporates the biological and fishery components, the links between them, and the procedures for ecosystem assessment and for the provision of management advice and the resulting management actions.

7.38 The term ‘strategic’ in the phrase ‘strategic modelling’ has been used to describe a number of different things. For the purposes of this report, strategic modelling is distinguished by:

- (i) explicit consideration of uncertainties in (a) parameter values and (b) the underlying dynamic processes operating in both the components of the system being modelled and the linkages between them; and

- (ii) its primary purpose, which is to allow evaluation of the efficacy of the principal output (management advice) from the procedure being studied (here, ecosystem assessment or ecosystem management). This evaluation should enable identification of the uncertainties in the system that contribute most to inadequate performance in the output, thereby identifying requirements for information which will lead to the greatest improvement in performance.

7.39 In the papers that have so far been presented to the Working Group and its predecessors, no strategic model of the overall system has been attempted. Most progress has been made in a model of a subsystem that links the fishery, the harvested species (krill) and management. This is the so-called krill yield model (Butterworth et al., 1994¹⁴). Previously this model has mainly been discussed by WG-Krill. As this Working Group has merged the former WG-CEMP and WG-Krill, it was felt useful for an initial presentation to be made by Prof. Butterworth of the principles behind the extensions to the krill yield model designed to allow estimation of functional relationships between harvested and dependent species. These were described in papers WG-EMM-95/39 and 40 by Thomson and Butterworth (see also Butterworth and Thomson, 1995¹⁵).

7.40 The presentation and subsequent discussion led to a much greater understanding within the Working Group of the models, their assumptions and their properties. A number of important points emerged.

- (i) The models have several key assumptions. These are:
 - (a) the probability distribution of unexploited krill abundance is time invariant. This does not mean that the unexploited krill abundance is constant over time; rather that the annual krill abundances are sampled from the same probability distribution; and
 - (b) changing krill abundance affects predator fecundity and survival, but not vice versa.
- (ii) A clear distinction has to be made between the density of the krill available within the foraging range of a predator and the extent to which it is actually available to the

¹⁴ Butterworth, D.S., G.R. Gluckman, R.B. Thomson, S. Chalis, K. Hiramatsu and D.J. Agnew. 1994. Further computations of the consequences of setting the annual krill catch limit to a fixed fraction of the estimate of krill biomass from a survey. *CCAMLR Science*, Vol. 1: 81-106.

¹⁵ Butterworth, D.S. and R.B. Thomson. 1995. Possible effects of different levels of krill fishing on predators - some initial modelling attempts. *CCAMLR Science*, Vol. 2: (in press).

predator for consumption. This can vary widely between dependent species, sites and seasons.

- (iii) As described more fully in paragraphs 4.39 to 4.57, provided the assumption in subparagraph (i)(a) above is satisfied, the models take full account of the known extent of variability in krill recruitment by explicitly using existing krill recruitment estimates. Currently, the link between the environment and krill recruitment is modelled using an empirical probability distribution. Should an explanatory relationship for krill recruitment be established subsequently, e.g. using sea-ice data, this could be incorporated.
- (iv) A potential weakness in the models is that, while they operate properly at a regional or krill stock-unit scale, of necessity some of the input data (time series of predator survival and recruitment indices) were estimated on a much more localised spatial scale. This is a potential weakness, since use of small (local) spatial scale data in a regional scale model involves some degree of extrapolation.
- (v) One apparently simple way around this is to apply the models uniformly at a local spatial scale. Unfortunately, while doing so apparently resolves the scale problem with the recruitment or predator survival estimates, it introduces probably greater problems because of lack of closure of the krill population and difficulties in properly defining local krill recruitment.

7.41 Several issues arose in the discussion. These were that: (i) the current model of functional relationships between krill harvest and predator response uses only a small part of the predator data which are currently available; (ii) it would be useful to examine the importance of additional precision in several of the input parameters to ensure that attention is given to increasing the precision of measurements that will have the greatest influence on the results of the modelling exercise; and (iii) the scale at which the current model of functional relationships operates is often different to the scale at which predator data are collected.

7.42 Dr Boyd commented that there was an alternative approach, which used foraging and energetics models to treat harvested/dependent species interactions on a purely local scale. He also noted that of all the biological parameters for predators, adult survival rate is one of the most difficult to obtain. This is an important input parameter in the Butterworth-Thomson model. It may be possible to use other predator data, much more widely available than direct estimates of survival rates, in the local scale models being investigated.

7.43 Prof. Butterworth commented that it was possible to use other measures to index predator recruitment and survival rates, but it was necessary to take care to justify the assumed relationships between the indices and the actual rates.

7.44 Dr Boyd further explained that the modelling approach at the local scale should be seen as an alternative to, and not a potential replacement for, the Butterworth-Thomson models. Indeed, there were potential links between the two approaches, since the results from the local models could provide valuable insight and information on the recruitment estimates used in the Butterworth-Thomson model, as well improving knowledge about krill availability.

7.45 The Working Group then attempted to develop further the conceptual framework of the processes contained in Figure 1, and to identify those components and linkages for which models were either currently available or being developed. These are shown in Figures 3 and 4. In view of the importance attached to the scale on which the models operated, separate figures are shown for the models at local and regional scales.

7.46 Figure 3 shows a framework of system processes within which the Working Group discussed the development of a strategic model. Each link in the figure is associated with text describing the type of link. The Working Group emphasised the difference between the two important environment/system links. In the first, the direct effects of environment on the dependent species were of interest, for instance the presence of snow delaying the onset of egg laying, mortality of chicks in very high winds, or the inability of predators to forage because of problems of access to open water. The other environment link, to harvested species, primarily acts by influencing the recruitment of prey or the distribution and availability of prey.

7.47 Figure 4 shows the models that are available for describing certain components and links. For the environmental component there are a number of models (for instance the calculation of geostrophic current velocities and the FRAM model) that have been developed outside CCAMLR. The krill CPUE model (Butterworth, 1988¹⁶; Mangel, 1988¹⁷), the krill yield model (Butterworth et al., 1994¹⁸), the krill recruitment model (de la Mare, 1994¹⁹), the functional relationships model (Butterworth and Thomson, 1995²⁰), the krill spatial model (Mangel et al., 1994²¹) and the fishery

¹⁶ Butterworth, D.S. 1988. Some aspects of the relation between Antarctic krill abundance and CPUE measures in the Japanese krill fishery. In: *Selected Scientific Papers, 1988 (SC-CAMLR-SSP/5)*, Part I. CCAMLR, Hobart, Australia: 109-125.

¹⁷ Mangel, M. 1988. Analysis and modelling of the Soviet Southern Ocean krill fleet. In: *Selected Scientific Papers, 1988 (SC-CAMLR-SSP/5)*, Part I. CCAMLR, Hobart, Australia: 127-235.

¹⁸ Butterworth, D.S. et al., op. cit., p. 173.

¹⁹ de la Mare, W.K. 1994. Modelling krill recruitment. *CCAMLR Science*, Vol. 1: 49-54.

²⁰ Butterworth, D.S. and R.B. Thomson, op. cit., p. 174.

behaviour model (Agnew and Marín, 1994²²; Agnew, 1994²³) have all been developed within CCAMLR and address a number of components and links. Further dependent species models are also appropriate, for instance the model of dependent species energetics (Croxall et al., 1985²⁴) which was developed further for CCAMLR in 1991 (Croxall, 1991²⁵) and the crabeater seal energetics model (Bengtson et al., 1992²⁶). Although there are many different scales on which this exercise could be done, the figure is separated into local (within a subarea) and regional (statistical area based) spatial scales, and areas where additional work is required are highlighted.

7.48 In constructing Figure 3 the Working Group paid particular attention to the weights of the arrows (links) between components. It was felt that at both scales, the influence of environment on the fishery and of the fishery on dependent species was low. It was agreed that the influence of the fishery on harvested species was potentially large, while the influence of harvested species on dependent species was large by definition. It was felt that while the availability of harvested species, for instance, had some effect on the fishery, this was not a link of sufficient concern to be given a heavy arrow.

7.49 Because this exercise was done to highlight the strategic modelling, one important link is missing in these diagrams, that between the fishery and management (see Figure 1). It was noted that a model of primary importance to this link is the krill yield model. In Figure 4 this model is represented at the regional level as two components, 'yield model' and 'catch model'. It was recognised that separation of effects into the two scales was not always possible, as for instance where local dependent species dynamics affected the regional populations of those species.

7.50 It is obvious from Figures 3 and 4 that there are components and linkages between them for which no models currently exist. For some linkages, as indicated by the thin lines, this probably is not too much of a problem. However, there are other linkages that are definitely important that have so far received little or no modelling attention.

²¹ Mangel, M., A. Stansfield and S. Rumsey. 1994. Progress report on AMLR project 'A modelling study of the population biology of krill, seabirds and marine mammals in the Southern Ocean'. Document *WG-CEMP-94/30*. CCAMLR, Hobart, Australia.

²² Agnew, D.J. and V.H. Marín. 1994. Preliminary model of krill fishery behaviour in Subarea 48.1. *CCAMLR Science*, Vol. 1: 71-79.

²³ Agnew, D.J. 1994. Further development of a krill fishery simulation model. Document *WG-Joint-94/4*. CCAMLR, Hobart, Australia.

²⁴ Croxall, J.P., P.A. Prince and C. Ricketts. 1985. Relationships between prey life-cycles and the extent, nature and timing of seal and seabird predation in the Scotia Sea. In: Siegfried, W.R., P.R. Condy and R.M. Laws (Eds). *Antarctic Nutrient Cycles and Food Webs*. Springer-Verlag, Berlin Heidelberg: 516-533.

²⁵ Croxall, J.P. 1991. Estimates of prey requirements for krill predators. Document *WG-CEMP-91/37*. CCAMLR, Hobart, Australia.

²⁶ Bengtson, J.L., T.J. Härkönen and P. Boveng. 1992. Preliminary assessment of the data available for estimating the krill requirements of crabeater seals. Document *WG-CEMP-92/25*. CCAMLR, Hobart, Australia.

7.51 A brief discussion on these aspects was initiated and several useful suggestions were made as to how these gaps might be filled, both in terms of models and of the data required to parametrise them.

7.52 For the regional scale models, Dr Miller noted that there was no model of the fishery component. Given that our primary influence on the system was via the fishery, he believed it important that we learn more about what motivates the behaviour of the fishery. At the very least, this implies that we should maintain the current dialogue with the operators of the fishery on their future intentions.

7.53 Following on from this point, it was emphasised that from the point of view of potential management measures, these can apply only to the fishery operations. Understanding the other components and linkages was essential to identifying the knock-on effects of management actions on the various components, but the appearance of these other components and links in the strategic model does not mean that they can be directly affected by management actions.

7.54 As noted in paragraphs 6.12 to 6.16 and 6.26 to 6.30, several papers were tabled at this meeting presenting evidence in support of a conceptual model linking sea-ice cover with local krill recruitment and subsequent impacts on predator populations. This research opens the possibility for the local-scale strategic models (and potentially also for regional strategic models) of developing explanatory sub-models for the link between the environment and harvested species. These sub-models would require the collection of time series of data on sea-ice cover, SST and krill recruitment. Data on the fine-scale distribution of fishing will also allow the link between the fishery and harvested species to be incorporated into these sub-models.

7.55 For local strategic models, other important factors in the linkage between the environment and harvested species are the forces that drive krill flux between areas and that cause variations in krill availability.

7.56 In relation to krill flux, key factors are water circulation, current systems and frontal zones. Collection of data on these is essential for further investigation of this phenomenon. Another oceanographic feature that may lead to retention of krill in a local area is the presence of eddy systems.

7.57 For local-scale models, more reliable evaluation of krill availability and the extent to which it varies over space and time will require further study of krill vertical migration and swarming behaviour and of predator foraging behaviour in relation to this highly aggregated and patchily distributed prey.

7.58 More generally, the linkage between the environment and harvested species requires the elucidation of the factors that determine the distribution and abundance of the prey. The linkage between the environment and dependent species requires the determination of those factors that affect observations on dependent species that may confound interpretation of interactions between dependent and harvested species (see, for example, paragraph 7.21).

7.59 For regional models, more realistic modelling of the dynamics of dependent species requires clarification of sources of density dependence and of the importance of species other than krill in the diets of the predators. For local models, interpretation of the local dynamics of dependent species is greatly enhanced by the availability of time series of local estimates of predator abundance.

7.60 It was observed that, at least conceptually, the regional models apply at roughly the scale of a statistical area, whereas many of the studies relevant to local models applied at the scale of the foraging area. It is possible, therefore, that there may be a need to develop strategic models that applied at a scale intermediate between the local and regional scale (e.g., at the subarea or Integrated Study Region (ISR) scale).

Taking Account of Land-based Predator Populations When Setting Precautionary Catch Limits

7.61 When introducing WG-EMM-95/17, Dr Everson drew attention to the fact that concerns have regularly been expressed about the potential impact of krill fishing on local predator populations over the last 20 years. Despite the considerable amount of research that has been carried out during that period, this has not yet resulted in management advice directed specifically at these concerns. The aim in WG-EMM-95/17 was to seek methods that would closely integrate the activities of the former WG-CEMP and WG-Krill groups and produce management advice designed to meet the aims of Article 2 of the Convention. The main concern was that, at present, a considerable proportion of any statistical area or subarea precautionary limit could, in principle, be taken in or near the foraging areas of dependent land-based predators during the breeding season.

7.62 As outlined in WG-EMM-95/17, land-based predators on South Georgia were estimated in 1987 to consume on average around 10 million tonnes of krill annually. This implies that at least that amount of krill must pass through South Georgian waters each year, though in practice there must be much more, since account needs also to be taken of the consumption by pelagic predators and of the need to maintain sufficient krill production to support the stock in subsequent seasons. The paper suggested that if a precautionary catch limit was set for an area around South Georgia corresponding to the foraging range of the predators at 10% of the estimated annual land-based predator consumption, then the aims of Article 2 would be met for these predators.

7.63 The factor of 10% was essentially an arbitrary figure representing only a small proportion of the predator food consumption. In WG-EMM-95/17, illustrative areas in which this precautionary catch limit might apply extended to around 125 km from the coastline. Additional limitations were proposed on the timing of catches throughout the year corresponding to the CPDs for the predators.

7.64 The methodology proposed for calculating local precautionary catch limits was illustrated for South Georgia, because all the required information on predator consumption was available for that island. However, the method could be used for other areas, provided the information required could be supplied or collected. It was also noted that further strategic modelling could lead in time to a more biologically realistic implementation of this approach.

7.65 The Working Group had an extended discussion of this paper. The main points that arose are described below.

7.66 Prof. Butterworth welcomed the intent of the paper, but commented that the appropriateness of the proposed 10% factor depended critically on the flux of krill through the waters of South Georgia. If the flux was low, then indeed fishing could cause local depletion and thereby affect predators. However, if the flux was high, then it was unlikely that land-based predators would be affected. He proceeded to illustrate, using results from a mathematical model (Appendix G), that the 10% factor could be too conservative if the flux were sufficiently high.

7.67 Dr de la Mare preferred that, where possible, the existing method based on a proportion of standing stock should be used, but there may be some circumstances where an approach of the kind given in WG-EMM-95/17 would be more practical. He subsequently proposed a modified method for using predator consumption data and estimates of krill flux that would allow an estimate of the instantaneous standing stock around South Georgia to be calculated. This could then be used as input to the existing krill yield model.

7.68 In relation to both these alternative approaches, Dr Boyd observed that predator food consumption was one of the variables that can be estimated with quite high precision. He noted, however, that existing data on krill densities suggested that the turnover of krill around South Georgia could be quite variable both within and between years and over space. It was important that this variability be taken into account in any calculations, rather than just using an average figure. Dr Trivelpiece also emphasised the need to take full account of the distribution and variability of krill recruitment.

7.69 Dr de la Mare commented that, provided the levels of variation in these variables can be quantified, as described in paragraph 4.48, they could be specifically accounted for using the

approach of the krill yield model. He noted further, however, that research directed at obtaining the necessary information about levels and variability of krill flux could be very difficult, perhaps exceeding the difficulty of directly obtaining an estimate of the krill standing stock around South Georgia.

7.70 It was suggested that, in view of the krill flux between Subareas 48.1, 48.2 and 48.3, account needed to be taken of krill biomass and catches in Subareas 48.1 and 48.2 when determining precautionary limits for Subarea 48.3. In such circumstances, it may be necessary to apply a pro rata (percentage-based) system for the allocation of local precautionary limits amongst these areas.

7.71 Dr Naganobu thought that the method proposed in WG-EMM-95/17 had potential, but he foresaw problems in applying it as it presently stood. In particular, he queried the extent to which the method could be used in other areas, such as Subareas 48.1 and 48.2, which are characterised by heavy winter sea-ice and much lower predator populations than Subarea 48.3. He also queried how changes in predator populations that occurred for reasons other than fishing would be taken into account. For instance, if the predator populations (and thus consumption) at South Georgia halved or doubled in a year, would the corresponding precautionary limits halve or double respectively?

7.72 Mr Ichii raised the issue of whether predator populations were food- or breeding-site limited. If they were food-limited, then an approach based on food consumption may be appropriate, but if they were breeding-site limited, then the food consumption may not be relevant at all.

7.73 Dr Croxall responded that evaluations of most of the main krill-dependent predator species breeding at South Georgia had provided no evidence at present that populations were limited by availability of breeding habitat.

7.74 Mr Ichii suggested that a precautionary catch limit could be unrealistically low if it was based on food consumption by predators whose population sizes are limited by food abundance during the period when food abundance is very low.

7.75 Dr Croxall further commented that, given the difficulties experienced by CCAMLR in suggesting other kinds of precautionary measures in local areas (e.g., closed seasons, closed areas etc. in Subareas 48.1 and 48.2, see WG-EMM-95/17), it appears that the only remaining kind of measure available for use in these situations is a limitation on catches based, in some way, on the food requirements of predators.

7.76 With a view to putting the approach suggested in WG-EMM-95/17 in context with other approaches to determining precautionary limits, Dr Hewitt drew attention to the tradeoff matrix given in Watters and Hewitt, 1992²⁷. This rated possible approaches by the likely delay in their implementation and the extent to which they used existing biological data. The ideal was an approach that had a low delay in implementation but made high use of the biological data. In that paper, no approach fitted that description. It is possible that the approach in WG-EMM-95/17 or a development of it may achieve that goal.

7.77 In summary, all members agreed that:

- (i) there was a continuing need to ensure that krill catches are not concentrated in small areas and over short periods of time to such an extent that local populations of dependent species may be adversely affected;
- (ii) when determining precautionary catch limits and subdividing precautionary limits set for larger areas, as much environmental and biological information as relevant should be used; and
- (iii) the approach described in WG-EMM-95/17, which makes use of extensive predator food consumption data, represents a valuable new thrust towards achieving these goals.

7.78 In view of the points raised during the discussions, however, it was agreed that it would not be appropriate to attempt to develop recommendations for precautionary catch limits using this approach at this meeting.

7.79 The remaining discussion focused on identifying further work to be carried out intersessionally so that the topic could be discussed further at next year's meeting.

7.80 A small subgroup was asked to develop further the ideas described by Prof. Butterworth and Dr de la Mare, in order to identify more clearly the work needed to be done. The subgroup developed the plan of work given in Appendix H to investigate precautionary catch limits in time for the next meeting of the Working Group. A steering group consisting of Drs Agnew, Boyd, Prof. Butterworth, Drs Croxall, de la Mare, Everson, Holt and Naganobu and coordinated by Drs Boyd and Everson was appointed.

²⁷ Watters, G. and R.P. Hewitt. 1992. Alternative methods for determining subarea or local area catch limits for krill in Statistical Area 48. In: *Selected Scientific Papers, 1992 (SC-CAMLR-SSP/9)*. CCAMLR, Hobart, Australia: 237-249.

Ecosystem Assessment

7.81 As indicated in paragraph 2.13 in this report, the Working Group has agreed that an ecosystem assessment consisted of two parts:

- (i) an analysis of the status of key biotic components of the ecosystem; and
- (ii) a prediction of the likely consequences of alternative management actions on the future status of these components.

7.82 In working towards this end, Section 4 of this report summarises the current knowledge on the status of the krill populations and the krill fishery. It also examines knowledge of the interactions between harvested and dependent species from the harvested species perspective.

7.83 Section 5 summarises knowledge on the status of dependent species, and on their interactions with harvested species from the dependent species perspective.

7.84 Section 6 examines current knowledge on interactions between dependent and harvested species and the environment.

7.85 This information on interactions (linkages) amongst harvested species and fisheries, dependent species and the environment was further integrated in the discussions on linkages reported in paragraphs 7.5 to 7.20.

7.86 The information in these four sections of the report formed the basis for discussions on an ecosystem assessment. The relevance of the information to the ecosystem components and links identified in Figure 1 is shown in Figure 2.

7.87 The Working Group first noted that Sections 4 and 5 provided substantial information on the current status of both harvested and dependent species and of linkages between them. As a starting point for further discussions, the Working Group then turned to the summary tables (Tables 3.1 to 3.10), which are similar to those previously used by WG-CEMP for dependent species only (see paragraph 2.18).

7.88 For dependent species, only the information in the solid boxes, which has been collected and analysed by the standard methods developed by WG-CEMP, is in the official CCAMLR database. For these parameters, additional quantitative information and analyses are reported in WG-EMM-95/12 to 14. The remaining information on dependent species has been extracted from tabled papers. These

data are not in the CCAMLR database and while they have generally been collected using standard methods, it has not been possible to undertake similar analyses of the data in the source papers.

7.89 Shortage of available time at the meeting had prevented completion of the sections of Tables 3.1 to 3.10 dealing with data from the fishery and on environmental variables. A further difficulty facing the Working Group was the qualitative nature of the interpretation of trends. As noted above, while considerable progress has been made during the intersessional period in providing a quantitative assessment of the standard CEMP data, this has not been possible for the remaining data in the tables.

7.90 As a consequence, a number of members expressed the view that it remained very difficult to use the information in these tables to develop an ecosystem assessment. In particular, it was noted that qualitative indices are not necessarily accurate, and they can also disguise trends that would be apparent from quantitative data.

7.91 While acknowledging these points, Dr Hewitt felt that there were some interesting observations that could be made. Referring to the information in paragraphs 4.15 to 4.32, 5.81 to 5.83 and Tables 3.5 to 3.7, it was clear that 1994 was an unusual year at South Georgia, South Shetlands and the Antarctic Peninsula. The abundance of krill was very low in all three subareas in 1994. Predator responses to low krill availability were seen in all three areas, but these were more noticeable at South Georgia than in the Antarctic Peninsula. The reason for this is unknown, but one hypothesis was that it was because South Georgia was downstream of the other areas. In 1995, an estimate of krill abundance was only available for Elephant Island, where it was again low, but the predator breeding success was greater than in 1994.

7.92 In the context of the need, expressed in Part 2 of the description of an ecosystem assessment, to provide predictions of the consequences of alternative management actions (see paragraph 2.13), the Working Group agreed that the current absence of evidence that low krill abundances and subsequent effects on predators were due to krill fishing (i.e., the absence of 'Type I' error) was not alone sufficient to conclude that current levels of catches are not affecting dependent species. This is because the data available do not allow a test of sufficient power to detect such an effect (i.e., the possibility of 'Type II' errors needs to be considered). The Working Group took note of the importance of investigating which information had the greatest potential to enhance the power of tests for such effects, as an aid to the focus of future research.

7.93 Dr Croxall indicated that it was not possible to examine the full 17-year suite of submitted data for South Georgia at the WG-EMM meeting. These data suggest that the incidence of years of low krill availability to predators at South Georgia has been greater in the last decade than in the

1970s and early 1980s. There is no indication that this is due to the fishery, but in order for the fishery not to exacerbate the situation for krill-dependent predator species, there may be a need for the adoption of precautionary measures.

7.94 Discussion then turned to what needed to be done to improve the usefulness of the information in the tables and of their presentation, in terms of an ecosystem assessment.

7.95 The key requirement is to collate time series of quantitative data on both dependent and harvested species that are comparable across years and areas. This has now been done for the standard CEMP data on dependent species, but further re-analysis needs to be done of other data to ensure the necessary comparability.

7.96 The Working Group agreed that the following steps needed to be taken urgently:

- (i) request holders of existing data that have been collected using standard protocols to submit time series of such data for inclusion on the CCAMLR database;
- (ii) for any data submitted in the future, appropriate quantitative assessments should be undertaken, or where this is not possible, they should be assessed qualitatively in a consistent fashion;
- (iii) for existing CEMP time series data, new tables should be produced, as advised by the ad hoc statistics subgroup;
- (iv) development of new methods and standard approaches for examining linkages between dependent species, harvested species and the environment;
- (v) further development of methods appropriate for conducting an ecosystem assessment; and
- (vi) intersessional circulation of the existing table of spatio-temporal scales relevant to all existing parameters of dependent species monitored within CEMP for revision in time for the next meeting. This revision should also include specification of spatial and temporal scales appropriate for potential new monitoring parameters. This exercise may also contribute to possible revisions of CPDs.

7.97 It is essential that progress be made intersessionally on each of these topics, and discussed further at the next meeting on ecosystem assessment.

7.98 Two ad hoc intersessional subgroups already exist to address such issues: one on statistics and one on methods. The Working Group recommends that the membership, convenership and terms of reference of these two subgroups be reviewed. In particular, the Subgroup on Statistics should be expanded to include members with expertise in harvested species and the environment.

7.99 There is a clear need for a meeting of a reconstituted Subgroup on Statistics to meet intersessionally. For the Subgroup on Monitoring Methods, at the very least its intersessional work needs to be more formalised, and it may also be necessary for that subgroup to meet, rather than work by correspondence.

Consideration of Management Measures

7.100 There are currently two conservation measures which address harvesting for krill in the Convention Area: Conservation Measure 32/X which sets a precautionary catch limit of 1.5 million tonnes in Area 48 in any one season; and Conservation Measure 45/XI which sets a precautionary catch limit of 390 000 tonnes in Division 58.4.2 in any one season. Conservation Measure 46/XI, which allocated the 1.5 million tonnes to subareas within Area 48, lapsed at the end of the 1993/94 season and was not replaced.

7.101 At SC-CAMLR-XIII, there was some uncertainty surrounding the use of the 1981 FIBEX survey results as an estimate of B_0 . In particular, SC-CAMLR-XIII paragraph 5.40 suggested that:

- the survey was old and therefore of no practical use; and
- that it was possible that it could have been taken in a year when the krill biomass was high.

The Working Group addressed these points in paragraphs 4.39 to 4.41, and concluded that they had no effect on the calculation of potential yield using the model developed by WG-Krill. The Working Group therefore re-affirmed the advice of WG-Krill in 1994, that the current best estimate of B_0 is 35.4 million tonnes for Area 48 and 3.9 million tonnes for Division 58.4.2.

7.102 At its meeting in 1994, the Scientific Committee had extensive discussions on the calculation of precautionary catch limit in Area 48. Two basic views were expressed. One was that a revised precautionary catch limit of 4.1 million tonnes, calculated by multiplying the most recent estimate of γ (0.116) by the unexploited biomass of 35.4 million tonnes estimated from the FIBEX survey should be applied. An alternative view was that there was no need to revise the overall precautionary limit of 1.5 million tonnes (SC-CAMLR-XIII, paragraphs 5.31 to 5.45). The Commission has urged the

Scientific Committee to continue work on providing estimates of potential yield for all areas (CCAMLR-XIII, paragraph 8.6).

7.103 The Working Group investigated a number of refinements to the calculation of a precautionary catch limit (paragraphs 4.42 to 4.47). Investigations of the effect of increased variance in the estimate of B_0 on the results of the yield model (paragraphs 4.48 to 4.56) confirmed that the appropriate value of γ (in the equation $\text{Yield} = \gamma B_0$) in the absence of any additional information was 0.116. This is identical to that calculated previously by WG-Krill (SC-CAMLR-XIII, paragraphs 5.27 to 5.30).

7.104 For Division 58.4.2, no further data are available which could refine this value of γ . The Working Group therefore advised that the current best estimate of a catch limit in Division 58.4.2 is 450 000 tonnes (B_0 of 3.9 million tonnes combined with a γ of 0.116).

7.105 Data on recruitment which could be used to refine the yield model are available for Area 48. The Working Group agreed that the analyses suggested in paragraphs 4.46 to 4.48, which would incorporate these data, should be performed prior to the next meeting of WG-EMM. This analysis is expected to refine the values used to calculate a precautionary catch limit for Area 48. Accordingly, advice on a precautionary catch limit in Area 48 was postponed until the next meeting of WG-EMM.

7.106 Concerning the subdivision of precautionary catch within Area 48, the Working Group could not offer any further advice until the results of analyses described in paragraphs 4.46 to 4.48 and 7.80 had been examined. The Working Group expected that this would be done at its next meeting.

Extension of the Scope of CEMP

7.107 Last year, in considering the topic of the desirability of expanding CEMP beyond its exclusive focus on the krill-based system (SC-CAMLR-XIII, paragraph 6.34) the Scientific Committee requested Working Groups to consider the topic of appropriate research and monitoring activities on selected predators of certain fish species (SC-CAMLR-XIII, paragraph 6.40).

7.108 *P. antarcticum* has been a CEMP selected species since the start of the program in 1985. However, no proposals for monitoring studies or methods have been brought forward, although several papers on this species as prey have been tabled.

7.109 WG-EMM noted that in these circumstances it seemed inappropriate to propose any coordinated directed research and/or related CEMP monitoring activities on this species.

7.110 However, it was noted that, as was the case last year (SC-CAMLR-XIII, paragraph 6.35(iii)), several Members have programs which include research on predators that regularly eat *P. antarcticum*. Australian research indicates that Adélie penguins breeding at Béchervaise Island (Division 58.4.2) feed on *P. antarcticum* in areas where small-scale commercial harvesting took place in the past. The main foraging range of Adélie penguins, however, is in areas where fishing is known to be difficult due to sea-ice or bottom topography.

7.111 In the Ross Sea, *P. antarcticum* is particularly important in the diet of seals and penguins and is therefore a key component in the local food web. The current enhanced CEMP-related research activity in that area suggests increased opportunities for research on *P. antarcticum* and its trophic interactions.

7.112 The Working Group therefore suggested that Members currently conducting research on *P. antarcticum* should consolidate and review information on this species and its interactions relevant to CEMP and WG-EMM and seek to coordinate this research where feasible. WG-FSA was asked to contribute to this process.

7.113 In reviewing other fish predator/prey interactions, the Working Group recollected information provided in previous years and took particular note of the earlier discussions, summarised in paragraphs 5.127 to 5.135.

7.114 The interactions between Antarctic fur seals and *C. gunnari* at South Georgia (Subarea 48.3) were obviously of substantial potential significance to the management of the *C. gunnari* fishery. The attention of WG-FSA was drawn to the new data now available from predators relevant to this topic and to the importance of the cooperative evaluation of these data by predator and fish biologists.

7.115 Quantitative research on the role of blue-eyed shags as consumers of coastal fish species in Subareas 48.1 and 48.2 had shown that (i) shags consume juveniles of a range of previously-harvested fish species, and (ii) the relative abundance of fish species in shag diets and in net samples is similar. Interactions between shags and certain fish species are thus likely to be of interest to WG-FSA; WG-EMM felt that WG-FSA should consider the proposal for using shags to monitor coastal fish populations (WG-EMM-95/84).

7.116 Research within the Convention Area on predator/prey interactions involving myctophids has increased substantially in recent years. Studies, often conducted year round, of the diet and feeding ecology of king penguins by Sweden at South Georgia (Subarea 48.3), South Africa at Marion

Island (Subarea 58.7), France at Crozet Islands (Subarea 58.6) and Australia at Heard (Division 58.5.2) and Macquarie Islands (adjacent to the Convention Area) have all shown that this species (whose populations are increasing at almost all breeding sites) depends on myctophids (>90% by mass of diet in summer and rarely less than 75% by mass in any winter month). The attention of WG-FSA was drawn to the considerable potential for using coordinated research on diet and feeding ecology of king penguins to monitor the relative abundance of myctophid species and overall changes in myctophid populations.

7.117 Other predators known to consume significant quantities of myctophids include black-browed albatrosses (unpublished UK data) and white-chinned petrels (WG-CEMP-94/14) at South Georgia. Antarctic fur seals at South Georgia also take small quantities of myctophids in February/March (WG-EMM-95/28). Quantitative data on the consumption of myctophids by predators outside Subarea 48.3 are very scarce. There are suggestions, however, that myctophids could sometimes be important in trophic interactions in Subarea 48.1 (WG-EMM-95/87) and further research is encouraged.

7.118 Overall, WG-EMM recommended that the Scientific Committee should discuss interactions between fish and their predators, and especially those between predators and harvestable species, in a more formal way and should consider appropriate mechanisms for coordinating and evaluating research. Links between WG-FSA and scientists working on these predator/prey interactions should be strengthened.

ADVICE TO THE SCIENTIFIC COMMITTEE

Management Advice

8.1 The Working Group recommended that the precautionary catch limit on krill for Division 58.4.2, currently set at 390 000 tonnes in Conservation Measure 45/XI, should be increased to 450 000 tonnes (paragraph 7.104).

8.2 The Working Group could not offer further advice on a precautionary limit in Area 48, or appropriate subdivision within Area 48 in response to the request from CCAMLR-XIII, paragraph 8.6, but anticipated that it would be able to do so at its next meeting following additional analyses.

General Advice with Budgetary/Organisational Implications

Cooperation with Other Groups

- An effective mechanism for consideration of interactions between fish and their predators should be devised (paragraph 7.118).
- CCAMLR should consider co-sponsoring a symposium on krill biology on receipt of a request and proposal from the organising committee (paragraphs 9.4 and 9.5).
- A CCAMLR representative should be nominated to the IWC Workshop on Effects of Climatic Change on Cetaceans (paragraph 9.15).
- CCAMLR should nominate an observer to the SCAR-COMNAP group (paragraph 9.19).
- CCAMLR should nominate an observer to the krill fisheries workshop (Vancouver, Canada, 1995) (paragraph 9.20).

Publications

- Several modifications should be made to the *Scientific Observers Manual* (paragraph 3.15).
- Revisions to the *CEMP Standard Methods* should be distributed (paragraph 5.14).
- A high-quality booklet explaining, in non-specialised language, the ecosystem approach and assessment methods developed by the Working Group, should be considered (paragraph 9.10).
- The work of WG-EMM should be reported to the wider scientific community in a WG-EMM newsletter which would be written by the Convener.

Meetings

- The workshop on proposals for indices to monitor at-sea behaviour, which was to have been held in 1996, should be postponed until 1997. Dr Boyd will pursue its organisation

during the intersessional period. The Scientific Committee was requested to adjust its budget accordingly (paragraph 5.32).

- The Subgroup on Statistics should meet to develop methods for presentation of comprehensive quantitative data on dependent and harvested species and data from the fishery and environment to replace the current ordinal presentation of data in Table 3. The subgroup will be expanded to include participants expert in harvested species and environmental data and the Convener, Dr Agnew, was requested to correspond with interested participants and submit a proposal for a meeting in 1996 to the Scientific Committee (paragraphs 7.98 and 7.99).
- The Subgroup on Monitoring Methods may need to meet to consider new methods and revisions to old methods as identified above, preferably immediately prior to the next meeting of WG-EMM. The Secretariat will correspond with interested participants to establish a proposal for such a meeting, to be presented to the Scientific Committee (paragraphs 7.98 and 7.99).

Future Work for WG-EMM

Development of an Ecosystem Assessment

- Further work on defining a strategic approach to ecosystem assessment is encouraged (paragraph 2.9).
- Further development of methods appropriate for conducting an ecosystem assessment is required (paragraph 7.96).
- Assessments should be developed from the current qualitative approach to a quantitative analysis (paragraph 7.96).

Surveys

- A new near-synoptic survey of Area 48 is recommended (paragraph 4.8). Papers considering detailed plans for this survey should be prepared for the next meeting.
- Further examination of errors in acoustic surveys of krill should be conducted (paragraph 4.12).

- The use of multifrequency acoustic techniques in surveying should be examined (paragraph 4.13).
- The report of a survey of Division 58.4.1 to be conducted in early 1996 by Australia should be presented for consideration at the next meeting of WG-EMM.

Data Collection/Analysis Methods

- Members are requested to report their experience with gastric lavage and stomach sample techniques (paragraph 5.22).
- Standard methods for Antarctic fur seal demography and diet studies should be prepared (paragraphs 5.38 and 5.39).
- Draft methods for analysis of petrel diet samples should be prepared (paragraph 5.42).
- Methods for albatross and petrel lavage should be prepared (paragraph 5.44).
- Instructions for the collection and preservation of samples to be taken in the event of disease outbreak should be circulated (paragraph 5.51).
- The Subgroup on Monitoring Methods should circulate for review proposed changes to existing CEMP methods and proposals for new ones (paragraph 5.53).
- More extensive studies on the occurrence of fish in krill catches, particularly assessments of when and where larval fish are most likely to be most vulnerable, should be conducted (paragraph 7.4).
- A table of existing spatio-temporal scales should be circulated for revision during the intersessional period (paragraph 7.96).

Data Submission/Acquisition/Access

- All appropriate data on CEMP indicator species currently held by Members and which have not yet been submitted, including historical data sets, should be compiled and submitted in CCAMLR formats (paragraphs 5.12, 5.61, 5.62, 5.64 and 7.96).

- A bibliography of publications on diets, energy budgets and foraging ranges of dependent species should be maintained by CCAMLR (paragraph 5.101).
- The acquisition of comprehensive bathymetric and SST data should be pursued by the Secretariat.
- CCAMLR should consider developing access to a number of its publicly available data sets via a World Wide Web site (www) (paragraph 9.17) .

Modelling/Analysis

- CPD calculations for 1994/95 should be presented by the Secretariat to the Scientific Committee (paragraph 5.97).
- Final calculations of the krill/dependent species model for black-browed albatross and Antarctic fur seal should be completed and presented at the next meeting (paragraph 5.112) together with initial requests for a revised version of the Adélie penguin model.
- Members should compare krill length frequency data from nets and predators (paragraph 5.118) and examine time series of krill length frequencies from predators for information on krill recruitment (paragraph 5.120).
- The relationship between overall krill abundance and actual krill availability to predators within a CPD requires investigation (paragraph 7.27).
- Further work on the sub-models within the conceptual framework of Figures 3 and 4 is encouraged (paragraph 7.50 to 7.54).

Correspondence Groups

- A correspondence subgroup should complete the analysis of recruitment estimates (Dr Agnew (Convener), Prof. Butterworth, Drs de la Mare, Hewitt, Loeb and Siegel) (paragraphs 4.48, 4.49 and Appendix D).

- A correspondence subgroup should consider Method A5 (Drs Agnew, Boyd, Kerry (Convener), Kooyman and Trivelpiece) (paragraph 5.19).
- A correspondence subgroup should consider the development of appropriate sea-ice indices (paragraph 6.49) and the formulation of specific hypotheses on the potential effects of sea-ice on components of the ecosystem (Drs Agnew, Croxall, Holt, Miller (Convener), Naganobu, Siegel and Trivelpiece) (paragraphs 6.48 and 6.49).
- A subgroup will carry out further work on the incorporation of information on predator demand in the calculation of precautionary catch limits and their allocation to subareas (Drs Agnew, Boyd (Co-convener), Butterworth, Croxall, de la Mare, Everson (Co-convener), Holt and Naganobu) (paragraphs 7.77 to 7.80 and Appendix H).
- The group led by Dr Kim whose work resulted in a workshop in Hamburg, Germany (Appendix I), should continue to correspond to coordinate research activities (paragraph 9.8).

OTHER BUSINESS

9.1 Given the many developments in the study of euphausiid biology since the last symposium held in 1982, it was suggested that CCAMLR, SCAR and other interested parties might investigate ways of conducting and jointly sponsoring an international symposium in the near future.

9.2 Such a proposal had been made in the last CCAMLR WG-Krill newsletter circulated in January 1995 by Dr Miller (Convener of WG-Krill) and Dr Watkins (Secretary, SCAR Subcommittee on Krill) (WG-EMM-95/35).

9.3 The Working Group felt that, in general, the practice of conducting scientific symposia would facilitate the consideration of a large volume of scientific information of a broad nature contained in papers submitted to CCAMLR meetings. Because of time constraints, CCAMLR Working Groups are usually only able to discuss matters of direct relevance to CCAMLR, leaving other biological information without detailed consideration.

9.4 The Working Group agreed that there was a need and widespread support for such a symposium. It was also mentioned that the place and timing of the symposium should be decided as early as possible in order to enable potential participants to prepare their contributions and secure funds. It was considered that the symposium could not be convened earlier than in the next two or three years.

9.5 It was agreed that the attention of the Scientific Committee should be drawn to the proposal and to the necessity of establishing a symposium steering committee. Meanwhile, Dr Miller was invited to continue with plans and prepare a proposal for the Scientific Committee.

9.6 Since 1993 a group of CCAMLR Members, under the convenership of Dr Kim, has conducted consultations to coordinate their shipboard research in the vicinity of the South Shetland Islands during in the 1994/95 season and to arrange for collaborative evaluation of survey results.

9.7 Coordinated research surveys were conducted from late November 1994 to late February 1995 by Germany, Japan, Republic of Korea and the USA. Dr Kim informed the Working Group of results obtained by the CCAMLR Workshop 'Temporal changes in marine environments in the Antarctic Peninsula area during the 1994/95 austral summer' held from 16 to 21 July 1995 in Hamburg, Germany (WG-EMM-95/58). A summary of the workshop report is given in Appendix I.

9.8 The Working Group congratulated Dr Kim on this initiative which provided for coordination of research effort of several countries and facilitated collection of valuable data, increasing our knowledge of the area. The Working Group encouraged CCAMLR Members to continue to provide outlines of their future research plans to the Scientific Committee and its Working Groups in order to undertake such coordination in future.

9.9 Dr Kock (Chairman of the Scientific Committee) suggested that the Scientific Committee might consider preparation of a booklet describing CCAMLR approaches to ecosystem monitoring and management including a general description of scientific concepts and mathematical models. Such a booklet would be a useful guide for the CCAMLR community in understanding details of the mathematical models used and the development of the long-term strategy for ecosystem monitoring and management. The booklet would also assist in raising the profile of CCAMLR in international scientific and fisheries management communities.

9.10 The Working Group welcomed the proposal and emphasised that the booklet should highlight ongoing processes in CCAMLR. It referred the proposal for further consideration at the forthcoming meeting of the Scientific Committee.

9.11 The attention of the Working Group was drawn to the report of the 1995 planning meeting of the SCAR APIS research program (SC-CAMLR-XIV/BG/11). Dr Boyd highlighted the common areas of interest between APIS and CCAMLR, particularly as regards the estimation of krill consumption by pack-ice seals. Crabeater seals are probably the most numerous single consumer of krill in the

Antarctic and, since they are already recognised by CCAMLR as a selected indicator species, this program will provide data of direct relevance to the management of krill fisheries.

9.12 The Working Group welcomed recent developments in formalisation of the APIS program. It also noted the link established between CCAMLR and APIS through Dr Boyd.

9.13 The attention of the Working Group was drawn to the recent letter received by Drs Everson and Marín from Dr S. Reilly, Chairman of the IWC Scientific Committee. In this letter Dr Reilly invites CCAMLR scientists to take part in the Workshop on the Effects of Climatic Change on Cetaceans, to be held in March 1996 on Oahu Island, Hawaii.

9.14 The Working Group welcomed the opportunity of further developing cooperation with IWC and considered that CCAMLR scientists may contribute to this workshop on the following two topics:

- (i) biological changes in the marine environment which may affect distribution and availability of krill; and
- (ii) CCAMLR approach to strategic modelling - a tool to develop management advice in the context of a changing environment.

9.15 Several CCAMLR scientists are likely to participate in the workshop and the Working Group suggested that CCAMLR be officially represented. Dr de la Mare and Mr Ichii agreed to prepare a paper on behalf of the CCAMLR Scientific Committee outlining the CCAMLR approach to the topics in paragraph 9.14.

9.16 The Working Group acknowledged that much of the data collected as a result of initiatives by WG-Krill and WG-CEMP now formed data sets which both CCAMLR and other organisations were finding increasingly useful. For instance, the IWC steering committee for research related to the conservation of large baleen whales in the Southern Ocean (WG-EMM-95/31) examined the catch distributions of krill published in the *Statistical Bulletin* in relation to their investigations of krill as a major prey item for whales. The APIS report (SC-CAMLR-XIV/BG/11) also makes reference to the potential use of CCAMLR data.

9.17 In this connection, the Scientific Committee's attention is drawn to the increasing value of CCAMLR's long-term data sets not only to CCAMLR, but also the international community. It was suggested that some consideration should be given to the possibility of increasing ease of access to these data sets for the CCAMLR community (e.g., CCAMLR home page on the WWW).

9.18 Paper WG-EMM-95/30 drew attention to the involvement of SCAR and COMNAP in monitoring man's impact on the Antarctic environment and recorded the intention to harmonise their activities with any related activities of CCAMLR. The Working Group noted that the introduction of exotic disease into the bird and seal populations was an important concern to CCAMLR. A draft protocol for the collection of samples for diagnosis in the event of a disease outbreak had been developed (WG-EMM-95/44) and was discussed (see paragraphs 5.46 to 5.51).

9.19 Dr Penhale noted that SCAR and COMNAP were holding two related workshops on 'The Role of Environmental Monitoring in Preserving Antarctic Values and Resources' (Oslo, Norway, 17 to 20 October 1995; College Station, Texas, USA, 28 November to 1 December 1995). She understood that SCAR and COMNAP were interested in learning from the CCAMLR experience of developing monitoring protocols and a data management program. Since she would be attending both workshops, she agreed to report the interest of WG-EMM/Scientific Committee to the workshops and to report the outcome of these meetings to WG-EMM/Scientific Committee in 1996.

9.20 Dr Miller drew the Working Group's attention to a workshop on krill fisheries scheduled for the period 13 to 16 November 1995 under the convenership of Dr A. Pitcher at the University of British Columbia in Vancouver. Although various members of WG-EMM have been invited to attend the meeting in their private capacities, given the meeting's potential importance, the Working Group urged that CCAMLR should be represented. Dr Miller undertook to put Dr Pitcher in contact with the Scientific Committee chairman with a view to soliciting the necessary invitation to CCAMLR.

9.21 On a related matter, the Working Group noted that WG-EMM-95/48 had been tabled in response to a request by WG-Krill for information on krill fisheries outside the Convention Area. The Working Group welcomed this paper and recognised that the important information on the Japanese *E. pacifica* fishery which it contained was of particular interest to CCAMLR. In particular, such information described management measures and the ancillary use of environmental data in their formulation. The Working Group recommended that the paper be tabled at the Scientific Committee's next meeting so that the information it contained could be more widely disseminated.

ADOPTION OF THE REPORT

10.1 The report of the first meeting of WG-EMM was adopted.

CLOSE OF THE MEETING

11.1 In closing the meeting, the Convener expressed the sincere thanks of the Working Group to Prof. Focardi and his colleagues in Siena for the substantial amount of work they had done to ensure that the meeting ran smoothly.

11.2 He also thanked participants, section coordinators, all rapporteurs and the Secretariat for their contributions to an extremely successful meeting. The direction of work for this new Working Group (WG-EMM) has been set by this meeting and it has made substantial progress towards its objectives.

11.3 Dr Kock, the Scientific Committee Chairman, congratulated the Convener on a meeting that had taken such important steps forward, and noted that a major part of this was due to the Convener's detailed preparation for the meeting.

11.4 The Convener closed the meeting.

Table 1: Output from the krill yield model, with variance of the survey estimate (σ_s) set at various levels to take account of imprecision additional to that arising from inter-transect variation (paragraph 4.55).

γ	P ($B_{sp} < 0.2$ in 20 years)			Median B_{sp} after 20 years		
	$\sigma_s = 0.3$	$\sigma_s = 0.4$	$\sigma_s = 0.5$	$\sigma_s = 0.3$	$\sigma_s = 0.4$	$\sigma_s = 0.5$
0	0	0	0	1.00	1.00	1.00
0.1	0.02	0.03	0.04	0.78	0.79	0.79
0.11	0.04	0.05	0.06	0.76	0.77	0.77
0.12	0.05	0.06	0.07	0.74	0.74	0.75
0.13	0.06	0.08	0.09	0.72	0.72	0.73
0.14	0.08	0.10	0.12	0.69	0.70	0.71
0.15	0.10	0.12	0.14	0.67	0.68	0.68
0.16	0.13	0.15	0.17	0.65	0.65	0.66
γ_1	0.149	0.140	0.133			
γ_2				0.116	0.116	0.120

Table 2: Data submission for the 1994/95 season.

Site	Parameter/Species																					
	A1		A2	A3				A5		A6				A7				A8				
	EUC	PYD	PYD	EUC	PYD	PYN	PYP	PYD	PYN	EUC	PYD	PYN	PYP	EUC	PYD	PYN	PYP	EUC	PYD	PYN	PYP	
Anvers Is				USA				USA		USA				USA				USA				
Béchervaise Is		AUS	AUS	AUS				AUS		AUS				AUS				AUS				
Bird Is	GBR			GBR			GBR			GBR			GBR	GBR				GBR			GBR	GBR
Cape Shirreff																						
Magnetic Is																						
Seal Is																		USA				
Signy Is				GBR	GBR	GBR				GBR	GBR	GBR										
Terra Nova			ITA	ITA				ITA		ITA				ITA				ITA			ITA	
Hope Bay		ARG	ARG	ARG						ARG				ARG				ARG				

Species code:

EUC macaroni penguin
 PYD Adélie penguin
 PYN chinstrap penguin
 PYP gentoo penguin
 DIM black-browed albatross
 SEA fur seal

Country code:

ARG Argentina
 AUS Australia
 CHL Chile
 ITA Italy
 GBR UK
 USA USA

Site	Parameter/Species					
	A9			B1, 2	C1	C2
	EUC	PYD	PYN	DIM	SEA	SEA
Anvers Is	USA					
Béchervaise Is	AUS					
Bird Is				GBR	GBR	GBR
Cape Shirreff						CHL
Magnetic Is						
Seal Is	USA		USA			USA
Signy Is						
Terra Nova		ITA				
Hope Bay		ARG				

Table 3: Assessment of predator and prey studies, 1988 to 1995. Predator parameters were obtained from WG-CEMP-94/16 unless otherwise referenced in the tables. Data are given qualitative rankings: High, Medium, Low, Very Low (H, M, L, VL). The symbols +, 0, - indicate changes in parameters between successive years. Foraging duration is expressed as the relative length of foraging trips to sea (S = short, M = medium, L = long, VL = very long). Information within the boxes relates to assessments based on the data, collected in accordance with standard methods and actually submitted to the CEMP database.

3.1 Site: Anvers Is, Subarea 48.1

Year	Adélie				Krill			Environment			
	Breeding Population Size/Change (A3)	Breeding Success (A6)	Fledging Mass (A7)	Foraging Trip (A5)	Catch		CPUE	Biomass	Snow	Sea-ice	Ocean
					100-km radius	Subarea					
1988		-									
1989		-									
1990		L	L	M							
1991		L	M	L							
1992	H (First census)	H	H	L							
1993	L --	M	H	S							
1994	L - or 0	M	L	M							
1995	L --	H	L	M							

3.2 Site: Cape Shirreff, Livingston Is, Subarea 48.1

Year	Antarctic Fur Seal ¹			Chinstrap ²		Krill				
	Breeding Population Size/Change		Breeding Success	Pup Growth Rate (C2)	Breeding Population Size/Change (A3)	Breeding Success (A6)	Catch		CPUE	Biomass
							100-km radius	Subarea		
1988	L		M							
1989										
1990			L							
1991	M	+	H		?					
1992	H	+	H		0					
1993	H	+	H		0					
1994	H	+	H		-					
1995	L	+	H		H					

Year	Environment		
	Snow	Sea-ice	Ocean
1988			
1989			
1990			
1991	H		
1992	M	+Brash	
1993	L	iceberg	
1994	L	-	
1995	H	+ iceberg	

¹ WG-CEMP-92/53; WG-CEMP-94/28; WG-EMM-95/77

² *Boletín Antártico Chileno*, Vol. 11 (1): 12-14

³ Submitted data comprise only two sets of weighings

3.3 Site: Admiralty Bay, King George Is, Subarea 48.1

Year	Gentoo		Adélie		Chinstrap		Krill			Environment			
	Breeding Population Size/Change (A3)	Breeding Success (A6)	Breeding Population Size/Change (A3)	Breeding Success (A6)	Breeding Population Size/Change (A3)	Breeding Success (A6)	Catch		CPUE	Biomass	Snow	Sea-ice	Ocean
							100-km radius	Subarea					
1988	M -	M	H +	M	L -	M							
1989	M +	H	H +	H	M +	H							
1990	M -	M	M -	M	M -	L							
1991	L --	M	L --	L	L --	L							
1992	H ++	H	L +	H	M +	H							
1993	H +	H	L -	M	M +	M							
1994	H - or 0	M	L +	H	M +	M							
1995	H 0	H	L -	H	L -	H							

(This summary table was constructed without reviewing the actual data and may contain source errors)

3.4 Site: Ardley Island and Stranger Point combined, King George Island, Subarea 48.1. Esperanza data used for 1991 for Stranger Point.

Year	Adélie ¹ - Ardley		Chinstrap ² - Ardley		Adélie ³ - Stranger		Krill			Environment			
	Breeding Population Size/Change (A3)	Breeding Success (A6)	Breeding Population Size/Change (A3)	Breeding Success (A6)	Breeding Population Size/Change (A3)	Breeding Success (A6)	Catch		CPUE	Biomass	Snow	Sea-ice	Ocean
							100-km radius	Subarea					
1988	H	H	M	M	L -	H							
1989	H	M	M	H	L -	H							
1990	M	L	H	L	M -	M							
1991	L	M	L	M	M -	L							
1992	M	?	L	M	? +	?							
1993	M	L	L	M									
1994	H +	M	L +	M									

¹ WG-Krill-92/21; WG-CEMP-92/54; Valencia, unpublished data

² WG-CEMP-92/54; Valencia, unpublished data

³ WG-CEMP-92/6; WG-CEMP-92/45

Note: 1991 data from Esperanza

3.5 Site: Seal Island, Elephant Island, Subarea 48.1

Year	Chinstrap ¹				Antarctic Fur Seal ²				Krill ³			Environment			
	Breeding Population Size/Change (A3)	Breeding Success (A6)	Fledging Mass (A7)	Foraging Trip (A5)	Pups Born Number/Change	Foraging Trip	Pup Growth Rate (C2)	Weight at Age	Catch		CPUE	Biomass g/m ²	Snow	Sea-ice	Ocean
									100-km radius	Subarea					
1988	M ?	M	H	S	M +	M	M	H							
1989	L -	L	H	L	VL -	?	H	L							
1990	H +	H	M	L	M +	M	L	L			58.6				
1991	M -	L	L	M	L -	L	H	L			26.3				
1992	H +	M	M	M	M +	M	M	H			45.4				
1993	H -	M	M	S	M 0	L	M	M			111.4 ⁴				
1994		M	L	M	M 0	M	M	H			8.8				
1995			M		M 0		M	M			10-15				

¹ Data are from the CCAMLR Data Centre and WG-CEMP-90/21, 91/11, 91/33, 92/17 and 93/27

² Data are from the CCAMLR Data Centre and WG-CEMP-89/21, 90/34, 90/41, 91/11, 92/17 and 93/27

³ Data from document WG-Joint-94/9 ⁴ Value may be artificially high due to difficulty differentiating between echo signals from salps and krill

3.6 Site: Signy Is, South Orkneys, Subarea 48.2

Year	Adélie		Chinstrap		Gentoo		Krill			Environment			
	Breeding Population Size/Change (A3)	Breeding Success (A6)	Breeding Population Size/Change (A3)	Breeding Success (A6)	Breeding Population Size/Change (A3)	Breeding Success (A6)	Catch		CPUE	Biomass	Snow	Sea-ice ¹	Ocean
							100-km radius	Subarea					
1988	H +	M	L -	H	H ++	H						H	
1989	H 0	L-M	L 0	H	H +	H						H	
1990	M -	L-M	M +	L	H +	L						L	
1991	L --	M	L -	H	M -	H						M	
1992	M +	M-H	L-M +	H	M -	H						H	
1993	M 0	H	M 0	H	H +	M						?	
1994	M +	L	M +	L	H +	L						?	
1995	L --	M	L --	M	H +	M							

¹ Murphy *et al.*, (in press)

3.7 Site: Bird Island, South Georgia, Subarea 48.3

Year	Gentoo					Macaroni						Black-browed Albatross			
	Breeding Population Size/Change (A3)	Breeding Success (A6)	Krill in Diet (A8)	Meal Size (A8)	Fledging Mass (A5)	Breeding Population Size/Change (A3)	Breeding Success (A6)	Krill in Diet (A8)	Meal Size (A8)	Arrival Mass (A1)	Fledging Mass (A5)	Breeding Population Size/Change (B1)	Breeding Success (B2)	Adult Survival (B3)	Growth Rate ¹
1988	M -	M	M	H		M -	L	-	-			L ---	VL	M	-
1989	H ++	M	H	M-H	M	H +	H	M	M	M	H	M ++	M	L	H
1990	H -	L-M	M	M	H	M -	H	M	M	H	M	M 0	M	VL	L
1991	L --	VL	L	L	L	M -	H	L	L	L	M	L-M -	VL	M	M
1992	M +	H	M	M	H	M 0	M	H	H	M	H	L -	M	?	H
1993	M 0	H	H	M-L	M	M 0	M-H	H	M	M	M	L +	H	?	H
1994	L-M -	VL	VL	VL	L	L-M -	M	VL	L	M	L	L -	VL	?	?
1995	L --	L-M	M	H	L-M	L --	M	M	L	M	L	VL --	VL	?	?

Year	Krill				Environment		
	Catch		CPUE	Biomass	Snow ²	Sea-ice ³	Ocean
	100-km radius	Subarea					
1988					H	H	
1989					M	M	
1990					M	L	
1991					M	L	
1992					H	M-H	
1993					M	L-M	
1994					M	?	
1995					H		

¹ P.A. Prince, unpublished data

² Black-browed albatross only

³ Lunn *et al.*, 1993 (WG-CEMP-93/10)

3.8 Site: Bird Island, South Georgia, Subarea 48.3

Year	Antarctic Fur Seal ¹										
	Pups Born Number/ Change ¹		Birth Mass ²	Perinatal Period ²	Foraging Trip (C1)	Pup Growth Rate (C2)	Wean Mass ²	Breeding Success ¹	Pregnancy Rate ³	Survival Rate ³	Recruitment Rate ³
1988	H	-	H	M	S	M	M	M	L-M	M	M
1989	H	-	H	M	M	M	H	M	L	H	M
1990	H	+	H	M	S	L-M	M	M	M-H	M	VL
1991	L	--	L	S	VL	M	M	H	L-M	M	L
1992	L-M	+	M	M	M	M	M-H	L	M	H	M
1993	H	+	M	M	M-L	M-H	M-H	M	H	M-H	L
1994	M	-	M	?	VVL	M	L	VL	H	?	?
1995	L-M	-	M	?	M	L - M	M	M	?	?	?

Year	Krill				Environment		
	Catch		CPUE	Biomass	Snow	Sea-ice ¹	Ocean
	100-km radius	Subarea					
1988						H	
1989						M	
1990						L	
1991						L	
1992						M-L	
1993						M-L	
1994						?	
1995							

¹ Boyd *et al.*, 1995 (WG-EMM-95/26) and BAS unpublished data

² Data from Lunn and Boyd, 1993 (WG-CEMP-92/41), Lunn *et al.*, 1993 (WG-CEMP-93/9), Boyd, unpublished data

³ Boyd *et al.*, 1995 (WG-EMM-95/26)

3.9 Site: Béchervaise Island, Mawson, Division 58.4.2

Year	Adélie							Krill			Environment			
	Arrival Mass (A1)	Incubation Shift (A2)		Breeding Population Size/change (A3)	Breeding Success (A6)	Fledge Mass (A7)	Krill in Diet (A8)	Catch		CPUE	Biomass	Snow	Sea-Ice	Ocean
		1st	2nd					100-km radius	Subarea					
1991		Start		Start	Start		Start					L	M	
1992	Start	0	0	+1	0	Start	0					L	M	
1993	0	-	-	-	0	-	0					Ma	M	
1994		-	-	+	0	+	0					L	L	
1995	0	0		0	Nil	Nil	VL					L	H	

¹ Proc. Nat. Inst. Polar Res., 6 (1993)

0 = no change

Snow: L = little snow or none; Ma = medium snow during pre-egg stage; Mb = medium snow during chick fledging; H = snow in colony for most of the season

1995 Note: No chicks fledged. All died during guard phase.

Ice: H = fast ice continuous to horizon late January; M = open water to horizon mid-January; L = late December

3.10 Site: Edmonson Point, Ross Sea region, Subarea 88.2.

Year	Adélie					
	Incubation Shift (A2)	Breeding Population Size/Change (A3)	Foraging Trip Duration (A5)	Breeding Success (A6)	Fledge Mass (A7)	Krill in Diet (A8)
1994	-	start	-	-	-	-
1995	start	0	start	start	start	start

0 = no change

WG-EMM-95/47

Table 4: Time series of data concerning foraging performance, diet and foraging range of predators. Indices referred to in the table are:

- a. Chick/pup survival
- b. Chick/pup growth
- c. Foraging trip duration
- d. Parental condition
- e. Foraging location
 - e.(i) Area/range
 - e.(ii) Depth
- f. Diet
 - f.(i) Meal size
 - f.(ii) Meal frequency
 - f.(iii) Meal composition
 - f.(iii).a Krill length
 - f.(iii).b Fish age/size
 - f.(iii).c Squid size

Species	Location	Country/Operator	Index	Time Series
Antarctic fur seal	Bird Island	UK	a, b, c, d (pup birth mass)	1984-1995
			e.(i)	1995
			e.(ii)	1988-1995
			f.(iii).a, f.(iii).b	1991-1995
	Seal Island	USA/AMLR	a, b, c, d, e.(i), e.(ii)	1988-1995
Black-browed albatross	Bird Island	UK	a	1976-1995
			b, c	1976-1977, 1980, 1989-1995
			d	1994-1995
			e.(i)	1993-1994
			e.(ii)	1994-1995
			f.(iii).a, f.(iii).b, f.(iii).c	1976-1977, 1980, 1985, 1988, 1994
			f.(i), f.(ii)	1976-1977, 1980, 1990-1995
Gentoo penguin	Bird Island	UK	a	1976-1995
			b	5y in 1977-88; 1989 -1995
			c, d (mass at arrival)	1986-1989
			e.(i) (range)	1986-1988
			e.(ii)	1986-1988
			f.(i)	5y in 1977-88; 1989-1995
			f.(ii)	1977; 1986-1988
			f.(iii).a	5y in 1977-88; 1989-1995
			f.(iii).b	1986-1988; 1990-1995
	f.(iii).c	1990-1995		
	Admiralty Bay	USA/NSF	a	1977, 1981-1995
			b	1977, 1981-1982
			d (adult mass)	1981-1995
			e.(i)	1989-1992, 1994
			f.(i), f.(ii), f.(iii).a	1977-1982, 1987-1995
f.(iii).b			1987-1995	

Table 4 (continued)

Species	Location	Country/Operator	Index	Time Series
Macaroni penguin	Bird Island	UK	a	1977-1995
			b	1977, 1980, 1986 -1995
			c	1977
			d (mass at arrival)	1977, 1989-1995
			e.(i) (range)	1989, 1993
			e.(ii)	1989, 1993
			f.(i)	5y 1977-1988, 1990-1995
			f.(ii)	1977
f.(iii).a	5y 1977-1988, 1990-1995			
Adélie penguin	Béchervaise Island	Australia	a, b, c, d (various derived indices), e.(i), e.(ii), f.(i), f.(ii), f.(iii).a, f.(iii).b	1991-1995
	Admiralty Bay	USA/NSF	a	1977, 1981-1995
			b	1977, 1981-1982
			c	1981-1982, 1987-1995
			d (adult mass)	1981-1995
			e.(ii)	1989-1992
			f.(i), f.(ii), f.(iii).a	1977-1982, 1987-1975
	f.(iii).b	1987-1995		
	Terra Nova Bay (Edmonson Point)	Italy	a, b, c, d (various derived indices), e.(i), e.(ii), f.(i), f(ii), f.(iii).a, f.(iii).b, f.(iii).c	1995
	Palmer Station	USA/AMLR/NSF	a, b, c	1990-1995
f.(i), f.(ii), f.(iii), a, b, c			1987-1995	
Chinstrap penguin	Admiralty Bay	USA/NSF	a	1977, 1981-1995
			b	1977, 1981-1982
			d (adult mass)	1981-1995
			c	1989-1992
			e.(i)	1977-1982, 1987-1995
			f.(i), f.(ii), f.(iii).a, f.(iii).b	1987-1995
	Seal Island	USA/AMLR	a, b, c, d, e.(i), e.(ii)	1988-1995

Table 5: Environmental variables considered important to an ecosystem assessment. The rows are not aligned to imply specific relationships between columns.

Medium	Features	Variables	Methods	Examples	Comments	
Ocean	Global circulation	Water mass distribution	Standard transects and grids	East wind drift	Affects prey biology, distribution, and transport.	
	Regional circulation	Physical properties (temperature, salinity, density, etc.)	Current measurements (current meters, buoys, ADCP, drifters, geostrophic)	Weddell gyre	Affects predator foraging capabilities, e.g. through changes in wave height, water column light attenuation.	
	Fronts	Nutrient fields	Satellite (SST)	Weddell-Scotia confluence		
	Topographic interactions	Current velocity field	Model data	Shelf circulation		
	Eddies	Eddy field	Bathymetric data	Circumpolar deep water in the Peninsula region		
Wave height		Sound velocity, sea level, tide				
Ice	Interannual/seasonal sea-ice development	Ice area - global/regional	Satellite	Interannual variability in maximum extent in the Peninsula region	Refugia	
	Global	Ice edge position	Field - ship/station	Regional connections; Bellingshausen - Peninsula - Weddell	Overwintering - possible link to recruitment strength?	
	Regional	Ice dynamics	Ground truthing		Prey redistribution?	
	Local	Rate of change	Ice coring	Access for predators to prey.		
	Ice-edge processes	Concentration	Light measurements for optical properties	Longterm change	Suitability as breeding sites.	
	Polynya and leads	Type/thickness	Snow cover thickness	Ecology of MIZ		Affects fishery operations (ice cover).
		Floe size				
		Albedo				
		Ice Colour				
		Optical properties				
	Melting stages					

Table 5 (continued)

Medium	Features	Variables	Methods	Examples	Comments
Atmosphere	Global climate Regional Weather systems Katabatic winds	Pressure gradients Wind stress field Cloud cover Precipitation Temperature, humidity, etc. Irradiance	Satellites, e.g. scatterometer, cloud cover, irradiance, UV Field measurements - meteorological observations - ground truthing	Weather system - frequency in the Peninsula region - tracks in Scotia Sea Global change Wind stress effects on water column structure	Indirect effect on marine life? (except UV?) Direct effect on predators. Flight tracks. Foraging strategies. Breeding success?
Terrestrial	Topography Geology Habitat suitability Vegetation cover Glacier	Snow cover Breeding site suitability - height - wind direction - substrate Vegetation Access Glacial retreat	Satellite + field measurements Aerial photography Field observations for ground truthing and direct measurements	Seasonal variability Site availability for population expansion?	Availability of nesting sites. Penguin population changes.

Good characterisation of bathymetry is required.

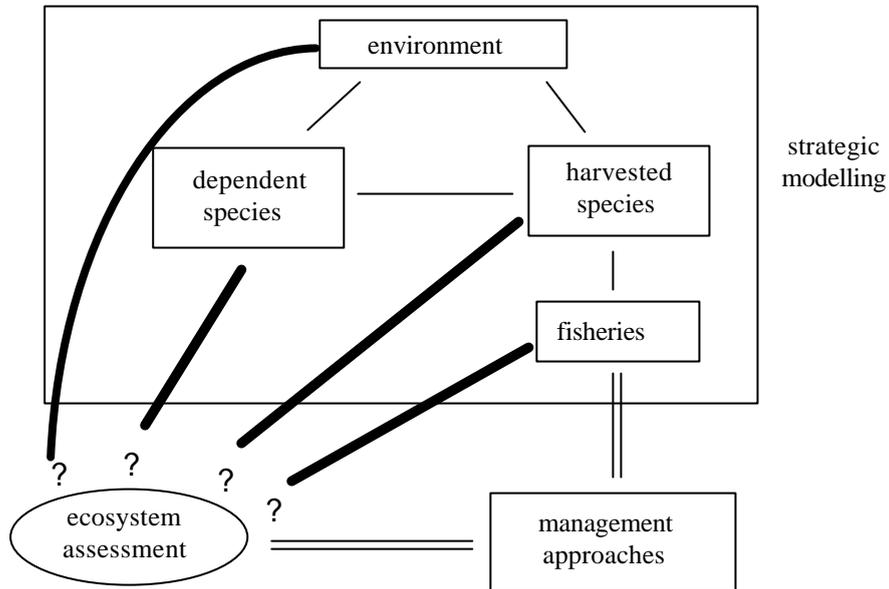


Figure 1: Schematic diagram of the processes involved in ecosystem monitoring and management. The basic ecosystem COMPONENTS are Environment, Dependent Species, Harvested Species and Fisheries. They interact via ecosystem LINKS (thin lines). They also all have an as yet undefined relationship (thick lines) with an 'ecosystem assessment' which incorporates ecosystem monitoring. Strategic modelling is the process whereby the links between components, and between components and the ecosystem assessment are evaluated. The final step in the scheme is the evaluation of management approaches, and the determination of its links with the ecosystem assessment (double lines).

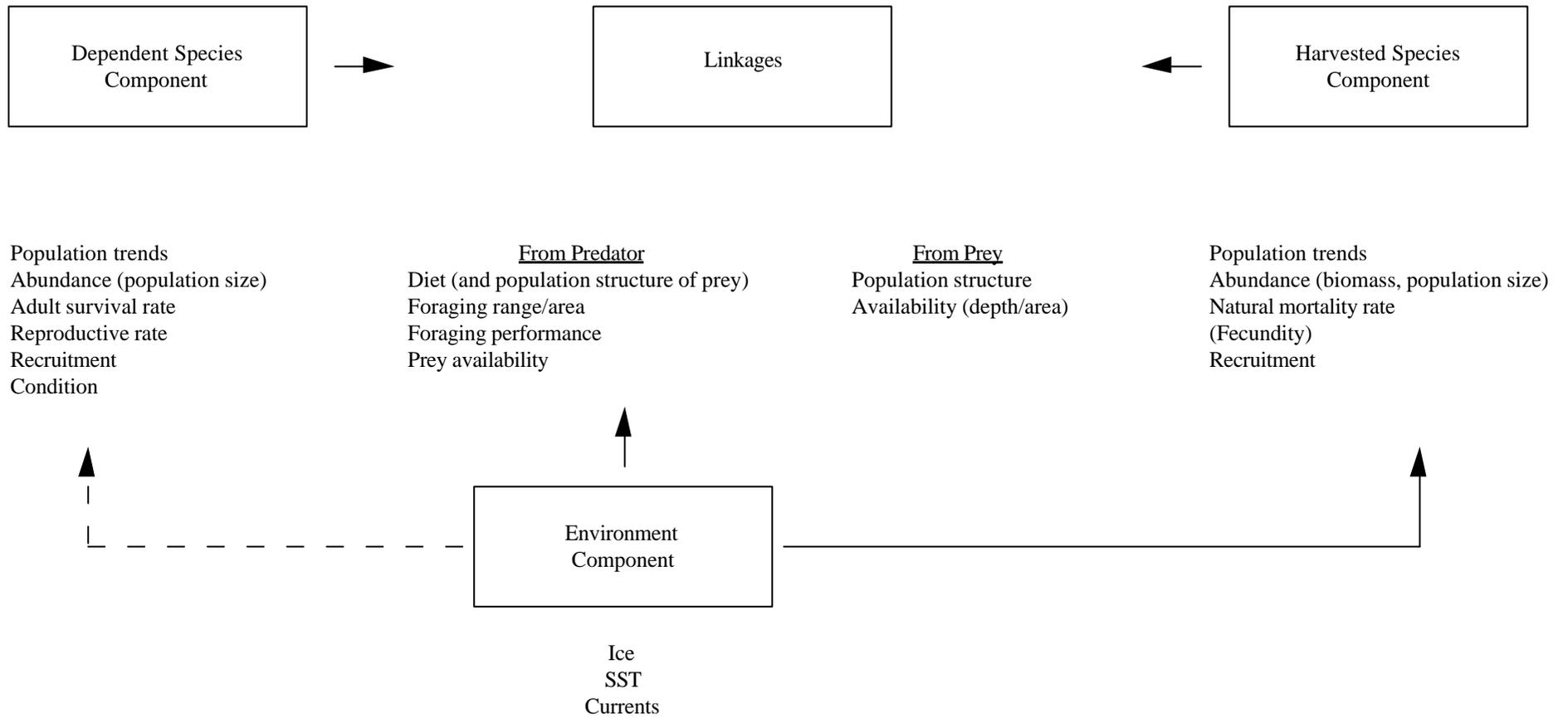


Figure 2: Relevance of various ecosystem parameters to the components and links identified in Figure 1.

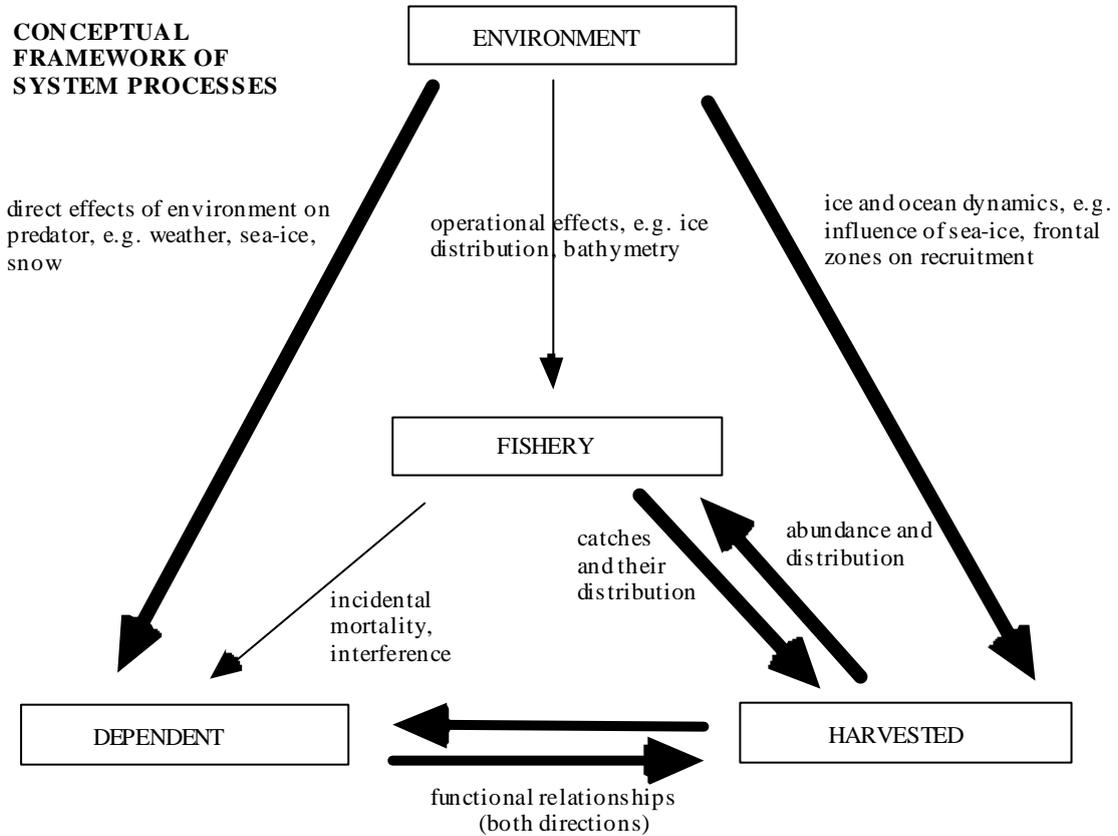


Figure 3: Conceptual framework of system processes. This figure describes the first step in a strategic modelling exercise and demonstrates the relationships between ecosystem components. The direction of arrows indicates the effect of one component on another, and the thickness of an arrow indicates the perceived importance of that link.

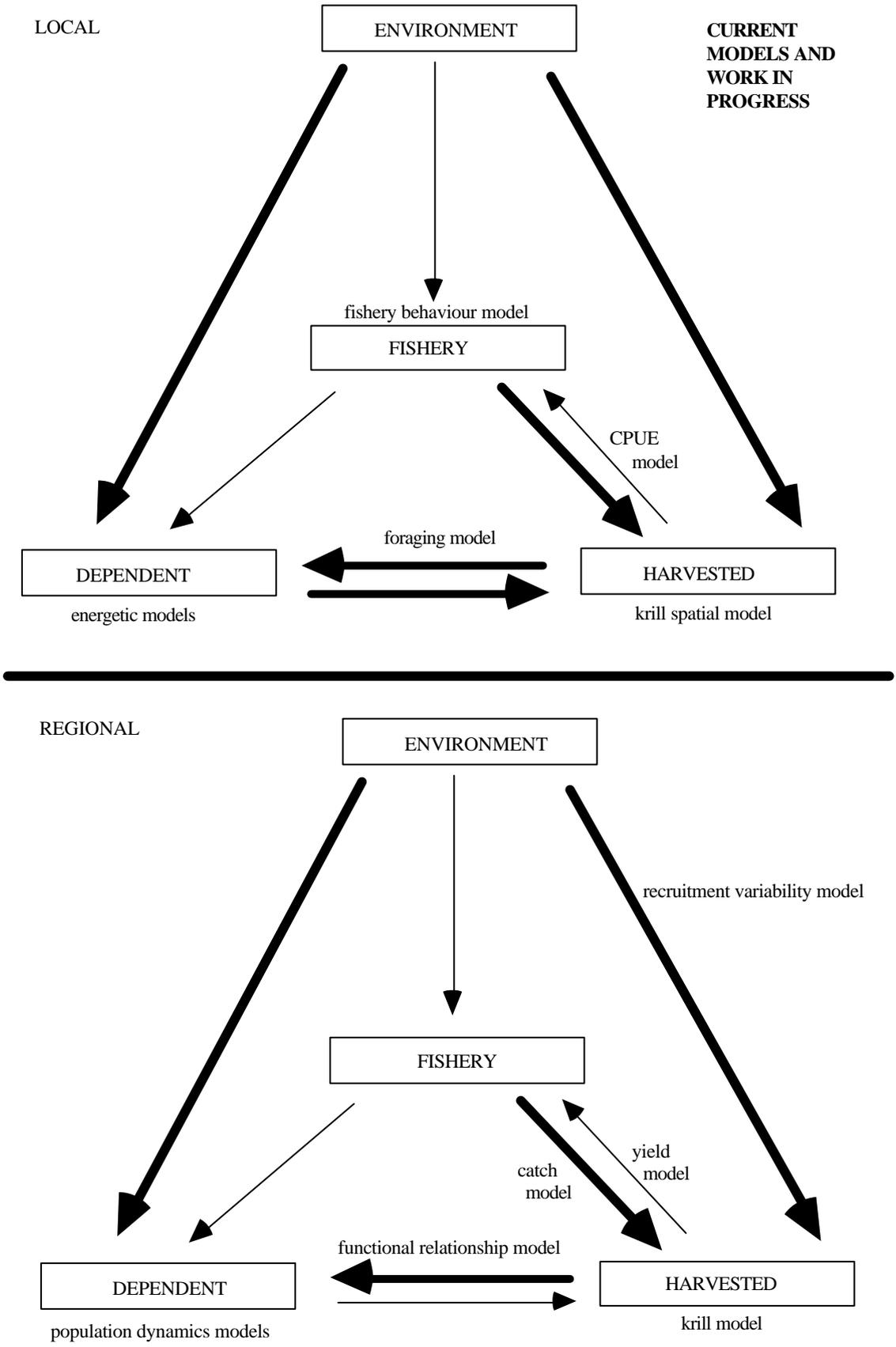


Figure 4: Current models and work in progress. Models are either associated with the components (in which case the models describe the relationships between parts of the ecosystem which are within component boxes) or with links.

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(Siena, Italy, 24 July to 3 August 1995)

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- SC-CAMLR-XIV/BG/11 REPORT OF THE 1995 APIS PROGRAM PLANNING MEETING

AGENDA

Working Group on Ecosystem Monitoring and Management
(Siena, Italy, 24 July to 3 August 1995)

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 - (ii) Organisation of the Meeting and Adoption of the Agenda

2. Aims and Objectives of WG-EMM

3. Data
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 - (a) Catches, Status and Trends
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 - (ii) Surveys on Harvested Species
 - (iii) Dependent Species
 - (iv) Environment
 - (v) Biology and Ecology of Harvested and Dependent Species of Particular Relevance to Fisheries Management and CEMP

4. Harvested Species
 - (i) Methods for Estimating Distribution, Standing Stock, Recruitment and Production of Harvested Species
 - (ii) Analysis and Results of Studies on Distribution, Standing Stock, Recruitment and Production of Harvested Species
 - (iii) Interannual and Within-Season Variability in Distribution, Standing Stock, Recruitment and Production of Harvested Species
 - (iv) Estimation of Potential Yield
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5. Dependent Species
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 - (i) Identification of Key Variables
 - (ii) Availability of Data
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 - (iii) Environmental Data Required for the Understanding of Other Ecosystem Components

7. Ecosystem Assessment
 - (i) By-catch of Fish in the Krill Fishery
 - (ii) Interactions Between Harvested and Dependent Species
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 - (iv) Environment \oslash Harvested Species/Dependent Species Interactions
 - (v) Approaches to the Integration of Harvested Species/Dependent Species/ Environment Interactions into Management Advice
 - (vi) Consideration of Possible Management Measures
 - (vii) Extension of the Scope of CEMP
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8. Advice to the Scientific Committee
 - (i) General Advice
 - (ii) Management Advice
 - (iii) Future Work

9. Other Business

10. Adoption of the Report

11. Close of the Meeting.

**REPORT OF THE SUBGROUP FOR THE RE-ANALYSIS OF RECRUITMENT
AND ABUNDANCE INDICES FOR ELEPHANT ISLAND**

The subgroup developed specifications for re-analysis of the net haul survey data presented in WG-EMM-95/15 using the methods employed by WG-Krill at its last meeting. The subgroup agreed that the following analyses should be undertaken.

Prepare a review of the information available about the distribution of krill by age in and around the study area as an aid to interpreting the results of analysis. This should include a review of available information about krill movements into and out of the study area, and, to the extent possible, where and for how long krill may be retained in the area.

Analysis of recruitment proportions using the maximum likelihood method (de la Mare, 1994¹) for both 1+ and 2+ recruitment proportions.

Analysis of net haul abundance estimates using the delta distribution estimators (Pennington, 1983²; de la Mare, 1994¹).

Analysis of the 1+ and 2+ recruitment proportions for possible serial correlation.

2. For producing a time series of annual recruitment proportions from the Elephant Island surveys, the analyses will be split by month and pooled after analysis using inverse variance weighting. Where one or more of the separate surveys show zero recruitment, i.e. empty classes over the range of lengths for recruits, the raw data should be pooled before analysis, so as to avoid averaging with an infinite weight.

3. The complete net haul data from wide-area surveys in 1985, 1987 and 1989 should also be analysed for recruitment proportions and densities.

¹ de la Mare, W.K. 1994. Estimating krill recruitment and its variability. *CCAMLR Science*, Vol. 1: 55-69.

² Pennington, M. 1983. Efficient estimators of abundance for fish and plankton surveys. *Biometrics*, 39: 281-286.

4. It is recommended that the Working Group establish a steering group to coordinate the analysis and develop the methodology to be employed in incorporating the recruitment indices into the krill yield model. The steering group should include at least Dr Agnew, Prof. Butterworth, Drs de la Mare, Hewitt, Loeb and Siegel.

5. Dr De la Mare will make available the most recent version of the maximum likelihood program, complete with user notes, to Drs Siegel and Loeb as soon as possible after the meeting (early September).

6. Drs Siegel and Loeb will circulate the results of the review of krill distribution and the re-analyses before January 1996 to members of the steering group. Dr De la Mare will estimate the autocorrelation coefficients and possible trends from the analyses. The steering group will provide such comments as it believes to be necessary in interpreting the results, and make the results available to members of the Scientific Committee and WG-EMM. The steering group will, by correspondence, determine the next steps to be taken to take the results into account in calculating precautionary catch limits for Area 48, and arrange for preliminary calculations to be completed in time for the next meeting of WG-EMM.

REPORTS OF MEMBERS' ACTIVITIES RELATING TO CEMP

This appendix contains descriptions of Members' activities in relation to CEMP that were submitted to this meeting by participants (Argentina, Australia, Chile, Italy, Japan, New Zealand, Norway, South Africa, Sweden, UK and USA).

2. In February and March 1995, Argentina conducted a research cruise around the South Georgia and South Orkney Islands as well as in the waters of the Weddell/Scotia confluence. The first leg of the cruise was focused on a fish survey and the second on a krill survey. During the krill survey, acoustic data using a Simrad EK500 echosounder as well as net samples were collected. The data from both surveys will be available to CCAMLR-XIV. A similar cruise is planned for the next season.

3. Studies on the use of shag dietary data to monitor changes in coastal fish populations at Dutoit Point and Half-moon Island were continued, in the South Shetland Islands and at Pirie Peninsula at Laurie Island in the South Orkney Islands. Next season, the study area will be extended to include Harmony Point, Nelson Island.

4. Several parameters of Adélie penguins were measured in accordance with CEMP Standard Methods at Stranger Point, Hope Bay and Laurie Island. For the next season it is planned to continue this routine.

5. The diet of the cape petrel at Laurie Island has been studied as part of bird monitoring studies. This line of work will be continued.

6. Australia continued its CEMP monitoring program at Béchervaise Island using automated means supplemented by manual observations. The 1994/95 season was unusual in that all chicks died in the guard phase. Studies reported in WG-EMM-95/33 suggested that these deaths were due to starvation. Disease has not been implicated and no fishing has occurred in the foraging region over the past five years. Plans for the 1995/96 season include further investigations of this phenomenon in addition to routine monitoring at Béchervaise Island.

7. Australia will also conduct monitoring studies during the 1995/96 season only at Casey and probably Dumont d'Urville in collaboration with France. These studies are being

undertaken in conjunction with the extensive krill survey to be conducted by Australia in Division 58.4.1 (WG-EMM-95/43). Satellite tracking combined with TDRs will be used to determine foraging range/depth at all sites.

8. During the Antarctic season 1994/95 the Instituto Antártico Chileno carried out a census including weighing pups in the *Arctocephalus gazella* breeding colony at the CEMP site, Cape Shirreff and San Telmo Islands.

9. Counts from this season (15 841 animals) and all previous seasons were tabled (WG-EMM-95/77). Pups were weighed using CEMP Standard Method C2.B. On each occasion 50 individuals of each sex were measured.

10. A census of post-breeding colonies of elephant seals at Cape Shirreff was also conducted. A total of 656 elephant seals was counted in 1995 in comparison to 1 375 animals counted in 1994.

11. A total of 251 kg of marine debris was collected in 1995 at Cape Shirreff, after the study baseline was established in 1994. Two specimens of *A. gazella* were recorded entangled, and one of them - a female - was released from the neck collar (piece of net). An exploratory analysis of heavy metals in bones from carcasses of Antarctic fur seals has also been undertaken.

12. A bathymetric chart of waters around Cape Shirreff and the San Telmo Islands CEMP site and SSSI No. 32 was published in September 1994 by the Servicio Hidrográfico y Oceanográfico de la Armada de Chile (SHOA), (SHOA chart No. 14301, scale 1:15 000). A copy of this chart has been submitted to the CCAMLR Secretariat.

13. During the 1994/95 season a joint Italy/Australia biological research program on the biology of Adélie penguins was undertaken at Edmonson Point (74°21'S, 165°05'E) in the Ross Sea region. The site, colony layout and breeding chronology were documented.

14. Investigation of diet and foraging activities were carried out using analysis of foraging trip duration and stomach contents combined with satellite tracking and time-depth recordings. Toxicological and disease studies were commenced.

15. As part of the program an automated penguin monitoring system (APMS) was installed to collect data automatically. Data on CEMP parameters A2, A3 and A5 to A9 were submitted. The program will continue in season 1995/96.

16. Japan continues to monitor the annual trends in breeding population size of Adélie penguins near Syowa Station. From this coming season, studies on Adélie penguins will be conducted with an emphasis on predator-ice interaction using new techniques.
17. New Zealand continues its research activities in the Ross Sea which are closely related to CEMP goals. Monitoring of the size of some of the southernmost Adélie penguin breeding colonies on Ross Island has been carried out regularly since the 1960s, and for all other colonies in the Ross Sea since 1981.
18. In 1995 Norway continued studies of Antarctic petrels at Svarthamaren, Dronning Maud Land with logistic support from South Africa.
19. Norway also participated in the survey of pack-ice seals conducted from a US coastguard ice-breaker during February/March 1995.
20. In May 1994, South Africa initiated monitoring of various aspects of the biology of gentoo penguins (*Pygoscelis papua*) and macaroni penguins (*Eudyptes chrysolophus*) at Marion Island (Prince Edward Islands), in accordance with CEMP Standard Methods. Some of the CEMP procedures were also applied to rockhopper penguins (*Eudyptes chrysocome*). Breeding colonies of gentoo penguins were found to be unduly disturbed by some of the more intensive monitoring procedures. To reduce disturbance to this species, information on its breeding success and breeding chronology in 1995/96 will be based on observations made from outside breeding colonies using binoculars.
21. In July 1994, a census indicated that 1 346 pairs of gentoo penguins were breeding at Marion Island. In November 1994, counts were made of 173 077 pairs of rockhopper penguins and 841 pairs of imperial cormorants (*Phalacrocorax atriceps*) breeding at Marion Island. All three of these counts are substantially (25 to 52%) higher than the previously reported figures for breeding populations at Marion Island - 888, 137 652 and 589 pairs respectively (Cooper and Brown, 1990, *S. Afr. J. Antarct. Res.*, 20(2): 40-57).
22. Sweden has no CEMP-related monitoring activity. Basic research on king penguins and elephant seals is undertaken in cooperation with BAS (UK).
23. During March/April 1995 a bottom fauna survey around South Georgia using a ROV (SeaOwl MK II) was undertaken in collaboration with the USA (AMLR program).

24. UK land-based research in support of CEMP is conducted at Signy Island, South Orkney Islands and Bird Island, South Georgia. Parameters measured in 1995 were identical to those recorded in 1992 to 1994 (SC-CAMLR-XI, Annex 7, Appendix D, paragraph 20) and are listed in Table 1 of SC-CAMLR-XIV/BG/2.

25. In addition, the detailed demographic studies on grey-headed and black-browed albatrosses and on Antarctic fur seals were continued, and these now provide annual data on population size, adult survival, juvenile survival (recruitment), breeding frequency and breeding success for albatrosses and age-specific fecundity rate, maternal mass, pup birth mass and breeding success for fur seals.

26. Additional directed research (summarised in Table 2 of SC-CAMLR-XIV/BG/2) is being carried out on:

- (i) chick growth, foraging trip duration, meal size and at-sea activity budgets of albatrosses, especially black-browed albatross; and
- (ii) aspects of diving performance and at-sea activity and energy budgets in Antarctic fur seals.

27. The UK was represented on a research cruise on a US coastguard icebreaker in February/March 1995. During the cruise, a survey of pack-ice seal distribution and abundance between Adélie Land and the eastern Weddell Sea was carried out. The primary aim was to examine the methodology involved in carrying out surveys of seals in pack-ice and to deploy satellite transmitters on crabeater seals. The survey showed that line transect methods were greatly superior to those using strip transects and that surveys from ships moving through pack-ice can be as effective as helicopter-based surveys. This cruise contributed to the SCAR APIS research program.

28. United States activities in 1994/95 directly related to CEMP consisted of:

- (i) land-based predator studies at Seal Island, near Elephant Island, and at Palmer Station, Anvers Island;
- (ii) repeated surveys of hydrographic conditions, phytoplankton production, and krill abundance and distribution in the waters surrounding Elephant Island; and,
- (iii) cooperative Japanese/US predator/prey interactions study at Elephant Island.

Preliminary reports on activities (i) and (ii) are provided in the AMLR field season report, WG-CEMP-94/37.

29. At Seal Island, monitoring according to CEMP Standard Methods and directed research in support of CEMP objectives were conducted on populations of Antarctic fur seals, chinstrap penguins and macaroni penguins. Field procedures were conducted for Standard Methods A4, A5, A6 (procedures A and C), A7, A8, A9, C1 and C2. In addition, directed research was conducted on foraging ecology and at-sea behaviour of fur seals and penguins, and penguin breeding population size. An automated, land-based system for tracking seals and penguins to determine foraging locations was further developed and tested.

30. Two 30-day cruises were conducted aboard the NOAA ship *Surveyor* from mid-January to mid-March 1995 in the vicinity of the Seal Island CEMP site near Elephant Island. Chlorophyll *a* concentrations, primary production rates, organic carbon concentrations, phytoplankton species compositions, nutrient concentrations, and solar irradiance were measured and mapped. In addition, the distribution and abundance of krill were measured using sampling nets and hydroacoustic instrumentation.

31. During December 1994 and January 1995, a collaborative cruise with Japanese scientists on board the RV *Kaiyo Maru* was conducted near Elephant Island to investigate predator/prey interactions among Antarctic krill and its marine mammal and bird predators. Shipboard surveys of hydrographic conditions, phytoplankton production, krill distribution, abundance and demography were conducted.

32. In support of the NSF's LTER Program an oceanographic cruise was conducted by the NSF ship *Polar Duke* in January 1995. Primary production rates, chlorophyll *a* concentrations, organic carbon concentrations, microbial production rates, nutrient concentrations and irradiance were investigated in an area from Palmer Station to Rothera Station. Krill distributions were measured using nets and acoustic instrumentation. Seabird surveys were conducted and Adélie penguin diet samples were collected in the Palmer Station area.

33. Anticipated CEMP-related field work in 1995/96 will include continued penguin monitoring at Palmer Station. Studies at Seal Island are likely to be suspended because of safety conditions on the island. Various sites suitable for the relocation of the camp will be inspected during the 1995/96 season and a new site will be established in the 1996/97 season. The LTER program will continue to conduct field research similar to that conducted this year. Additionally, there will be an increased focus on modelling studies of value to the LTER, AMLR, to CCAMLR and to GLOBEC.

34. In addition, a collaborative study with Sweden was conducted aboard the RV *Surveyor* during January/February 1995 in waters around South Georgia using a ROV. The study's primary objective was to investigate Antarctic crab abundance and distribution. However, this objective could not be accomplished because of severe sea states and currents; therefore, the secondary objectives were investigated. These were to investigate benthic communities in inshore regions around South Georgia.

EXTENSIONS TO KRILL-PREDATOR MODELLING EXERCISES

- (a) Black-browed albatross
- (i) Adult survival rate: Annual estimates and associated variance to be taken from Prince et al. (1994)¹.
 - (ii) Fecundity: Data on annual laying rates and fledging success to be taken from Prince et al. (1994)¹. The associated precision may be estimated under the assumption of a binomial distribution (as these data pertain to the whole study population).
 - (iii) Population trend: Sub-adult survival rate to be adjusted so that the model population reflects the observed decline of 31% from 1976 to 1989 (Prince et al., 1994¹).
 - (iv) Density dependence: It may be assumed that fecundity alone is responsible for density dependence. As a guide to the possible level of such dependence, an estimated maximum population rate of increase of 5% per annum for the wandering albatross (de la Mare and Kerry, 1994²) may be used. A further guide which may be more appropriate is provided by the data on observed maximum rates of increase of black-browed albatrosses at different colonies at Bird Island as set out in Croxall et al., 1994³.
 - (v) Age at first laying: This is to be taken as 10 years (a modal value - see Croxall et al., 1994³).

¹ Prince, P.A., P. Rothery, J.P. Croxall and A.G. Wood. 1994. Population dynamics of black-browed and grey-headed albatrosses *Diomedea melanophris* and *D. chrysostoma* at Bird Island, South Georgia. *Ibis*, 136: 50-71.

² de la Mare, W.K. and K. Kerry. 1994. Population dynamics of the wandering albatross (*Diomedea exulans*) on Macquarie Island and the effect of mortality from longline fishing. *Polar Biology*, 14(4): 231-241.

³ Croxall, J.P., I.L. Boyd and P.A. Prince. 1994. Modelling functional relationships between predators and prey. Document *WG-Joint-94/5*. CCAMLR, Hobart, Australia.

(b) Antarctic fur seal

- (i) Adult survival rate: The annual estimates provided in Table 1 of Boyd et al. (1995)⁴, which also provides estimates of precision, are to be inflated so that the model population can achieve the annual growth rate of some 10% observed in the recent past (Boyd, 1993⁵). These mark-recapture-based estimates are probably biased downwards because of (1) effects of tag loss, (2) emigration of tagged animals and (3) the study colony animals may have a larger average age than those in the overall population.
- (ii) Age at first parturition: Results should be computed for values of this age of both three and four years, though three is probably closer to the actual situation.
- (iii) Fecundity: This is a combination of pregnancy rate and pup survival rate. Table 1 of Boyd et al. (1995)⁴ provides annual estimates of both pregnancy rate (with confidence intervals) and pup survival rate. The precision of pup survival rate may be estimated under the assumption of a binomial distribution (as these data pertain to the whole study colony).
- (iv) Sub-adult survival rate: The value of the parameter that relates this to the adult survival rate will be confounded with the value of the parameter which ‘inflates’ the estimates for the adult rate (see (i) above). As a guide to the region of parameter space to be investigated, the high costs (in survival terms) of reproduction are considered to suggest a sub-adult rate somewhat higher than the adult rate.
- (v) Density dependence: There was a population rate increase of 16.8% per annum through the 1960s. This may have been driven by either high adult survival or immigration. Data on age structure from the early 1970s suggest adult female survival may have been greater than through the 1980s. There is also a relationship between adult female survival and an index of food availability, as reported in Boyd et al. (1995)⁴. Therefore, both adult survival rate and fecundity are likely to be responsible for density dependence.

⁴ Boyd, I.L., J.P. Croxall, N.J. Lunn and K. Reid. 1995. Population demography of Antarctic fur seals: the costs of reproduction and implications for life-histories. *Journal of Animal Ecology*, 64: 505-518.

⁵ Boyd, I.L. 1993. Pup production and distribution of breeding Antarctic fur seals (*Arctocephalus gazella*) at South Georgia. *Antarctic Science*, 5: 17-24.

Given the uncertainty associated with the various estimates of population rates of increase, a range of values for the maximum annual rate of population increase possible (from 5 to 17%) will be considered. A range of combinations of density dependence on fecundity and on the adult survival rate will also be considered.

(c) Adélie penguin

Fundamental model assumptions

After discussion, the assumptions for this model were recast in the following form.

- (i) The population consists of two components:
 - (a) non-colony birds aged 0 to 4, which are non-breeding; and
 - (b) colony birds aged 2 to 5+.
- (ii) Non-colony birds may move to the colony at the start of each year. All 5-year-old birds move. A fraction (λ_y) of the birds aged 2 to 4 also move - this fraction varies from year to year.
- (iii) Birds attempting to breed for the first time have a lower fledging success rate because of their inexperience. This rate varies from year to year (τ_y). These are the birds aged 3 to 5 which have just moved to the colony.
- (iv) Birds which first move to the colony at age 2 do not breed that year. It is unclear whether such birds gain 'experience' from this process, and therefore whether the experienced (κ_y) or inexperienced (τ_y) fledging rate applies to them when they first breed the following year when aged 3. Calculations are to be attempted for both possibilities.
- (v) Experienced (non-first-time) breeders have a yearly varying fledging success rate (κ_y) which exceeds that for the first-time breeders (i.e., $\kappa_y > \tau_y$).
- (vi) Survival rates are as follows:

0-year-old non-colony birds:	S^J	(i.e., annually varying)
1- to 4-year-old non-colony birds:	S^I	(fixed in time)
first-breeding colony birds:	μS^A	(fixed in time)

non-first breeding colony birds:	S^A (fixed in time)
2-year-old non-breeding colony birds:	a range of options from S^A to S^J to be investigated (note that when breeding the following year, calculations should include a range of options from μS^A to S^A for the survival rate).

The rationale for the distinctions above is as follows.

The heaviest pre-breeding mortality probably occurs immediately after fledging when the animals struggle to learn to forage for themselves. This is the reason for the distinction between S^J and S^I ; as this is the stage most likely to depend on krill availability, S^J is made year-dependent. $S^J < S^I$.

S^A is less than S^J because of the penalties of breeding (involving greater energy requirements and exposure to leopard seal predation) and migration to the colony.

There is a further survival rate penalty in the year the first attempt is made to breed (the factor μ) due to inexperience.

Data

The existing data (though some of these have yet to be extracted and coded) for input to and fitting of the model are:

- (i) annual estimates of the number of colony birds (available for most years), whose CV is to be taken to be 5%;
- (ii) annual estimates of fledging success rates κ_y and τ_y for most years (values missing should be substituted by random sampling with replacement from known (κ_y, τ_y) paired values within the Monte Carlo Bayesian integration process).

Prior distributions for unknown parameters

- (i) Non-first-time breeders survival rate, S^A : calculations for a series of fixed values of 0.7, 0.75, 0.8 and 0.85 (based upon the 0.8 estimate of Ainley (1983)⁶).
- (ii) First-time breeding survival penalty, μ : From U[0, 1].

⁶ Ainley, D.G., R.E. Leresche and W.J.L. Sladen. 1993. *Breeding Biology of the Adélie Penguin*. University of California Press: 1-240.

- (iii) Non-colony birds survival rate from age 1, S' : From U[S^A , 1].
- (iv) First year of life survival rate, S^J : From U[0, S^A].
- (v) Fraction of non-colony birds migrating to colony, λ_y : From U[0, 1].

Subsequent calculations may attempt simple positive correlation relationships between λ_y and S^J , as both are likely reflections of local krill availability that year, e.g.:

$$\lambda_y = S^J/S^A + \epsilon \quad \text{where } \epsilon \text{ from U} [-0.1, 0.1]$$

subject to $0 \leq \lambda_y \leq 1$.

Key outputs for subsequent krill-predator modelling

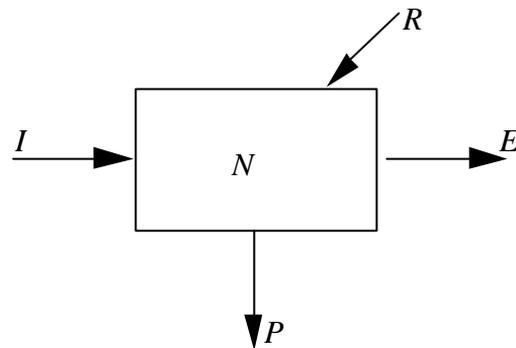
Posterior estimates of a time series for S^J (and also λ_y), from which to estimate a functional relationship to krill abundance via the krill yield model.

Further, correlation of the posterior estimates of these two quantities with each other, with κ_y and τ_y , and with environmental indices would be of interest as a basis for testing hypotheses about environmental factors which may (through their impact on krill) influence Adélie penguin demographics.

**FURTHER DEVELOPMENT OF THE APPROACH OF BASING A
PRECAUTIONARY LIMIT FOR KRILL FISHING IN A REGION
ON THE PREDATOR CONSUMPTION IN THAT REGION**

D.S. Butterworth

Consider the following schematic representation of krill dynamics in a region in the absence of a krill fishery. The region (R) could, for example, be the shaded area around South Georgia in Figure 1 of WG-EMM-95/17.



N is the number of krill in the region at a particular time;

I is the flux of krill (numbers/year) into the region;

E is the flux of krill (numbers/year) out of the region;

P is the consumption of krill (numbers/year) by predators in the region.

Then, in the absence of krill recruitment within the region:

$$\frac{dN}{dt} = I - E - P \quad (1)$$

so that in a steady state:

$$I - E - P = 0 \quad (2)$$

$$N = N_u \text{ (} u \text{ indicating 'unexploited')}$$

Further relationships can be written as follows

$$\begin{aligned}
 P &= M N \\
 E &= \epsilon N \\
 T &= N_u / I
 \end{aligned}
 \tag{3}$$

where M = krill natural mortality rate (yr^{-1})

ϵ = krill (per capita) outflow rate (yr^{-1})

T = krill turnover rate in region R in the absence of exploitation (yr).

Equation (2) can then be written:

$$\begin{aligned}
 N_u / T &= \epsilon N_u - M N_u = 0 \\
 \text{i.e. } 1/T &= \epsilon + M
 \end{aligned}
 \tag{4}$$

Now add a krill harvest C (numbers/yr), which is set at a fraction λ^* of the predators' consumption of krill in the absence of exploitation, i.e.:

$$C = \lambda^* P_u = \lambda^* M N_u.$$

Equations (1) and (2) now become:

$$\begin{aligned}
 \frac{dN}{dt} &= I - E - P - C \\
 I - E - P - C &= 0 \quad ; \quad N = N_e \text{ (} e \text{ indicating 'exploitation')}
 \end{aligned}
 \tag{5}$$

The predators will be affected by a decrease in the density of krill in region R , so that the ratio of interest is N_e / N_u . Now, from equation (5):

$$I - \epsilon N_e - M N_e - C = 0$$

so that:

$$N_e = (I - C) / (\epsilon + M) \tag{6}$$

while from equation (2):

$$N_u = I / (\epsilon + M) \tag{7}$$

Thus:

$$N_e / N_u = 1 - \frac{C}{\epsilon + M} (1 / N_u)$$

but $1 / (\epsilon + M) = T$ from equation (2) and $C = \lambda^* M N_u$, so eventually:

$N_e / N_u = 1 - \lambda^* M T$	(8)
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Say we believe that the predators could tolerate an average drop in the krill density of $x\%$. The allowable krill harvest as a fraction of predator consumption (λ^*) is then given by:

$$x/100 = \lambda^* M T$$

i.e. $\lambda^* = x/(100 M T)$ (9)

For example, if we take $x = 10$, $M = 0.7 \text{ yr}^{-1}$ and $T = 0.25 \text{ yr}$, then a krill harvest as a fraction of predator consumption of $\lambda^* = 0.57$ (57%) would cause a 10% drop in krill density in region R .

Conversely, if λ^* is set to 10%, then the drop in krill abundance is $x = 0.0175$ (1³/₄%).

Questions:

- (i) This analysis is entirely in terms of krill NUMBERS - what happens if we change to BIOMASS? Note that strictly then, the growth in mass of individual krill while within region R should also be taken into account. Overall, however, this aspect does not seem likely to affect results markedly, particularly if the predators and fishery have similar selectivity-at-age functions.
- (ii) How does M as used here relate to the value customarily taken to reflect the krill natural mortality rate? Since R is a region of higher predator density, the M value to be used here should be somewhat higher than the 'global' value customarily used for krill natural mortality. However, this might be counterbalanced by the fact that the estimate of predator consumption ($P = M N_u$) which the calculated λ^* value would multiply may take account only of land-breeding predators. In other words, setting $C = \lambda^* P$, we may overestimate λ^* by using too small a value for M in equation (8), but may simultaneously underestimate P by not taking account of pelagic predators.

- (iii) If C is all concentrated in a small sub-region of region R , would this affect conclusions? Yes - IF the predators in the region make particular use of that sub-region AND krill mixing within R is slow in relation to the rate of removals from the sub-region.

- (iv) What if C is taken upstream of region R ? The inward flux (I) would decrease so that krill density within R would again fall. The fall might be less than indicated by equation (8), however, as some of the catch C would be taken from krill that would otherwise have bypassed region R (to the north or south), and therefore not contribute to the diminution of I .

**REPORT OF THE SUBGROUP FOR CALCULATING PRECAUTIONARY
CATCH LIMITS WITHIN SUBAREA 48.3 BASED ON MASS
OF KRILL CONSUMED BY PREDATORS**

The subgroup considered the modification suggested by Dr de la Mare to the method proposed by Dr Everson in WG-EMM-95/17. The basic modification is to calculate a precautionary catch limit using the krill yield model with an unexploited biomass value derived from predator consumption. The precautionary catch limit is given by:

$$C = \gamma B_o$$

where g is the precautionary catch limit as a proportion of biomass, as calculated from the krill yield model. Applying this formula requires an estimate of B_o , which is not available for Subarea 48.3. However, the total krill consumed by land-breeding predators can be used to provide a calculated lower bound on the biomass which would be obtained if a survey were carried out in the area. This is given by the following formula:

$$B_o = \frac{P}{(1 - e^{-M})V}$$

where P is the annual consumption of krill by land-breeding predators;

M is the annual rate of krill natural mortality; and

V is the annual turnover of krill in the area (with dimension year⁻¹, i.e. 1/retention time).

2. g is calculated using the krill yield model. Applying the method requires estimates of P , M and V . However, the krill yield model also requires an estimate of the variance of B_o , and this could be calculated using the delta method from separate variance estimates for P , M and V . Estimates of M and its variance are already available as a component of the krill yield model, based on the analyses of krill recruitment proportions.

3. The subgroup recommended that the Working Group establish a steering group to coordinate the analyses and develop the methodology for estimating the parameters. The steering group should include at least Drs Agnew, Boyd, Prof. Butterworth, Drs Croxall, de la Mare, Everson, Holt and Naganobu.

4. Land-based predator consumption at South Georgia will be estimated by Drs Boyd and Croxall. They will attempt to provide a variance estimate for this parameter.
5. The subgroup agreed to attempt the application of the method on two geographic scales:
 - (i) the whole of Subarea 48.3; and
 - (ii) within the foraging distance of the key krill-dependent predators breeding at South Georgia.
6. Drs Everson and Murphy undertook to provide estimates of retention times at these two scales. At the subarea scale, the subgroup agreed that the FRAM model could be used to calculate an estimate of the water turnover. It may be difficult to assign a variance to this estimate, but it was agreed that consultations among the steering group will take place to consider how this might be attempted. At the smaller scale, the subgroup considered that direct hydrographic calculations would be needed using all available data.
7. The method would be applied initially at the temporal scale of the whole year; if time permitted other scales, including those relating to critical periods, would be investigated.
8. The estimates of P , M and V will be available by the end of June, 1996, so as to allow the re-calculation of g using the krill yield model in time for the next meeting of WG-EMM.

**TEMPORAL CHANGES IN MARINE ENVIRONMENTS IN THE ANTARCTIC
PENINSULA AREA DURING THE 1994/95 AUSTRAL SUMMER**

(Executive Summary of the Report of a Workshop Held at the
Institut für Seefischerei, Hamburg, Germany, 16 to 21 July, 1995)

INTRODUCTION

1. At the 1993 meeting of the CCAMLR Scientific Committee and again at the 1994 meeting of the Working Group on Krill (WG-Krill), Dr S. Kim (Republic of Korea) noted that several Members had announced plans to conduct shipboard research in the vicinity of the South Shetland Islands (Figure I.1). Dr Kim further suggested that it would be advantageous to coordinate the planning of such work and to meet afterwards to discuss results.
2. Accordingly, representatives from Germany, Japan, Republic of Korea and the USA met during the 1994 meeting of WG-Krill and agreed to adjust their respective field research plans to include observations at a common set of stations. Five stations were set 15 n miles apart along the 55°W meridian north of Elephant Island (Figure I.1) and corresponded to Stations 60 to 64 on the US AMLR grid which has been occupied twice each austral summer since 1991.
3. The five stations were occupied six times between late November 1994 and late February 1995 during research cruises conducted by Germany, Japan, Republic of Korea and the USA. Observations included CTD profiles, chlorophyll *a* and nutrient concentrations at various depths, net samples of zooplankton, and acoustic transects between stations. In addition, Japan inserted an extra inshore station, the Republic of Korea occupied additional stations along 55°W south of Elephant Island, Germany occupied 77 of the 91 stations in the AMLR grid, and the USA occupied all 91 stations. Table I.1 lists the cruise dates, the dates that the common stations along 55°W were occupied, the survey areas, the types of observations conducted and the equipment used by each Member country.
4. Dr V. Siegel (Germany) volunteered to host a post-season workshop at the Institut für Seefischerei in Hamburg immediately prior to the 1995 meeting of the Working Group on Ecosystem Monitoring and Management (WG-EMM) to discuss results of the field work.

Dr Kim, Dr Siegel, Dr M. Naganobu (Japan), and Dr R. Hewitt (USA) were co-conveners of the workshop entitled 'Temporal changes in marine environments in the Antarctic Peninsula area during the 1994/95 austral summer'.

5. The workshop was attended by Dr V. Siegel, (Germany), Mr T. Ichii, Drs M. Naganobu and S. Kawaguchi (Japan), Drs S. Kim and Sung Ho Kang (Republic of Korea), Dr I. Everson (UK), Drs D. Demer, R. Hewitt and V. Loeb (USA).

6. The workshop was organized into four subgroups: physical oceanography, phytoplankton and nutrients, zooplankton (including krill demographics), and acoustics. The sub-group reports and recommendations of the workshop for future work are presented in the following paragraphs for consideration by WG-EMM.

7. Of particular note are four conclusions: (i) the north/south position of the oceanic frontal zone north of Elephant Island along 55°W varied by 15 n miles and the relatively narrow northeasterly current associated with this front varied in strength depending on position of the front; (ii) nutrient depletion occurred as the season progressed, probably associated with phytoplankton species succession; (iii) krill spawning during the 1994/95 season was early, extensive and apparently successful; and (iv) taxa other than krill may have caused a substantial portion of the observed acoustic backscattering strength.

Recommendations

8. The causes of the frontal zone movement north of Elephant Island and its influence on the behaviour of organisms should be investigated. The persistent feature of cold water between 75 and 100 m north of Elephant Island should be investigated in relation to zooplankton distribution and primary production.

9. Observations of only chlorophyll *a* concentrations limited the assessment of phytoplankton populations as food reservoirs for krill. We recommend that measurements of the size distribution of cells, carbon biomass, and species composition be made in addition to measurements of chlorophyll *a* concentrations.

10. The factors that control krill recruitment have been described in a conceptual model in WG-EMM-95/15. The 1994/95 field season data analysed during the workshop seem to confirm the first half of the model (early krill spawning, high larval production, low salp density). The second half of the model (recruitment) can be tested during the coming austral summer season 1995/96. We

strongly recommend a survey, or at least a representative sampling program, in the Elephant Island area at that time to provide the essential data to test the prediction made regarding krill recruitment.

11. A two-frequency approach was shown to be useful in delineating size classes and in identifying a previously undescribed acoustic scattering layer. In the future, multiple frequency echosounders and species delineation techniques should be used to apportion the total integrated echo energy to the various scatters. Frequency combinations which include both the Rayleigh and geometric scattering regimes are most powerful when using inversion techniques.

Table I.1: Antarctic 1994/95 cruises conducted by Member countries.

Dates of Entire Cruise (Dates at 55°W Transect)	Country	Observations
26 November - 5 December 1995 (2 December 1995)	Germany	North and south of Elephant Island; water properties, krill/zooplankton; CTD, RMT8 (4 mm) net
30 November - 30 December 1994 (15 - 16 December 1994)	Japan (Leg I)	North of South Shetland Islands; krill/zooplankton, phytoplankton, nutrients; acoustics, CTD, rosette, WP-2 (0.350 mm), KYMT, (3 x 3 m with 3.4 mm mesh), MOCNESS at three stations (0.335 mm mesh), Furuno FQ-72 echosounder
4 - 17 January 1995 (7 - 8 January 1995)	Republic of Korea	Bransfield Strait and northwestern Weddell Sea; krill/zooplankton, phytoplankton, water properties, nutrients; CTD, rosette, Bongo (0.333 mm mesh and 0.505 mm mesh), MOCNESS (0.505 mm mesh)
15 January - 12 February 1995 (18 - 19 January 1995)	Japan (Leg II)	North of South Shetland Islands; krill/zooplankton, phytoplankton, water properties, nutrients; acoustics, CTD, rosette, WP-2 (0.350 mm), MOCNESS (0.335 mm mesh) at six stations
11 January - 4 February 1995 (24 - 25 January 1995)	USA (Leg I)	North and south of Elephant Island; krill/zooplankton, phytoplankton, nutrients; acoustics, CTD, IKMT (1.8 x 1.8 m with 0.505 mm mesh), rosette, Simrad EK-500 echosounder
8 February - 5 March 1995 (18 - 19 February 1995)	USA (Leg II)	North and south of Elephant Island; krill/zooplankton, phytoplankton, nutrients; acoustics, CTD, IKMT (1.8 x 1.8 m with 0.505 mm mesh), rosette, Simrad EK-500 echosounder

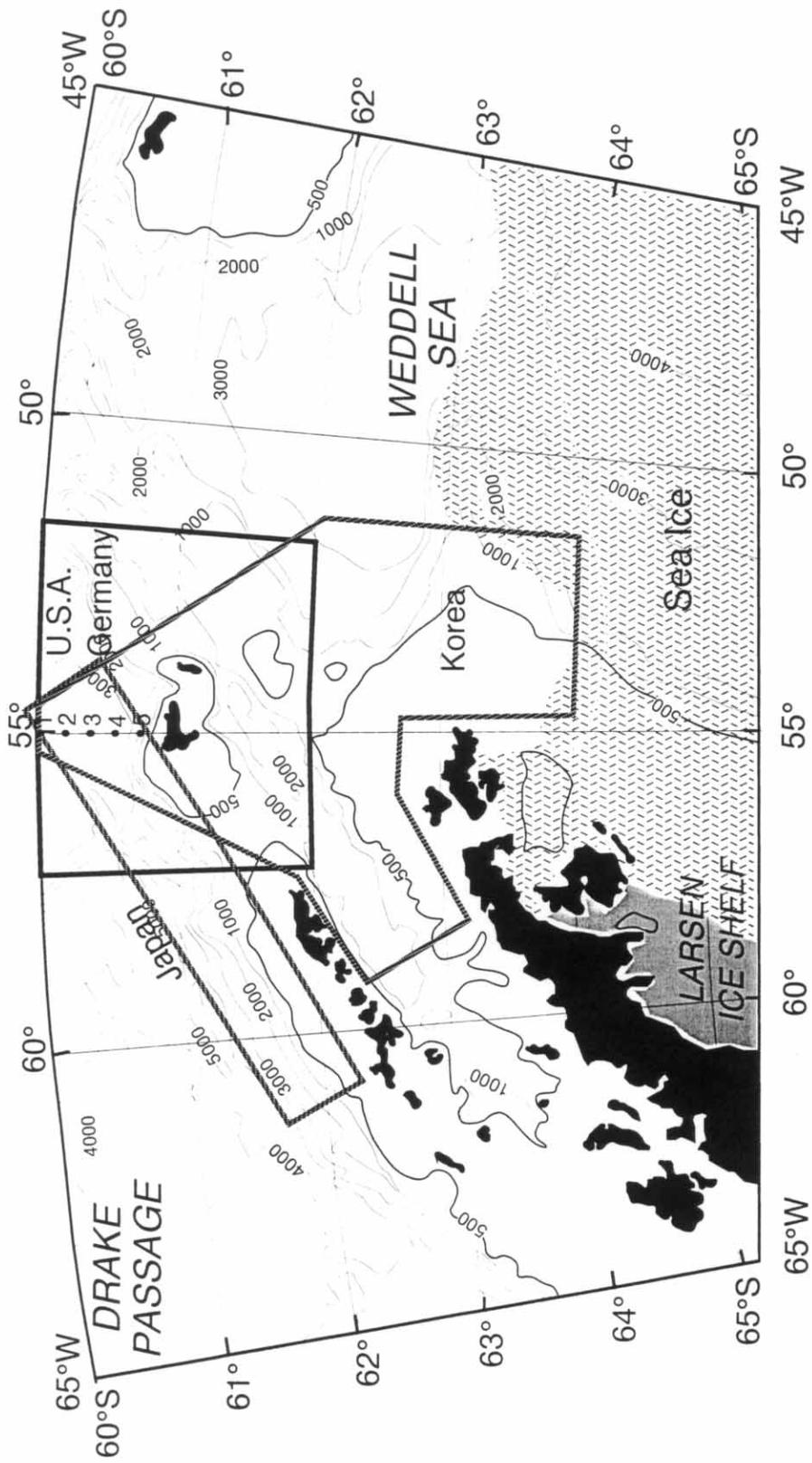


Figure I.1: Survey areas covered by different nations during late November 1994 to late February 1995.

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

(Hobart, Australia, 10 to 18 October 1995)

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REPORT OF THE WORKING GROUP ON FISH STOCK ASSESSMENT

(Hobart, Australia, 10 to 18 October 1995)

INTRODUCTION

1.1 The meeting of the Working Group on Fish Stock Assessment (WG-FSA) was held at CCAMLR Headquarters, Hobart, Australia from 10 to 18 October 1995. The Convener, Dr W. de La Mare (Australia), chaired the meeting.

ORGANISATION OF THE MEETING AND ADOPTION OF THE AGENDA

2.1 The Convener welcomed participants to the meeting and introduced the Provisional Agenda which had been circulated prior to the meeting. The following additions were made:

- Sub-item 7.3 'Notification of Intended Research Activity';
- Sub-item 10.2 'UN Convention on Straddling Stocks';
- Sub-item 11.3 'Work of Scientific Observers - Observer Data Handling and Future Work'; and
- Item 12 'Advice to the Scientific Committee'.

With these additions the Agenda was adopted.

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

2.3 The report was prepared by Drs D. Agnew (Secretariat), A. Constable (Australia), J. Croxall and I. Everson (UK), S. Hanchet (New Zealand), R. Holt (USA), G. Kirkwood (UK), Lic. E. Marschoff (Argentina), Dr D. Miller (South Africa), Prof. C. Moreno (Chile), Drs G. Parkes (UK), G. Watters (USA) and Mr R. Williams (Australia).

REVIEW OF AVAILABLE INFORMATION

Data Requirements Endorsed by the Commission in 1994

3.1 At its last meeting, WG-FSA identified specific data that were required for its future work (SC-CAMLR-XIII, Annex 4, Appendix D). The Data Manager reported that a number of requests for information on *Dissostichus eleginoides* had been fulfilled through submissions of scientific observer data and reports to the present meeting, the completion of new data reporting formats and the acquisition of catch data from *D. eleginoides* fisheries in areas adjacent to CCAMLR (see Appendix D).

3.2 On the other hand, little of the information from other fisheries requested in Appendix D, Annex 4 of SC-CAMLR-XIII had been forthcoming. The Working Group recalled that there had often been poor responses to similar forms of data request in the past, and concluded that repeated requests for data through the format given in Appendix D did not seem to be particularly effective. Further discussion of this problem is reported in section 11.

Fisheries Information

New Catch, Effort, Length and Age Data

3.3 The Data Manager reported that revised historical catch data from fishing directed at *Lepidonotothen squamifrons*¹ on the Ob and Lena Banks (Division 58.4.4) had been submitted by Ukraine, and were now incorporated in the CCAMLR databases. Data on pre-1970 catches of *Notothenia rossii* in Subarea 48.3, obtained from the FAO, have also been incorporated in the CCAMLR databases (WG-FSA-95/17). Revisions of Ukrainian historical catches of *Pleuragramma antarcticum* and *Chaenodraco wilsoni* in Divisions 58.4.1 and 58.4.2 are currently being validated by the Secretariat.

3.4 Dr K.-H. Kock (Chairman of the Scientific Committee) reported that cooperative research between Germany and Russia aimed at acquiring and analysing historical USSR scout vessel information was likely to yield data which could be submitted to CCAMLR in the near future. The Working Group encouraged further initiatives towards the revision of historical catch data records since these data are often important in determining critical parameters of stocks prior to exploitation. However, it acknowledged that this work was usually only possible with the provision of adequate funds.

¹ Formerly known as *Notothenia squamifrons*

3.5 The Data Manager reported that the Secretariat had experienced some difficulties in processing haul-by-haul data from the *D. eleginoides* fishery this year. These difficulties were primarily the result of the submission of data in unconventional formats, and the large volume of very detailed data submitted by scientific observers. The suggestions of the Working Group towards a standardisation of the formats for submitting scientific observer reports and observer data (see paragraphs 11.10) should alleviate these problems, although the Secretariat anticipates a continued heavy workload should the quantity of submitted data continue to increase.

3.6 Further problems were caused by submission on computer spreadsheets, which are difficult to convert to the data structures expected by a relational database. Members are urged to submit data in the agreed CCAMLR reporting formats.

3.7 As requested by WG-FSA-94 (SC-CAMLR-XIII, Annex 4, paragraph 4.22), the CCAMLR database of haul-by-haul data from the *D. eleginoides* fishery has been modified so that most vessels are now individually identified, enabling analyses of standardised catch per unit effort (CPUE) to be performed across fleets and years (Appendix E, paragraphs 3.5 to 3.8). Efforts towards the correct identification of vessels should continue, especially when vessels re-flag or re-register, and the Working Group recommended that the Scientific Committee consider mechanisms to achieve this.

3.8 A study of discrepancies between various data sources (WG-FSA-95/25 Rev. 2) found that sometimes processed rather than live weight was reported, zero catches were unreported, or series of lines were amalgamated. However, it concluded that these errors were probably the result of misunderstandings of what data were required by CCAMLR and of the purpose and importance of the data. The Working Group recommended that attempts be made to clarify misunderstandings that national reporting agencies might have, to explain that accurate and complete data were extremely important for the work of WG-FSA and that errors could significantly bias the Working Group's analyses.

3.9 Information contained in the reports of scientific observers and the haul-by-haul data reported to CCAMLR for the same vessels revealed a number of discrepancies:

- catches from the two report types differed by $\pm 1-2\%$. The differences were probably the result of the application of slightly different conversion factors by the fishing vessel masters and scientific observers. Four conversion factors were described in the scientific observer reports;

- there were two cases where the two reports were identical, which suggested that the vessel reports had been compiled by the scientific observer. In general, this should not be recommended since it reduces the capacity to evaluate the accuracy of the reports provided by vessel masters. This ability would be particularly important in fisheries where there was less than 100% scientific observer coverage;
- three hauls out of the 208 had been reported by the scientific observers as having zero catch of *D. eleginoides*, but did not appear in the vessel reports;
- for one vessel, the observer had reported 90 hauls and the vessel 74. The total catch was the same from both sources, however, implying that this was the result of the amalgamation of hauls in the vessel report; and
- although there were scientific observer reports on six vessels, only five vessels are represented in the haul-by-haul data received to date by CCAMLR.

3.10 With the exception of the last point, these differences were relatively small. However, a refinement of conversion factors could reduce some of the discrepancies (paragraphs 3.8 and 3.9). It is also important that all hauls are reported separately, irrespective of catch quantity, so that CPUE is unbiased.

3.11 Other analyses from scientific observer reports are discussed in paragraphs 3.13, 5.13 and 8.54.

Scientific Observer Information

3.12 Eighteen scientific observer reports were available to the Working Group this year (WG-FSA-95/4 Rev. 1, 95/5 Rev.1, 95/16 Rev. 1, 95/46, 49, 50, 51, 52, 53, 54, 55, 56, 57, SC-CAMLR-XIV/BG/23, 24, 25, 26 and 27), most of which reported on observations of the longline fishery for *D. eleginoides* in Subarea 48.3 (scientific observers were obligatory on every vessel engaged in this fishery in the 1995 season). In addition, a number of scientific observers submitted their raw data directly to the Secretariat, generally using the data collection formats given in the *Scientific Observers Manual*. The Working Group expressed its deep appreciation to all scientific observers active in the 1994/95 season, and emphasised that it placed great importance on scientific observer information. These reports, as well as the raw scientific observer data, were used extensively by the Working Group for a number of different analyses.

3.13 A number of important points were noted from these reports:

- there appear to have been some difficulties in recognising maturity stage (Appendix E, paragraph 2.23);
- paper WG-FSA-95/4 reports that some vessels use a number of short longline sets while searching for good fishing areas;
- considerable information on by-catch was reported by all scientific observers (Table 1);
- paper WG-FSA-95/4 indicates that some gear loss is associated with the fishery. The Working Group had no information to quantify this loss, but Mr D. Japp (invited expert) reported that information from the South African fishery (WG-FSA-95/20) suggests that gear loss may be significant in longline fisheries;
- data on the proportion of fish with a jellymeat condition, which are discarded and may not always be reported, are available from some reports. If retained, these fish may provide important biological information;
- some reports include details of catch losses to marine mammal predation (Table 2);
- some reports include information on the numbers of other longline vessels in the scientific observer's vicinity, which may assist quantification of total effort in the fishery; and
- most reports contain detailed environmental information which is not, currently, recorded in the CCAMLR databases. A study of a trawl fishery at Macquarie Island (WG-FSA-95/6) indicated that such information may be important in interpreting catch and effort data from the fishery.

Table 1: By-catch in the *D. eleginoides* longline fishery in Subarea 48.3 during the 1995 season. All data in kilograms.

Vessel	<i>Paralomis</i> spp.	Raji -dae	Lamni -dae	Macrouri -dae	Mori -dae	Other Fish ¹	Other Invertebra -tae	Total Catch ² (kg)	% By-catch
<i>RK-1</i>	92	1153		756	11	13		254985	0.79
<i>Ihn Sung 66</i>		31879		797				340705	9.59
<i>Isla Camila</i>	266	5565		125	158			494241	1.24
<i>Itkul</i>		236		2450				12225	21.97
<i>Arbumasa XXII</i>	91	12715		1122	177		18	140053	10.08
<i>Estela</i>	7	307		1321				134413	1.22
<i>Marunaka</i>	43	1548	120	5942	371	1	1	226329	3.55
<i>Mar del Sur II</i>	14	2293		2373				83390	5.61
<i>Arbumasa XX</i>	35	1557		7295	830			91917	10.57
<i>Arbumasa XXIII</i>	34	11325		1389	665		1	212637	6.31
Total	582	68577	120	23570	2210	14	20	1990895	4.78
% By-catch	0.02921	3.44453	0.00603	1.18389	0.11103	0.00070	0.00100	Mean =	7.09
								Std =	6.43
								Max =	21.97
								Min =	0.79

¹ Includes Muraenolepidae, Nototheniidae and Channichthyidae

² Includes by-catch and *D. eleginoides*

Table 2: Records obtained from scientific observer reports of fish lost directly from the line as it is being hauled, and from the line attributed to killer whale predation.

Reference/Vessel	Lost		Loss Attributed to Killer Whales		
	Lost Fish	Total Catch Number	Number of Haul	Estimated Lost Weight ¹ (kg)	% of Total Catch of the Vessel
WG-FSA-95/49 <i>Arbumasa XXIII</i>	142	13992	1	3252	3
WG-FSA-95/50 and 52 <i>Estela</i>			No interactions observed		
WG-FSA-95/51 <i>Marunaka</i>			3	8314	4
WG-FSA-95/53 <i>Mar del Sur II</i>			3	8673	11
WG-FSA-95/54 <i>Arbumasa XX</i>			2	4837	6
WG-FSA-95/55 <i>Arbumasa XXIII</i>			4	14860	7

¹ Estimated using the mean catch per haul of each vessel

3.14 The Working Group experienced some difficulty in assimilating the information contained in the scientific observer reports, since the reports were usually very detailed and often extended to considerable analysis of the scientific observer data. The Working Group considered that there is a need for standardisation of scientific observer report formats, and a mechanism for archiving the information contained in them, which would both reduce the amount of work required of scientific observers and enable observer data to be analysed in a constructive way by the Working Group; this is taken up further in paragraphs 11.9 to 11.11.

Research Surveys

3.15 Four research or exploratory surveys were described in documents submitted to the meeting. Papers dealing with the results of the Argentinian survey of Subarea 48.3 are discussed further under Agenda Item 5, the other surveys being discussed here.

3.16 Paper WG-FSA-95/10 described the results of French exploratory trawling in Subarea 58.6 (Crozet archipelago). These expeditions, by a single vessel, took place in six separate seasons between 1983 and 1995 and found *D. eleginoides* to be dominant in all catches. Although it was highly variable, CPUE averaged about 0.6 tonnes per hour, some six times lower than at Kerguelen. Trawling took place in progressively deeper water over the six seasons (hauls were made at maximum depths of 300 m in 1983 and 750 m in 1995). Data on length composition indicate that larger fish were caught in deeper water, supporting evidence for the distribution of sizes by depth in this species discussed by the Workshop on Methods for the Assessment of *Dissostichus eleginoides* (WS-MAD) (Appendix E, paragraph 2.38). The paper concluded that there were limited resources in the subarea to support a continuous commercial fishery.

3.17 The Working Group welcomed this detailed report of exploration in an area for which it has never performed a stock assessment. Although catch rates were low, it was noted that they were somewhat similar to those obtained in a developing fishery around Macquarie Island (WG-FSA-95/6), and that there may therefore be some interest in a limited fishery in the area in the future. However, it was difficult to draw conclusions about trends in CPUE since the number of hauls made in some years was quite low. Submission of all haul-by-haul catch, effort and biological data from these exploratory cruises was strongly encouraged so that the Working Group might attempt detailed analyses at a future meeting.

3.18 Prof. G. Duhamel (France) informed the Working Group that France was considering a comprehensive research survey in Subarea 58.6 for 1997, which should contribute to such an assessment. The Working Group especially welcomed this news. He also informed the meeting that

France had carried out a myctophid survey around Kerguelen (Division 58.5.1) in 1995. This survey was conducted simultaneously with a study of king penguin foraging and diet. The results will be presented at the next meeting of WG-FSA. The attention of the Working Group on Ecosystem Monitoring and Management (WG-EMM) was drawn to this study.

3.19 Paper WG-FSA-95/11 described ichthyoplankton samples obtained during the Italian oceanographic cruise in the western Ross Sea (Subarea 88.1) in November/December 1994 (see also paragraph 3.30). *P. antarcticum* was the most abundant post larvae and juvenile fish followed by *Chionodraco* spp. A high number of larvae of *Trematomus lepidorhinus* were found in a single station in Terra Nova Bay, but were absent from all other stations. Both abundance and diversity of fish larvae were greater inshore than offshore.

3.20 The Working Group welcomed this study, from an area where there is little information on larval fish distribution, and noted that although there has never been a fishery in the area, *P. antarcticum* has been taken in the past by commercial vessels in Area 58.

3.21 Paper WG-FSA-95/6 described the results of exploratory fishing for *D. eleginoides* to the immediate west of Macquarie Island. Although this island is not within the Convention Area, this fishery has some similarities with CCAMLR fisheries for *D. eleginoides*. Despite repeated trawling in the same location for six weeks, CPUE was highly variable, showed no evidence of systematic depletion, and appeared to increase following storms. These changes were interpreted as evidence of fish movement, possibly following oceanographically induced changes in prey distribution. The Working Group agreed that the paper provided further argument for the collection of environmental variables in other *D. eleginoides* fisheries.

Selectivity Studies

3.22 Dr Everson drew the attention of the Working Group to a recent report of the ICES Working Group on Fishing Technology and Fish Behaviour (ICES CM 1995/B:2) which included reports of the Study Group on Unaccounted Mortality (ICES CM 1995/B:1 Ref. Assess) and the Sub-group on Selectivity Methods.

3.23 The Study Group had considered the following components of fishing mortality: landed catch, illegal and misreported landings, discard mortality, escape mortality, ghost fishing mortality, avoidance mortality, predation mortality and habitat degradation mortality. It was recognised that the relative magnitudes of each of these would vary according to target species, locality and gear. A key factor in determining mortality arising from the stress associated with either escape or avoidance

of gear was the size and condition of the fish and it was noted that in a recent study, contrary to expectation, mortality is higher in small fish when compared to larger fish escaping from trawls.

3.24 The Sub-group on Selectivity Methods has prepared a draft 'Manual on Recommended Methodology of Selectivity Experiments' which would be finalised later in the year for presentation to the 1995 ICES Annual Science Conference.

3.25 The Working Group welcomed these developments and asked the Secretariat to request copies of future reports from the ICES Secretariat.

Fish and Crab Biology/Demography/Ecology

Taxonomy

3.26 Papers WG-FSA-95/8 and 9, available as abstracts, review the genus *Channichthys* and describe four new species. The subject had been discussed during a recent meeting of the Antarctic Fish Network of the European Science Foundation in Liege, Belgium, at which doubts had been raised regarding the validity of the proposed species. The Working Group was unable to comment at this stage.

Reproduction

3.27 Ovarian maturation rates in three Channichthyids from South Georgia are discussed in WG-FSA-95/32. It is concluded that the transition from immature to spawning in female fish takes about one year for *Champocephalus gunnari* and *Pseudochaenichthys georgianus*. For *Chaenocephalus aceratus* this transition is thought to take about four years. It is concluded that, as a general rule, the spawning stock biomass should be based on fish of maturity stage III-V and not stage II-V.

3.28 Information on sex ratios and maturity stages for *D. eleginoides* was presented in the reports of two CCAMLR scientific observers. Catches from *Itkul* (WG-FSA-95/12) tended to contain more male than female fish. The sex ratio of fish from *Ihn Sung 66* (WG-FSA-95/16) was approximately 50:50, but varied greatly from haul to haul, probably indicating a high degree of mobility of the fish. In both studies many of the larger fish were coming into maturity stage III, confirming that the spawning season was likely to be near to the middle of winter.

3.29 The need for closer standardisation of technique when determining maturity stages for *D. eleginoides* had been identified as a priority task for action following WS-MAD (Appendix E, paragraph 2.24).

Larval Fish Distribution

3.30 Paper WG-FSA-95/11, based on a recent survey, describes the distribution of larval fish in the Ross Sea (see also paragraph 3.19). Although there was one haul containing large numbers of *T. lepidorhinus* (larvae), the dominant species in the catches was *P. antarcticum* (post larvae and juveniles). The largest catches of early life history stages of *P. antarcticum* were made to the southern end of the survey area.

3.31 Paper WG-FSA-95/7 describes the distribution of larvae and assumed spawning areas of *Electrona carlsbergi* in the southwest Atlantic. Survey results indicate that the main spawning areas are in the sub-Antarctic and sub-Tropical Frontal Zones and that the fish migrate into the Antarctic Polar Frontal Zone to feed. These observations therefore corroborated information previously supplied to the Working Group.

Feeding and Diet

3.32 Information from *D. eleginoides* taken on longlines presented in WG-FSA-95/12 and 16 indicates that, of the less than 10% of fish with food in their stomachs, over half had fish in their stomachs. Other major components were crabs and squid. It was felt that such results would be biased for two reasons. Firstly, because hook-caught fish were actively searching for food and therefore likely to have empty stomachs and secondly, because when hooked they are likely to regurgitate their stomach contents. In view of these biases, the Working Group considered whether it was worth continuing to recommend that such data be collected by scientific observers. It was agreed that, although the data would be of limited quantitative value, they did provide qualitative estimates of value in an ecosystem analysis.

3.33 Information from *C. gunnari* in Subarea 48.3 during February 1995 in WG-FSA-95/36 indicates that around South Georgia the fish were feeding predominantly on crustacea, taking approximately equal proportions of *Euphausia superba* and the Hyperiid amphipod *Themisto*. In the vicinity of Shag Rocks a much larger proportion of *Themisto* was present in the stomachs. Fish represented only a very small proportion of the diet at both sites. These results suggest that the availability of krill around South Georgia was about average.

3.34 At Kerguelen there was a seasonal change in the diet of *C. gunnari*, which during November were feeding almost totally on the euphausiid *E. frigida*, to January, February and March 1995 when the dominant component in the diet was hyperiid amphipods (WG-FSA-95/13). *C. gunnari* at Kerguelen are thought to be major food for the larger icefish *Channichthys rhinocerotus*.

3.35 Studies on feeding, particularly involving krill, had been highlighted at WG-EMM. The Working Group emphasised the need for such studies to be based on large sample sizes and also that the sampling design should take account of the aggregated distribution of *C. gunnari*.

Parasites

3.36 The metazoan endoparasitic fauna found in *D. eleginoides* is described in WG-FSA-95/28. The frequency of occurrence and abundance of eleven parasites had been recorded from fish from Chile, Patagonia and South Georgia. These had been compared with published information from the sub-Antarctic islands in the Indian Ocean. The infestation ratios and parasite species indicate that there is a slightly closer relationship between fish from Subarea 48.3 and the Indian Ocean sector than between fish from Subarea 48.3 and South America. The Working Group considered that this similarity was due to similar host parasite cycles being present at South Georgia and the Indian Ocean sites rather than a real closeness of breeding populations and therefore urged caution in drawing conclusions on the distribution of stocks from parasite information alone.

Age Determination and Growth

3.37 Papers dealing with age determination of *D. eleginoides* were considered during WS-MAD and the conclusions summarised in the Workshop report (Appendix E).

3.38 During recent seasons, collections of otoliths and scales from *D. eleginoides* had been made as a result of the CCAMLR Scheme of International Scientific Observation. It was accepted that extensive analysis of these samples should await further study on otolith and scale reading but in the meantime summary information on samples should be forwarded to CCAMLR.

Developments in Assessment Methods

3.39 Developments and evaluations of assessment methods were presented in WG-FSA-95/33 and 41.

3.40 Paper WG-FSA-95/33 reviewed the use of stock depletion models based on longline catch data for the assessment of *D. eleginoides* in Subarea 48.3 and in Chilean waters. This was an extension of analyses conducted for the Working Group last year (WG-FSA-94/24²; see SC-CAMLR-XIII, Annex 4, paragraphs 4.8 to 4.12 for discussion) but extended the analysis to include appropriate commercial and experimental data from the four following sources:

- (i) commercial fisheries data in the CCAMLR database from Chilean longline vessels operating in Subarea 48.3 and adjacent areas during 1991/92 (22 data sets) and 1992/93 (60 data sets);
- (ii) data from the commercial fishery for *D. eleginoides* toothfish off Valdivia, Chile in mid-1992 (four data sets);
- (iii) data from experimental fishing in southern Chile in 1991 and 1992 (15 data sets); and
- (iv) depletion experiments undertaken in Subarea 48.3 during the 1993/94 fishing season (six data sets).

3.41 The paper presented the results from applying the Leslie depletion method (Leslie and Davis, 1939³) to the suitable series of data. One hundred and seven data series were found to fulfil the required criteria of single vessels operating in a localised area for a period of several days. Of these, 18 (17%) showed significant negative slopes (one tailed *t*-test to detect significant negative slope, $p < 0.05$). The paper concluded that applying this model to longline catch data for assessing the abundance of *D. eleginoides* is not generally appropriate on the scale of single longline vessels operating in localised areas. Two factors were identified as being potentially important: (i) *D. eleginoides* is probably a highly mobile predator; and (ii) the relationship between catch per hook and abundance may not be able to be described by the simple linear model applied in this analysis.

² Parkes, G. and G. Pilling. 1994. Comments on the use of stock depletion models for the assessment of local abundance of toothfish in Subarea 48.3 and adjacent waters. Document WG-FSA-94/24. CCAMLR, Hobart, Australia.

³ Leslie, P.H. and D.H.S. Davis. 1939. An attempt to determine the absolute number of rats on a given area. *J. Anim. Ecol.*, 8: 94-113.

3.42 Paper WG-FSA-95/26 provided an assessment of the Falkland/Malvinas longline fishery for *D. eleginoides*, examining trends in CPUE data between 1994 and mid-1995. Some data were also able to be analysed using the Leslie depletion method. A trend of declining CPUE in 1994 was followed by an increase in 1995. The paper concluded that the assumption that no fish move into or out of the area being analysed was violated; the declines and increases in CPUE may have arisen from either short-term or seasonal migrations of fish through the area.

3.43 The Working Group agreed that the mobility of these fish is likely to influence CPUE. Understanding the migratory patterns of these fish (over large geographic areas, with depth and timing within seasons) will be an important factor in understanding how applicable these models are to assessments of this stock. Despite this, many of the data series showed strong temporal trends in CPUE even though the overall trends were highly variable and the regressions not significantly negative. Analyses presented elsewhere (WG-FSA-95/6; paragraphs 5.17 to 5.21) showed that trends in CPUE can be influenced greatly by vessel, season and weather conditions. These factors may have confounded these analyses and should be incorporated into future analyses of this type.

3.44 Paper WG-FSA-95/41 presents the development of a general yield model, extending the application of the krill yield model to assessments of fish stocks generally as discussed in 1994 (SC-CAMLR-XIII, Annex 4, paragraph 7.4). The new version incorporates a standard application of differential equations to solving fishery problems. It provides flexibility in assessing the influence of different patterns of growth, natural mortality, spawning and fishing on the estimates of yield per recruit. In a similar manner to the krill model, it can evaluate the performance of a stock under different catch regimes, nominated either as a proportion of the pre-exploitation biomass (γ) or as a specified catch. The model uses an adaptive Runge-Kutta procedure to calculate catches over each year by integrating a set of differential equations which incorporate functions that specify the rate of change or magnitude of parameters, such as growth, mortality, age-dependent selectivity and seasonal patterns in fishing mortality, at specified time intervals during the year. This model also includes an option for a stock to experience a known catch history before the constant catch regime is introduced.

3.45 The method for the projections and the way in which the spawning stock is modelled under specified catch regimes during simulations is presented in Appendix F. The model will be further refined over the intersessional period.

3.46 The results from the program were checked by running the input parameters of two models from Butterworth et al. (1994)⁴ and by using the program to conduct a yield-per-recruit analysis to

⁴ Butterworth, D.S., G.R. Gluckman, R.B. Thomson, S. Chalis, K. Hiramatsu and D.J. Agnew. 1994. Further computations of the consequences of setting the annual krill catch limit to a fixed fraction of the estimate of krill biomass from a survey. *CCAMLR Science*, Vol. 1: 81-106.

compare with the CCAMLR software for a Thompson and Bell yield-per-recruit analysis. The outputs from the new program were comparable with these two programs which had been previously verified by the CCAMLR Data Manager.

3.47 On the basis of these results, the Working Group accepted the model for use in assessment work at this meeting and requested that the CCAMLR Data Manager validate the program in the intersessional period. The Working Group noted that a general model of this kind is now required for routine stock assessments and thanked the authors for producing the new program for use at this meeting.

REPORT OF THE WORKSHOP ON METHODS FOR THE ASSESSMENT OF *DISSOSTICHUS ELEGINOIDES*

4.1 The Workshop on Methods for the Assessment of *Dissostichus eleginoides* (WS-MAD) was held at CCAMLR Headquarters, Hobart, Australia from 5 to 9 October 1995. The main aim of the Workshop was to develop methods for assessing the biomass and status of *D. eleginoides* stocks. The full terms of reference of the Workshop are given in SC-CAMLR-XIII, paragraph 2.17.

4.2 In addition to participants from Member States, two invited experts, Mr D. Japp from the Sea Fisheries Research Institute, South Africa and Dr A. Zuleta from the Instituto de Fomento Pesquero, Chile, also participated in the Workshop.

4.3 The Workshop first reviewed the approaches taken in previous CCAMLR assessments of *D. eleginoides*, and the approaches used in the assessments of the longline fishery for *D. eleginoides* in Chile and the trawl and longline fishery for hake in South Africa. Key problem areas in CCAMLR assessments were identified and potential solutions were discussed.

4.4 A brief summary of key sections of the Workshop report (Appendix E) is given below.

Biology and Demography

4.5 Shortcomings have been noticed in ageing *D. eleginoides* using both otoliths and scales. These would affect the accuracy of age/length keys derived from the estimated ages. Further efforts are needed to improve age determination using both methods. Also, experiments need to be designed and undertaken to determine the magnitude of biases in estimated age/length keys caused by the use of different hook types and sizes, and different bait sizes and species.

4.6 Existing age and length data were reviewed, and a table of estimates of size-at-age was prepared using data from trawl catches, trawl surveys and longline catches. In addition, revised estimates of von Bertalanffy growth parameters were calculated using a non-linear estimation procedure.

4.7 There is no precise information on the spawning location of *D. eleginoides*. The maturity scale developed for nototheniids has been used by observers examining catches from the *D. eleginoides* fishery. However, results from scientific observer reports indicated that there had been difficulties in recognising specific maturity stages. The Workshop recommended a number of detailed investigations designed to refine estimates of age-at-maturity.

4.8 *D. eleginoides* has a widespread distribution in the sub-Antarctic zone, being found off the east and west coasts of South America, South Georgia and Shag Rocks, South Sandwich Islands, Kerguelen Plateau, Crozet Island, Ob and Lena Banks, and Macquarie Ridge. There are, however, some areas of uncertainty, including the southern limit of distribution in the South Orkney/Antarctic Peninsula and southern Kerguelen Plateau areas, where the distribution may be confused with that of *Dissostichus mawsoni*. Recent findings of *D. eleginoides* on the South African shelf and the Campbell Plateau south of New Zealand, as well as a much larger population than previously thought on the Macquarie Ridge, demonstrate that our knowledge of the distribution of this species is still imperfect. It is likely that fish occur in other areas which have not yet been investigated.

4.9 Information on the extent and timing of movements was reviewed. Some information exists for possible movements on a time-scale of a few days from depletion experiments, and there is weak evidence relating to seasonal movements. The presence of larger fish in deeper water seems well established, and data from the Chilean fishery indicate that *D. eleginoides* apparently can move in depths to around 3 000 m. However, there is no information on the extent to which *D. eleginoides* is capable of movement over long distances in midwater. There is no direct information on movements between geographic areas but there is some indirect information from parasite loadings that the Chilean population is split at 47°S. Parasite loadings also suggest that fish from southern Chile to the southern Patagonian shelf have similar origins. There are greater differences between fish from the southern Patagonian shelf and South Georgia, which may reflect different host-parasite cycles (see paragraph 3.36).

4.10 The Workshop agreed that the most promising method for obtaining direct observations on movements on all temporal and spatial scales was from tagging experiments in commercial fishing areas, and it recommended that high priority be given to such studies in the future.

4.11 There do not appear to be any known spawning or feeding aggregations, but many fisheries exploit areas of consistently higher than average abundance. Acoustic methods using deep-towed bodies may provide some information on this. There is also no information at present on the number of stocks of *D. eleginoides*. Direct investigation by analysis of mitochondrial DNA has encountered technical problems.

Abundance

4.12 The Workshop reviewed a variety of methods for estimating the abundance of *D. eleginoides*. A number of attempts have been made to estimate local abundance using CPUE data from depletion experiments, but no consistent depletion has been detected. Longer term depletion-type analyses using CPUE data have also been attempted by WG-FSA at previous meetings, but these too have not revealed any consistent patterns.

4.13 Since this lack of consistency might be the result of a large number of variables influencing the CPUE and its relationship with abundance, standardisation of the CPUE series was considered to be a high priority. An analysis of the CPUE data using Generalised Linear Models (GLMs) was initiated during the Workshop.

4.14 A large number of bottom trawl surveys have been undertaken on the shelf in Subarea 48.3 during the last 20 years. These surveys were not targeted specifically at *D. eleginoides*, covering only the shallower part of their range, however, catches of young fish were occasionally taken. The Workshop initiated an analysis of fish density-at-length in order to develop an index of recruitment to the size classes fished by longlines.

Estimates of Total Catches

4.15 Circumstantial evidence and confidential records indicate clearly that the reported catches of *D. eleginoides* by longliners in Subarea 48.3 and adjacent banks do not represent the true level of removals. Since many of the methods of estimating the abundance of *D. eleginoides* rely on estimates of total removals, the Workshop agreed that every effort should be made to estimate these as accurately as possible.

4.16 The Workshop agreed on a procedure for estimating total removals that required the use of confidential records which are not officially available. The resulting estimates of real catches are shown in Table 3 of Appendix E.

4.17 The estimated total removal in Table 3 for each year is an approximation and it is likely to be slightly underestimated. However, it is apparent that over the last four years the reported catch is only about 40% of the total catch from Subarea 48.3 and adjacent areas.

Yield

4.18 Estimates of sustainable yields in previous CCAMLR assessments of *D. eleginoides* have been calculated from yield-per-recruit analyses. An alternative method for estimating precautionary yields has been used for the myctophid *E. carlsbergi* (WG-FSA-94/21⁵), similar to the method originally developed for estimating precautionary total allowable catches (TACs) for krill. A generalised version of this fish yield model was presented to the Workshop (WG-FSA-95/41). This model takes account of both demographic uncertainty and stochastic variability in recruitment.

4.19 The Workshop also discussed other assessment methodologies that might overcome some of the difficulties previously encountered in CCAMLR stock assessments for *D. eleginoides*. These are listed in paragraph 2.72 of the Workshop report (Appendix E).

Recommendations to WG-FSA

4.20 As a result of its discussions, the Workshop developed recommendations under four main areas:

- A. An experimental approach to assessing stock abundance must be initiated.
- B. Data consistency and quality from the commercial fishery must be improved.
- C. Estimates of biological and demographic parameters must be improved.
- D. Specific recommendations for assessments at WG-FSA-95 should be made.

The detailed recommendations are listed in paragraph 4.1 of the Workshop report (Appendix E).

4.21 The Working Group observed that the key recommendations of the Workshop related to the accuracy of estimates of total catches, the need for the development of new assessment methods,

⁵ Constable, A.J. and W.K. de la Mare. 1994. Revised estimates of yield for *Electrona carlsbergi* based on a generalised version of the CCAMLR krill yield model. Document WG-FSA-94/21. CCAMLR, Hobart, Australia.

and the need for a directed research program. In relation to the need for a directed research program, it was emphasised that it is no longer possible to rely on fishery-dependent data alone.

4.22 The Working Group endorsed all the recommendations of the Workshop.

ASSESSMENTS AND MANAGEMENT ADVICE

New Fisheries

5.1 CCAMLR received one proposal for a new fishery in 1995, from Australia (CCAMLR-XIV/8). The proposal was for a single trawler to undertake an exploratory cruise in Division 58.5.2 (Heard Island) to explore deeper water than has hitherto been investigated by Australian research cruises (>800 m), and Division 58.4.3 (Elan and Banzare Banks) for which there are no records of fishing or research except one paper submitted to the present meeting (WG-FSA-95/47).

5.2 A wide range of data will be collected by an on-board observer (detailed in CCAMLR-XIV/8). This information will be analysed by Australian scientists and presented at the next meeting of WG-FSA.

5.3 The Working Group congratulated Australia on the detail contained within the proposal. Of particular note was the assurance that the vessel would carry a transponder on board and that the vessel's position would be monitored using a vessel monitoring system by Australia.

5.4 The Working Group agreed that considering the paucity of existing information on the resources in Division 58.4.3, and the experience of the exploratory fishery in the South Sandwich Islands in 1993, for which similarly little was known (CCAMLR-XI/7⁶), the TACs suggested in the proposal would be unlikely to adversely affect the stocks in Division 58.4.3. It also agreed that bearing in mind that TACs already applied to *D. eleginoides* and *C. gunnari* in Division 58.5.2 (Conservation Measure 78/XIII), the suggested TACs for other species caught in the new exploratory cruise in that area were unlikely to cause problems. The full set of TAC proposals is listed in Table 3.

⁶ Delegation of Chile. 1992. Application for permit to carry out exploration around the South Sandwich Islands in order to determine the feasibility of a new fishery. Document CCAMLR-XI/7. CCAMLR, Hobart, Australia.

Table 3: Recommended TACs for the new fisheries proposed by Australia in Divisions 58.5.2 and 58.4.3.

Area	Species	TAC
Division 58.5.2 (new exploratory deep-water fishery)	<i>D. eleginoides</i>	No additional TAC: catches to be part of the 297 tonnes currently set by Conservation Measure 78/XIII
	<i>C. gunnari</i>	No additional TAC: catches to be part of the 311 tonnes currently set by Conservation Measure 78/XIII
	<i>L. squamifrons</i> , <i>N. rossii</i> , <i>C. rhinoceratus</i> and <i>Bathyraja</i> spp.	By-catch limitation of 5% of the catch in any haul
	Other species	50 tonnes each species
Division 58.4.3 Elan and Banzare Banks	<i>D. eleginoides</i> and <i>D. mawsoni</i>	200 tonnes combined catch
	Other species	50 tonnes each species

5.5 Bearing in mind that previous research surveys in Division 58.5.2 found a low biomass of *L. squamifrons*, *N. rossii*, *C. rhinoceratus* and *Bathyraja* spp., and that there is no TAC or prohibition on directed fishing for these species in this division, the Working Group suggested that a by-catch limitation should be considered, along the lines of that in Conservation Measure 84/XIII, paragraph 7. The relevant part of Conservation Measure 84/XIII, paragraph 7 with suggested insertions, reads:

‘If, in the course of the directed fishery [for *D. eleginoides* or *D. mawsoni*], the by-catch of any one haul of any of the species [*Lepidonotothen squamifrons*, *Notothenia rossii*, *Channichthys rhinoceratus* and *Bathyraja* spp] exceeds 5%, the fishing vessel shall move to another fishing ground ...’

5.6 The Working Group also recommended that in order to maximise the use to which information from the exploratory cruises could be put, fishing should take place over as large a geographical and bathymetric range as possible. In particular, areas where concentrations of fish are found should not be the only areas that are fished.

5.7 It was noted that both the new fishery for *D. eleginoides* in Subarea 48.4 which took place in 1993 (CCAMLR-XI/7) and this proposal in Divisions 58.5.2 and 58.4.3, were limited to a single vessel. The Working Group considered that this effort limitation was entirely appropriate for a new fishery.

South Georgia (Subarea 48.3)

Dissostichus eleginoides (Subarea 48.3)

Brief Review of 1994/95 Season and History of the Fishery

Catch and Effort Data

5.8 The total reported catch of *D. eleginoides* in Subarea 48.3 during the 1994/95 split-year was 3 241 tonnes. The catch was taken entirely by longline vessels, including six from Chile, five from Argentina, one from Bulgaria, one from the Republic of Korea and one from Russia. The catches by month are shown in Table 4.

Table 4: Catches by month from Subarea 48.3 reported to CCAMLR during the 1994/95 split-year. The catch in the 1994/95 season, from 1 March to 16 May 1995, was 3 062 tonnes.

Month	Total Catch of <i>D. eleginoides</i> (tonnes)
July	72.8
August	71.7
September	34.9
March	1278.4
April	1333.9
May	449.8
Total	3241.5

5.9 Longline fishing effort was again concentrated in patches on the 1 000 m contour around both South Georgia and Shag Rocks (Figure 1). No information was available to the Working Group on locations of catches on banks adjacent to Subarea 48.3 (North and Rhine Banks).

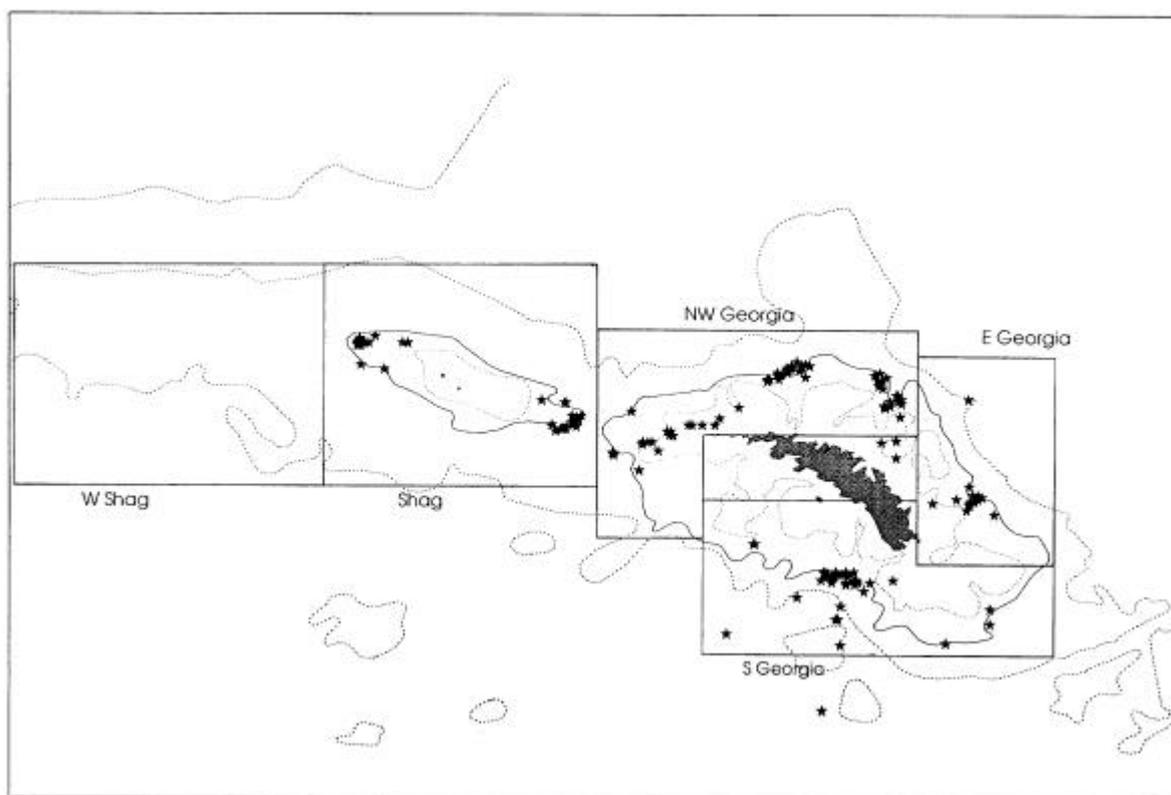


Figure 1: Locations of longline catches in Subarea 48.3 during 1994/95. Boxes indicate boundaries of areas used for GLM analysis (paragraphs 5.22 to 5.48).

5.10 At last year's meeting the Working Group requested that data on catches of *D. eleginoides* taken in areas of the southwest Atlantic, which are outside the Convention Area, be sought and compiled by the Secretariat. These data have been provided and are shown in Table 5.

Table 5: Catches by year from Statistical Areas 41 (southwest Atlantic), 87 (southeast Pacific), 48 (Atlantic Ocean sector) and 58 (Indian Ocean sector) for the period 1977 to 1994. Note that catches for CCAMLR Areas (48 and 58) are shown by split-year, but catches for Areas 41 and 87 are shown for calendar years from FAO and national statistics.

Year	Area 41	Area 87(1)	Total Adjacent Areas	Area 48	Area 58	Total CCAMLR Areas
1977	1096		1096	441	16	457
1978	2257		2257	2020	638	2658
1979	338		338	331	28	359
1980	843		843	261	208	469
1981	787		787	322	59	381
1982	612		612	354	287	641
1983	417	2	419	116	153	269
1984	325		325	109	153	262
1985	7174	375	7549	294	6685	6979
1986	1188	877	2065	564	494	1058
1987	5711	953	6664	1199	3186	4385
1988	3791	504	4295	1809	1053	2862
1989	7374	2002	9376	4138	1722	5860
1990	11757	3771	15528	8156	1075	9231
1991	7818	6523	14341	3640	1973	5613
1992	15461	10384	25845	3842	8750	12592
1993	9604	5972	15576	3089	2700	5789
1994	4814	5928	8004	460	5139	5599
Total	81367	37291	115920	31145	34319	65464

5.11 WS-MAD had reviewed the catch data for *D. eleginoides*. The importance of having as complete information as possible on removals of fish for the purposes of stock assessment was stressed by the Workshop. Circumstantial evidence and information from confidential sources indicated that the reported catches from the longline fishery in Subarea 48.3 did not represent the true level of removals (Appendix E, paragraph 3.2). The Workshop attempted to estimate the total removals from Subarea 48.3 and adjacent banks (North and Rhine Banks) using all available sources of data (Appendix E, paragraph 3.3). The results of this work are shown in Table 6.

Table 6: Estimated catches of *D. eleginoides* in Subarea 48.3 and adjacent Rhine and North Banks and TACs agreed by the Commission for Subarea 48.3.

Split-year	TAC (tonnes)	CCAMLR Catch (tonnes)	Estimate of Additional Catch	Best Estimate of Real Catches ¹
1990	-	8156.0	345	8501.0
1991	2500	3639.0	565	4206.0
1992	3500	3841.6	3470	6309.6
1993	3350	3088.5 ⁴	2500	5588.5
1994	1300	459.5 ³	6145	6604.5
1995	2800	3301.1 ²	2870	6171.1

¹ Includes the adjacent banks.

² Includes 180 tonnes taken by Bulgaria in August 1994, and 59 tonnes taken outside Subarea 48.3 on Rhine and North Banks but reported to CCAMLR. The total catch reported from Subarea 48.3 for the 1994/95 season (1 March to 16 May) was therefore 3 062 tonnes.

³ 180 tonnes of this TAC was taken after 1 July and appears below, under 1995.

⁴ Fishery closed early due to non-reporting of zero catches. Closure date was projected from previous non-zero catch rates. In all other cases, the difference between TAC and actual catch is due to differences between 5-day reports and final reports from the fishery.

5.12 Paper WG-FSA-95/25 Rev. 2 reported on a comparison of catch data reported to CCAMLR and information acquired by the UK from some longline vessels fishing in Subarea 48.3. This paper was reviewed under section 3 of the Agenda (paragraph 3.8).

Scientific Observer Reports

5.13 For the second year running, all longline vessels operating in Subarea 48.3 were required to have on board scientific observers appointed under the CCAMLR Scheme of Scientific Observation. The Working Group received a number of reports from observers, which were reviewed under section 3 of the Agenda (paragraphs 3.12 to 3.14).

5.14 In relation to the stock assessment of *D. eleginoides*, the Working Group was particularly interested in factors reported by scientific observers which affected the recording of total catch and CPUE. These included the following:

Factors affecting the recording of total catch:

- methods used to estimate the total weight and numbers of fish caught from the processed catch, including conversion factors. In some cases conversion factors recorded by scientific observers differed from those reported with the commercial data (paragraph 3.9);
- numbers and weight of fish discarded, which may not be included in the calculation of total catch, including the occurrence of the jellymeat condition; and
- loss rates from hooks, both due to fish falling from hooks before they reach the vessel and predation by marine mammals.

Factors affecting the recording of CPUE:

- gear loss: significant differences between the numbers of hooks deployed and the number of hooks recovered would affect the recording of CPUE; and
- baiting efficiency: this was particularly important for vessels using the autoliner system. If baiting efficiency changes over time due to changes in the set up of the automatic baiting system, this could significantly affect CPUE.

5.15 In relation to the second category (factors affecting CPUE), the Working Group also noted the apparent non-reporting of zero catches reported in WG-FSA-95/25 Rev. 2.

5.16 A more systematic approach to the reporting of such information from observations made by scientific observers to CCAMLR would help the Working Group to refine estimates of total removals of fish from the population for use in the assessments. This is discussed further under Agenda Item 11.

Assessment Work Presented to the Working Group

5.17 Paper WG-FSA-95/33 presented a review of the use of stock depletion models for the assessment of local abundance of *D. eleginoides*. This paper was also considered by the Working Group under item 3 of the Agenda (paragraphs 3.40 and 3.41). In general, the results of this analysis indicated that the depletion model was not appropriate for estimating local abundance in Subarea 48.3 and in the *D. eleginoides* fishery in Chilean waters. However, out of the 107 data sets examined 18 showed a significant negative trend in catch per hook. The Working Group considered that this was an indication that some areas might be more susceptible to local depletion than others and this possibility could be investigated further.

5.18 The Working Group endorsed the conclusion of WS-MAD that work on other approaches to stock assessment should take precedence. No further work on local depletion was undertaken by the Working Group at this meeting.

5.19 Paper WG-FSA-95/14 proposed VPA as a possible technique for the assessment of *D. eleginoides*. The Working Group acknowledged that this was likely to be a useful method for the future, however, there was presently insufficient information available, and problems with age determination needed to be overcome. The paper suggested that the FAO VPA program ANACO could be used. The Working Group considered that various VPA packages, including those used previously to assess other stocks in the CCAMLR Convention Area, should be evaluated as part of the future work. However, this work has a low priority at this stage.

Work Undertaken at WG-FSA-95

5.20 WS-MAD made a number of recommendations for future work on the assessment of *D. eleginoides*. A number of these were identified as specific recommendations for assessments at WG-FSA-95 (Appendix E, paragraph 4.1 section D):

- (i) the length-density analyses described in Appendix E, paragraphs 3.11 to 3.13 should be completed by WG-FSA during its 1995 meeting;
- (ii) WG-FSA should determine which of the estimates of von Bertalanffy growth parameters are appropriate for yield calculations in the light of size selectivity of different fishing methods;
- (iii) WG-FSA should perform stock projections and yield analysis using the information derived above; and
- (iv) the CPUE standardisation described in Appendix E, paragraph 2.51 should be completed by WG-FSA during its 1995 meeting.

5.21 The Working Group endorsed the recommendations of WS-MAD and agreed that work on the assessment of *D. eleginoides* at this year's meeting would follow these recommendations.

Standardisation of CPUE Indices from the *D. eleginoides* Fishery in Subarea 48.3

5.22 WS-MAD determined that there are probably many factors contributing to variability in CPUE data from the *D. eleginoides* fishery in Subarea 48.3. Since it is important to account for variability in catch rates when conducting assessments, the Workshop considered standardisation of CPUE data from this fishery to be a high priority (Appendix E, paragraphs 2.49 and 2.50).

5.23 GLMs provide a method for working with non-linear responses and non-normal error structures. These characteristics make GLMs well suited for use in the standardisation of CPUE data. Standardisation allows one to study variability in CPUE data by changing one predictor variable while simultaneously controlling for the effects of changes in other predictors.

5.24 The analysis of CPUE data using GLMs was continued by the Working Group. Details of the methodology are provided in Appendix G. The method was applied to time series of *D. eleginoides*

CPUE both in Subarea 48.3 (South Georgia) and Subarea 58.5 (Kerguelen) (paragraphs 5.156 et seq.).

5.25 GLMs were fitted to haul-by-haul data from Subarea 48.3 over the period 1992 to 1995. Data from years prior to 1992 were not available in haul-by-haul format, so they could not be used in the analyses. The data were screened according to the rules outlined in Appendix G.

5.26 The predictor variables (see Appendix G) were used to model four CPUE indices: kilograms per hook, numbers per hook, kilograms per hook-hour, and numbers per hook-hour.

5.27 In general, all four GLMs provided good fits to the CPUE data. Residual deviances (variations in CPUE not explained by the addition of factors and covariates to the model) were between 51% and 63% of the null deviances (variations in CPUE not explained solely by the mean catch rate) (Table 7).

5.28 Results from the GLM analyses indicated that vessel differences were always the most significant component of variability in catch rates (Table 7). Standardised kilogram-per-hook indices varied by an order of magnitude when plotted by vessel (Figure 2). There was a large amount of variability in catch rates between vessels from the Chilean fleet but these vessels generally had higher catch rates than vessels from other fleets.

5.29 The year factor was the second most important component of variability in catch rates (Table 7). Figure 3 plots a time series of each standardised CPUE index from 1992 to 1995. Kilograms per hook and kilogram per hook-hour were more variable in time than numbers per hook and numbers per hook-hour. The time series show no trends in kilogram per hook and kilogram per hook-hour, but numbers per hook and numbers per hook-hour do show trends in time. Numbers per hook increased between 1992 and 1993 and was steady between 1993 and 1995. Numbers per hook-hour generally appear to increase over the time series.

Table 7: Cumulative reductions of residual deviance from GLMs fit to catch rate data. Factors/covariates were entered into the models in order from top to bottom.

Factor/Covariate	Kg/hook	Numbers/hook	Kg/hook-hour	Numbers/hook-hour
Null	1145.7	891.9	2003.6	1532.8
Vessel	757.8	620.1	1208.0	1008.7
Year	695.5	586.4	1091.4	930.6
Month	679.0	578.4	1056.8	908.5
Area	666.6	565.2	1026.5	897.7
Depth	658.4	563.6	1023.9	897.5
Resid Dev/Null Dev	0.57	0.63	0.51	0.59

5.30 Differences between time series of kilograms per hook and numbers per hook suggest that the mean weight of captured *D. eleginoides* has decreased over the course of the fishery (Figure 3). This observation can also be made from the hook-hour time series.

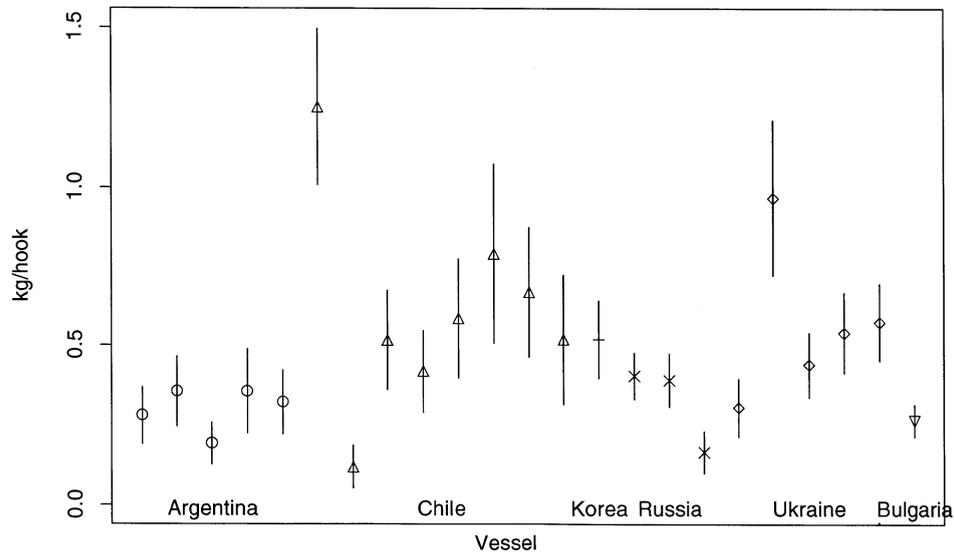


Figure 2: Estimated vessel effects from GLMs fit to CPUE data from the *D. eleginoides* fishery in Subarea 48.3. Hollow points are predicted mean responses and lines represent approximate 95% confidence intervals for the predictions.

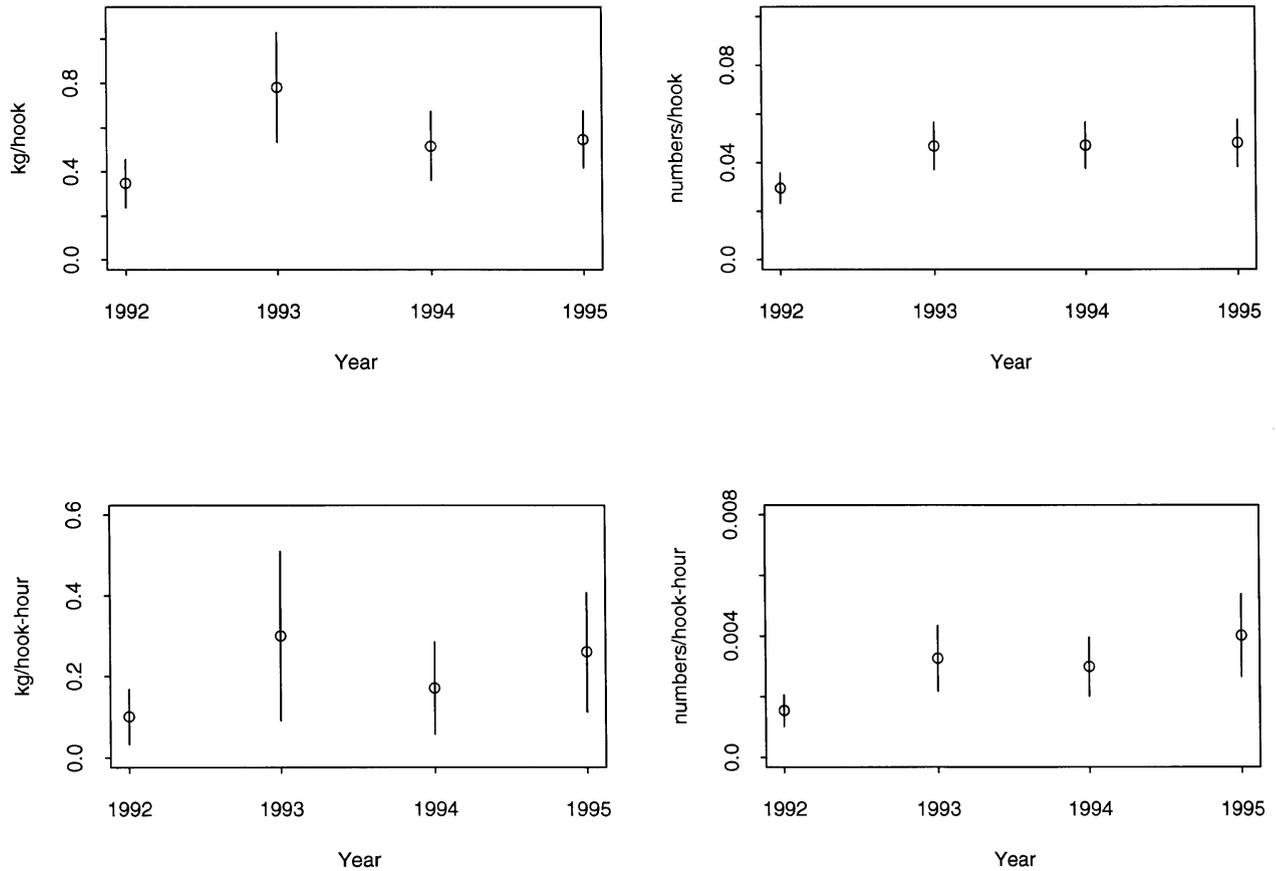


Figure 3: Estimated year effects for four different measures of effort from GLMs fit to CPUE data from the *D. eleginoides* fishery in Subarea 48.3. Hollow points are predicted mean responses and lines represent approximate 95% confidence intervals for the predictions.

5.31 The remaining predictors (month, area, and depth as a covariate) always explained a significant amount of variability in CPUE, but the significance level of these two factors and the single covariate depended on the order in which they were entered into the models.

5.32 All four CPUE indices showed a consistent decrease during July and August, although this was based principally on data from only one vessel fishing during this period in 1994. It was therefore not possible to draw any inference from this result regarding seasonal trends in catch rates. No data were available to estimate month effects for October and November.

5.33 Standardised catch rates from west Shag Rocks (Figure 2) were about half the size of catch rates from the other geographic areas.

5.34 All four CPUE indices were positively correlated with depth, but the rate of change in kilograms per hook with depth was greater than that for numbers per hook (a difference in slopes

was also evident when kilograms per hook-hour and numbers per hook-hour were compared). This seemed to support the observation that, on average, larger fish are found in deeper water.

5.35 Since there were differences between catch rates calculated in units of hooks and hook-hours, the Working Group completed a separate GLM analysis using soak time as a continuous covariate rather than as an element of the dependent variable. Results from this analysis suggested that soak time is an important component of the variability in catch rates, but soak time and depth are highly correlated. It was generally felt that calculating soak time as the difference between time at start of setting and time at start of hauling may not be appropriate for this fishery.

Comments on Data Requirements for Standardising CPUE Data

5.36 The Working Group recognised the utility of standardising CPUE data (paragraphs 5.40 to 5.43) and noted that haul-by-haul data are essential for such analyses. The Working Group further noted that, in the future, all of the haul-by-haul data submitted to the Commission should be of the highest possible quality, and that every effort should be made to ensure that all data types are reported.

5.37 The Working Group discussed the possibility of obtaining haul-by-haul data for fishing operations conducted prior to 1992 and concluded that such data would be very useful for future analyses. Members were urged to submit complete data sets as soon as possible.

5.38 The Working Group recognised that there are differences between CPUE indices (Figure 3) and determined that, as a minimum, kilograms per hook, numbers per hook, kilograms per hook-hour, and numbers per hook-hour should be used in future standardised analyses.

5.39 The Working Group determined that additional work should be done on defining an appropriate measure of soak time.

Comments on the Use of Standardised CPUE Indices

5.40 The Working Group considered standardised CPUE indices to be useful in both the short and long term. In the short-term, the standardised CPUE series can be used as an indicator of whether the stock of *D. eleginoides* is overexploited. Standardised catch rates should be more sensitive to

declining abundance than non-standardised catch rates, so declines in standardised CPUE between years might indicate that the stock is in danger of being overexploited.

5.41 On a longer term basis, the Working Group considered that standardised CPUE data will be useful for validating predictions from stochastic projections. The current assessment relies on survey data about young fish (paragraphs 5.44 to 5.49) to make predictions about the fate of animals that are just recruiting to the exploited stock. The standardised CPUE data will provide information about older, fully recruited fish and help determine whether the stock is behaving as predicted.

5.42 The Working Group noted that the successful integration of CPUE data into future assessments will be critically dependent on submission of haul-by-haul data from the fishery. The Working Group further emphasised the importance of scientific observers for collecting data to help validate and interpret information submitted by the fishing companies.

5.43 After some years, when more data of sufficient resolution are available, standardised catch rates can be used to tune VPAs and may facilitate the use of long-term depletion studies/production models for assessing *D. eleginoides* in Subarea 48.3. The Working Group noted that for VPAs to be used in future assessments scientific observers would be necessary for collecting information about the age distribution of the catch.

Length-Density Analysis

5.44 The Working Group continued with the analysis of trawl survey data using the length-density method started by WS-MAD.

5.45 The abundance of fish can be estimated from trawl survey data by the swept-area method, in which fish density (the number of fish caught in a known amount of trawling, for example in numbers per square kilometre) is scaled to the total area sampled by the survey. The swept-area method can be extended to estimate the number of fish in each age class if the trawl survey data can be expressed in terms of the density of fish at each age in the survey. This could be achieved by direct estimation of the ages of fish in the survey, or, as in this assessment, by an analysis of the length composition of the catches. Analysis of the length composition of the catches can be quite effective for separating age classes in smaller, younger fish because the high growth rates in young fish lead to clear groupings in the length data.

5.46 Paper WG-FSA-95/23 listed 12 trawl surveys in Subarea 48.3 in which *D. eleginoides* have been recorded, the data from which are stored in the CCAMLR database. The length-density analysis requires that length compositions of the catch from each haul be expressed in terms of density (e.g.,

numbers of fish per seabed area swept by the trawl). Technical problems were encountered in linking sample length distributions from survey hauls in the CCAMLR database to the total numbers of fish caught in those hauls. It was therefore not possible during the Working Group meeting to use the survey data stored in the CCAMLR database.

5.47 Data were made available to the Working Group from seven of the bottom trawl surveys carried out in Subarea 48.3 over the period 1989 to 1995. These were the UK surveys in 1989, 1990, 1991, 1992 and 1994, and the Argentine surveys in 1994 and 1995. In the event, data from the UK survey in 1989 and the Argentine survey in 1994 were not used. The UK survey in 1989 did not sample at Shag Rocks and was therefore not comparable with the other surveys. There was a problem in the analysis of the data from the 1994 Argentine survey which could not be resolved during the meeting.

5.48 The densities of fish in age classes 3, 4 and 5 for each survey were estimated by fitting a mixture of normal distributions directly to the length data expressed as fish densities in a series of length classes for each haul (Figure 4). The area under each fitted distribution component is assumed to estimate the density of the corresponding age class. Multiplying the age-class densities by the area surveyed leads to an absolute abundance estimate for each age class in the survey year. The mixture distribution has been fitted by maximum likelihood using the method and computer program developed by de la Mare (1994a)⁷. The mixture distributions could not be fitted for two surveys (UK 1990 and UK 1991) because, although there were substantial quantities of fish in some hauls, the number of hauls with fish in them were too few to give a reliable fit. In these cases the fish were allocated to age classes based on the means and standard deviations (SDs) of the mixture components found from fitting to the remainder of the surveys. This could be done with little error because the length distributions of 3-, 4- and 5-year-old fish have very little overlap. Once allocated to age classes, the densities were estimated using the maximum likelihood trawl survey program described in de la Mare (1994b)⁸.

⁷ de la Mare, W.K. 1994a. Estimating krill recruitment and its variability. *CCAMLR Science*, Vol. 1: 55-69.

⁸ de la Mare, W.K. 1994b. Estimating confidence intervals for fish stock abundance estimates from trawl surveys. *CCAMLR Science*, Vol. 1: 203-207.

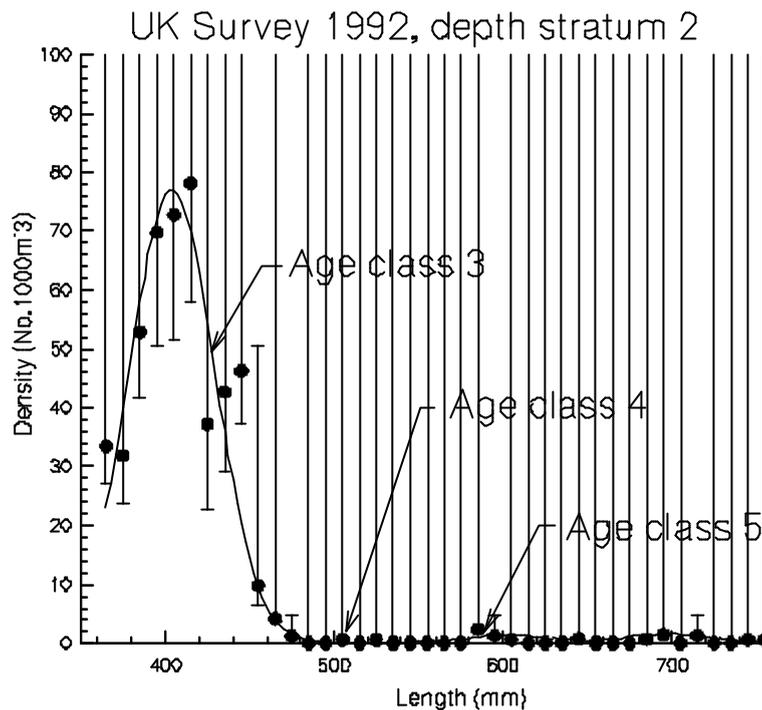


Figure 4: An example of a mixture of normal distributions fitted to a length-density distribution.

5.49 The absolute abundance estimates for each year class in the surveys analysed are shown in Table 8. The number of recruits was standardised to age 4 by correcting the 3- and 5-year-old numbers for the effects of natural mortality. In some cases, the same cohort is represented as a different year class in different surveys. In these cases the number of recruits was estimated from the weighted average of the log recruit numbers from the different surveys. The resultant estimates of recruits at age 4 in each year are given in Table 9. The recruitment estimates were used to estimate a lognormal recruitment function for use in stock projections. The Working Group noted that this procedure assumed that there was no trend in recruitment over the time period of the estimated recruitments. The parameters for this function are given in Table 10.

Table 8: Estimates of abundance by age for *D. eleginoides* Subarea 48.3 (WG-FSA-95) from UK surveys 1990, 1991, 1992 and 1994, and from Argentina 1995, obtained from length-density analyses assuming a catchability coefficient of 1.0 using the seabed areas in Everson and Campbell (1990)*.

Survey	Estimated Abundance-at-Age (millions of fish)					
	N3	SE(N3)	N4	SE(N4)	N5	SE(N5)
ARG 95 S.G.	-	-	1.212	0.599	2.118	0.627
ARG 95 S.R	2.384	1.644	3.360	1.163	1.092	0.726
Total	2.384	1.644	4.572	1.308	3.210	0.959
UK 94 depth 1	0.269	0.172	0.186	0.097	0.208	0.159
UK 94 depth 2	1.306	0.919	1.160	0.262	-	-
UK 94 depth 3	0.456	0.240	0.611	0.231	0.691	0.300
Total	2.031	0.965	1.957	0.363	0.899	0.340
UK 92 depth 1	2.410	0.791	-	-	-	-
UK 92 depth 2	10.236	3.651	0.171	0.949	0.213	0.239
UK 92 depth 3	4.449	1.101	0.879	0.756	0.633	0.443
Total	17.095	3.895	1.050	1.213	0.846	0.503
UK 91 depth 1	0.263	0.118	0.049	0.038	0.107	0.064
UK 91 depth 2	0.109	0.068	0.048	0.024	0.105	0.054
UK 91 depth 3	0.053	-	0.245	0.134	1.294	0.961
Total	0.425	0.136	0.342	0.141	1.506	0.965
UK 90 depth 1	2.680	2.662	12.262	11.239	7.813	7.000
UK 90 depth 2	0.107	0.064	0.150	0.116	0.306	0.191
UK 90 depth 3	0.020	-	0.017	-	0.075	0.056
Total	2.807	2.663	12.429	11.240	8.194	7.003

* Everson, I. and S. Campbell. 1990. Areas of seabed within selected depth ranges in CCAMLR Subarea 48.3, South Georgia. *Selected Scientific Papers, 1990 (SC-CAMLR-SSP/7)*. CCAMLR, Hobart, Australia: 459-466.

Table 9: Estimates of recruitment at age 4 by year class for *D. eleginoides* in Subarea 48.3. Variance-weighted means of estimated abundances-at-age from Table 8 were adjusted to correspond to age 4 by accounting for natural mortality ($M = 0.16$).

Year Class	Weighted Mean Recruitment Age 4 (millions)	Biomass (thousand tonnes)
1989	9.616	14.81
1990	3.392	5.22
1991	0.461	0.71
1992	0.391	0.60
1993	7.241	11.15
1994	2.348	3.62
1995	3.531	5.44
1996	2.032	3.13

Table 10: Estimates of parameters of log-normal distribution of annual recruitment at age 4: *D. eleginoides* Subarea 48.3 (WG-FSA-95). Estimates obtained from results in Table 9; estimated mean numbers of recruits calculated by back transformation from logs using variance correction.

Mean log-transformed recruitment	14.637
SD log-transformed recruitment	1.161
Mean numbers of recruits (millions)	4.463
CV numbers of recruits	1.161

Thompson and Bell Yield-Per-Recruit Program

5.50 The CCAMLR Thompson and Bell deterministic yield-per-recruit program was used to estimate the yield per recruit at $F_{0.1}$, as has been done for single species fisheries in the past. The biological parameters used in these calculations are summarised in Table 11.

Table 11: Data inputs into the yield-per-recruit program.

Data Input/parameter	Data
M	0.16
Selectivity (by age)	Selectivity changes from 0 to age 1 between ages 5 and 7 as follows: age 5 = 0.0, age 6 = 0.3, and 7 = 1.0 (age < 5 = 0, age > 7 = 1.0)
Maturity ogive	Maturity at age as follows (starting with age 1): 0.0001, 0.0005, 0.0014, 0.0055, 0.013, 0.036, 0.078, 0.2, 0.33, 0.54, 0.74, 0.84, 0.91, 0.96, 0.98, 0.99, 1.0 (full maturity at age 17)
Growth curve	$K = 0.088$, $L_{\infty} = 170.8$, $t_0 = 0$
Number of age classes	34 with a plus class

5.51 Values of M were re-calculated during the Working Group meeting on the basis of new von Bertalanffy growth parameters, estimated by non-linear methods during WS-MAD (Appendix E, paragraph 2.16). The growth parameters used in estimating M were $L_{\infty} = 170.8$ cm, $t_0 = 0$ and three values of K : 0.08, 0.085 and 0.09. M was estimated using the Beverton and Holt method, as described in WG-FSA-92/21⁹. The length distribution of the unexploited population was taken from exploratory longline catches in 1986. Three values of M were obtained, corresponding to the three values of K : $M = 0.152$ ($K = 0.08$), $M = 0.161$ ($K = 0.085$), and $M = 0.171$ ($K = 0.09$). The value of M in the yield-per-recruit analysis was fixed at 0.16.

5.52 There were problems estimating selectivity of longline gear directly from commercial length frequency data, due to the change in size distribution with depth. Analyses undertaken during WS-MAD indicated major differences between the selectivity of trawl and longline gear, with trawl gear taking smaller fish (Appendix E, Figure 4). Some data were available for areas where trawl and longline gear had been deployed at similar depths. These indicated that small fish may not be taken by longline gear, even if present in the area. Data from Argentina made available to the Working Group during the meeting showed differences in the size distribution of catches taken by trawlers and longliners operating in similar areas on the Patagonian Shelf (Figure 5). These indicated that fish of between 50 cm and 185 cm were present in the area, but longlines only caught fish of about 75 cm and larger. There was no depth overlap between the trawl survey and longline catches taken in Subarea 48.3 (Figure 6). However, length distributions of the catch from the 1994/95 season

⁹ Moreno, C.A. and P.S. Rubilar. 1992. Remarks on natural mortality of *Dissostichus eleginoides* in Subarea 48.3. Document WG-FSA-92/21. CCAMLR, Hobart, Australia.

indicated that fish recruited to the longline fishery at smaller lengths than on the Patagonian shelf. For the yield per recruit, selectivity by age was assumed to be quasi knife-edged, changing from 0 to 1 between ages 5 and 7 (Table 11).

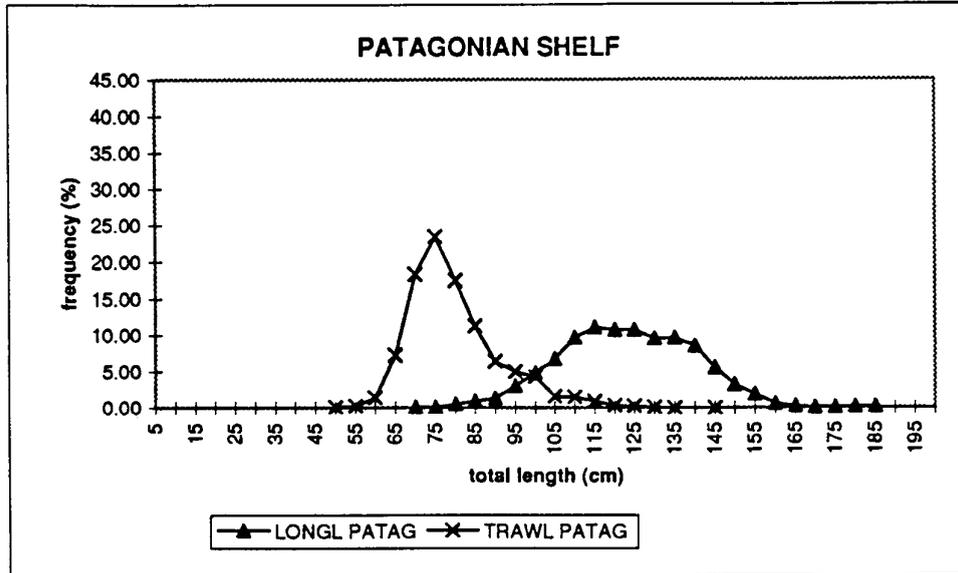


Figure 5: Length composition of catches from Argentinian trawl and longline fishing on the Patagonia shelf.

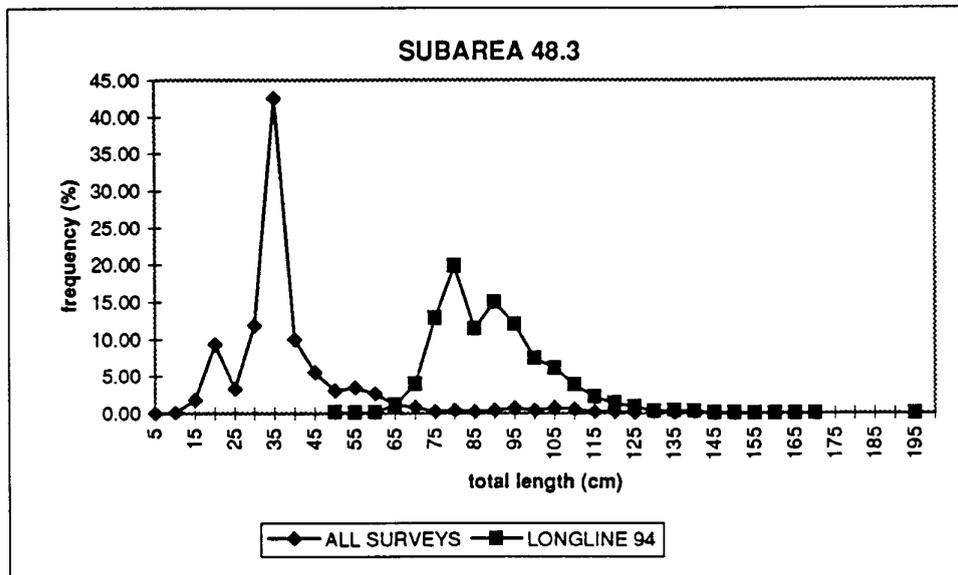


Figure 6: Length composition from trawl surveys and longline fishing in 1994 at South Georgia.

5.53 Percentage maturity-at-age was derived from the length-maturity data analysed by WS-MAD (Appendix E, Figure 2) and estimates of size-at-age from a number of sources (Appendix E, Figure 1).

5.54 The value of $F_{0.1}$ from yield-per-recruit analysis was 0.137, with a yield per recruit (age 1) of 1.72 kg. The estimate of yield at $F_{0.1}$ was 12 400 tonnes, calculated by multiplying the value of yield per recruit (age 1) by an estimate of the mean recruitment at age 1 from the length-density analysis (mean recruitment at age 4 (Table 10) $\times e^{-3M}$).

5.55 The Working Group noted that the yield-per-recruit analysis might be sensitive to variation in some of the input data. It was suggested that sensitivity to the von Bertalanffy growth parameters, the age at which the plus group was fixed and the maturity ogive, should be investigated at a future meeting.

Assessment of Yield Under Conditions of Uncertainty

5.56 The generalised yield model (WG-FSA-95/41), described in paragraphs 3.44 to 3.47, was used to examine the effects of various harvesting strategies under conditions of uncertainty.

5.57 The structure of the new generalised yield model provides for evaluation of the effects of nominated catches on the size of the spawning stock over a specified period. The program takes into account uncertainties in estimates of recruitment and mortality as well as interannual variability in recruitment.

5.58 The yield model was configured to mimic the CCAMLR deterministic yield-per-recruit program in order to test its performance. The results of the two analyses were virtually identical.

5.59 Some of the calculations involved in the assessment needed to be revised due to a misunderstanding about the calculation of some model parameters. This highlights the requirement for sufficient validation and documentation of assessment programs.

Data Inputs

5.60 The data inputs into the yield model are shown in Table 12.

Table 12: Data inputs into the yield model for *D. eleginoides* in Subarea 48.3.

Data input	Data
Recruitment Function	Log transformed recruitment: Mean = 14.637; SD = 1.161
M	Option 1: M fixed at 0.16 Option 2: M randomly selected between 0.1 and 0.2 (uniform distribution)
Selectivity (by length)	$L_{50} = 60\text{cm}$, assumed to change linearly from 0 to 1 over the range 55 cm to 65 cm (this is equivalent to the selectivity by age used in the yield-per-recruit analysis)
Maturity ogive	As per Table 11 (yield per recruit)
Growth curve	As per Table 11 (yield per recruit)
Duration of the projection	35 years
Number of evaluations per run	1 000

5.61 The recruitment function derived from the length-density analysis was used as the basis for the projections using the yield model. The deterministic yield-per-recruit analysis (paragraphs 5.50 to 5.55) indicated that a suitable time period for the projection of the *D. eleginoides* stock was 35 years. After this time the year class born at the start of the projection period would not be contributing significantly to the increase in biomass of the stock. Each projection using the generalised yield model was started in 1989, run to 1995 using known catches, and then run for a further 35 years assuming some specified harvesting strategy.

5.62 The estimates made by WS-MAD of real catches taken in Subarea 48.3 and adjacent areas (Table 6) were used in the yield model. All commercial catches were assumed to have been taken by longline vessels. The by-catch of small fish taken by the trawl fishery over the period 1977 to 1988 was not included in the calculations.

5.63 The Working Group considered the results of the projections using the yield model in relation to the decision rule for γ_1 adopted for krill and for *D. eleginoides* in Division 58.5.2 (Heard Island) at last year's meeting of the Scientific Committee. This decision rule criterion is that the probability during the projection period of the spawning stock biomass falling below 20% of its initial level should not exceed 10% (SC-CAMLR-XIII, paragraphs 5.18 to 5.26 and 2.70). Twenty per cent of the initial level of the spawning stock biomass has become a standard biological reference point used in fisheries management, based on Beddington and Cooke (1983)¹⁰, in which the probability of stock depletion influencing recruitment was found to increase once the spawning stock reached 20% of its equilibrium level.

¹⁰ Beddington, J.R. and J.G. Cooke. 1983. The potential yield of fish stocks. *FAO Fisheries Technical Paper*, 242: 47 pp.

5.64 Two criteria were used to indicate the performance of *D. eleginoides* in Subarea 48.3 during each projection run:

- (i) the probability of depletion of the spawning stock biomass to 0.2 (20%) of the pre-exploitation level (Depletion Probability); and
- (ii) the level of median spawning stock biomass expected at the end of the projection period relative to the median pre-exploitation spawning stock biomass (SB_e / SB_0).

5.65 A detailed explanation of the manner in which the projections are undertaken and the way in which the spawning stock is monitored under specified catch regimes during the runs is presented in Appendix F.

5.66 Two initial runs of the yield model were made. The harvesting strategies for these runs were based on the results of the deterministic yield-per-recruit analysis. The first run was a strategy of applying $F_{0.1}$ (0.137) over the whole period of the projection. The second run was a constant catch strategy, with the catch limit fixed at 12 400 tonnes per annum, equal to the catch value at $F_{0.1}$, calculated from the Thompson and Bell yield-per-recruit analysis (paragraph 5.54). Both projections were run with mean recruitment assuming no uncertainty (Table 12) and $M = 0.16$. The results are presented in Table 13.

Table 13: Evaluation of the performance of *D. eleginoides* in Subarea 48.3 during the 35 year projection under a fixed catch of 12 400 tonnes/year and constant F ($F_{0.1}$). Projections used a fixed mean recruitment with variability in annual recruitment (Table 12), and $M = 0.16$.

Exploitation Strategy	Depletion Probability	Median SB_e / Median SB_0
12 400 t/year	0.59	0.28
$F_{0.1} = 0.1369$	0.80	0.23

5.67 The strategy of applying $F_{0.1}$, or a constant catch equivalent to $F_{0.1}$ at mean recruitment, results in approximately a 60 to 80% chance of the spawning stock biomass falling below 20% of its initial level over the 35-year period. This violates the γ_1 decision rule by a considerable margin. In addition, at the end of the projection period, the spawning stock biomass was reduced to only 20 to 30% of the pre-exploitation level.

5.68 Following these two initial runs, four projections were carried out to identify the catch level at which γ_1 was satisfied. These four projections included uncertainty surrounding the estimate of mean recruitment, interannual variability in recruitment and the fixed estimate of natural mortality (Option 1 in Table 12). The results of these projections are presented in Table 14.

Table 14: Evaluation of the performance of *D. eleginoides* in Subarea 48.3 during the 35-year projection under a series of fixed catches. Projections incorporated uncertainty in mean recruitment and variability in annual recruitment (Table 12) and $M = 0.16$.

Exploitation Strategy	Depletion Probability	Median SB_e / Median SB_0
3 000 t/year	0.07	0.82
3 500 t/year	0.07	0.79
4 000 t/year	0.10	0.74
4 500 t/year	0.12	0.77
5 000 t/year	0.14	0.70

5.69 The results in Table 14 indicate that an annual yield of 4 000 tonnes would satisfy the γ_1 criterion. At this level of catch the median spawning stock at the end of the projection period is likely to be approximately 74% of the pre-exploitation level.

Sensitivity Analyses

Sensitivity to Uncertainty in Estimated Mean Recruitment

5.70 The Working Group investigated the effects of improving the precision of the estimate of mean recruitment on the estimated yield that would meet the criterion of γ_1 . The results in Table 15 can be compared directly with those in Table 14 at the same level of fixed annual catch. These results show that reducing uncertainty in mean recruitment could lead to an increase in the estimate of potential yield consistent with γ_1 (7 500 tonnes/year in Table 15), provided that the estimate of mean recruitment remained at or above the current level. Uncertainty in mean recruitment would be expected to be reduced as more data become available from which to estimate mean recruitment. These data may be obtained from trawl surveys not yet analysed using the length-density analysis, or future trawl surveys in Subarea 48.3. The Working Group noted, however, that care should be taken to watch for trends in recruitment as the time series of data from which recruitment is estimated increases. Any trends could introduce bias into the recruitment function.

Table 15: Evaluation of the performance of *D. eleginoides* in Subarea 48.3 during the 35-year projection under a series of fixed catches. Projections used a fixed mean recruitment combined with variation in annual recruitment (Table 12) and $M = 0.16$.

Exploitation Strategy	Depletion Probability	Median SB_e / Median SB_0
4 000 t/year	0.004	0.74
5 000 t/year	0.009	0.70
6 000 t/year	0.03	0.65
7 000 t/year	0.08	0.58
7 500 t/year	0.10	0.53
8 000 t/year	0.12	0.55

Sensitivity to Uncertainty in M

5.71 Assessments of yield per recruit are affected by the level of natural mortality used in the analysis. While the estimates of M used in this assessment are the best currently available, they may be refined in the future as more information becomes available. The sensitivity of the estimated yield to uncertainty in M was investigated for two catch regimes (4 000 and 5 000 tonnes) with both fixed mean recruitment and uncertain mean recruitment, as discussed above. In both cases, M was integrated over a range of values between 0.1 and 0.2. The results of these four projections are shown in Table 16. These results can be compared directly with the projection results with the same exploitation strategy (Tables 14 and 15). The results showed no appreciable change in the outcome with uncertainty in mean recruitment, and only slight differences when mean recruitment was fixed.

Table 16: Evaluation of the performance of *D. eleginoides* in Subarea 48.3 during the 35-year projection under a series of fixed catches but integrating over a range of M (0.1 to 0.2). These projections investigated the effects of both fixed and uncertain mean recruitment.

Exploitation Strategy	Mean Recruitment	Depletion Probability	Median SB_e / Median SB_0
4 000 t/year	Uncertain	0.15	0.76
4 000 t/year	Fixed	0.08	0.75
5 000 t/year	Uncertain	0.20	0.72
5 000 t/year	Fixed	0.13	0.69

5.72 The Working Group considered that further analysis of the sensitivity of the model to variability in M could be undertaken, for instance, variable M with age. This was identified as a topic for future work on the yield model.

Comparison of Model Projections with CPUE Data

5.73 Figure 7 presents a comparison of the standardised CPUE series from the GLM analysis (kilogram/hook and number/hook), and estimated abundance from the yield model projections, over the period 1992 to 1995. It was not possible to interpret the relationship between CPUE and abundance based on the information currently available.

5.74 The Working Group considered a number of assumptions made in this assessment of *D. eleginoides* using the generalised yield model, and the potential effect of variations in these assumptions on the results (Table 17).

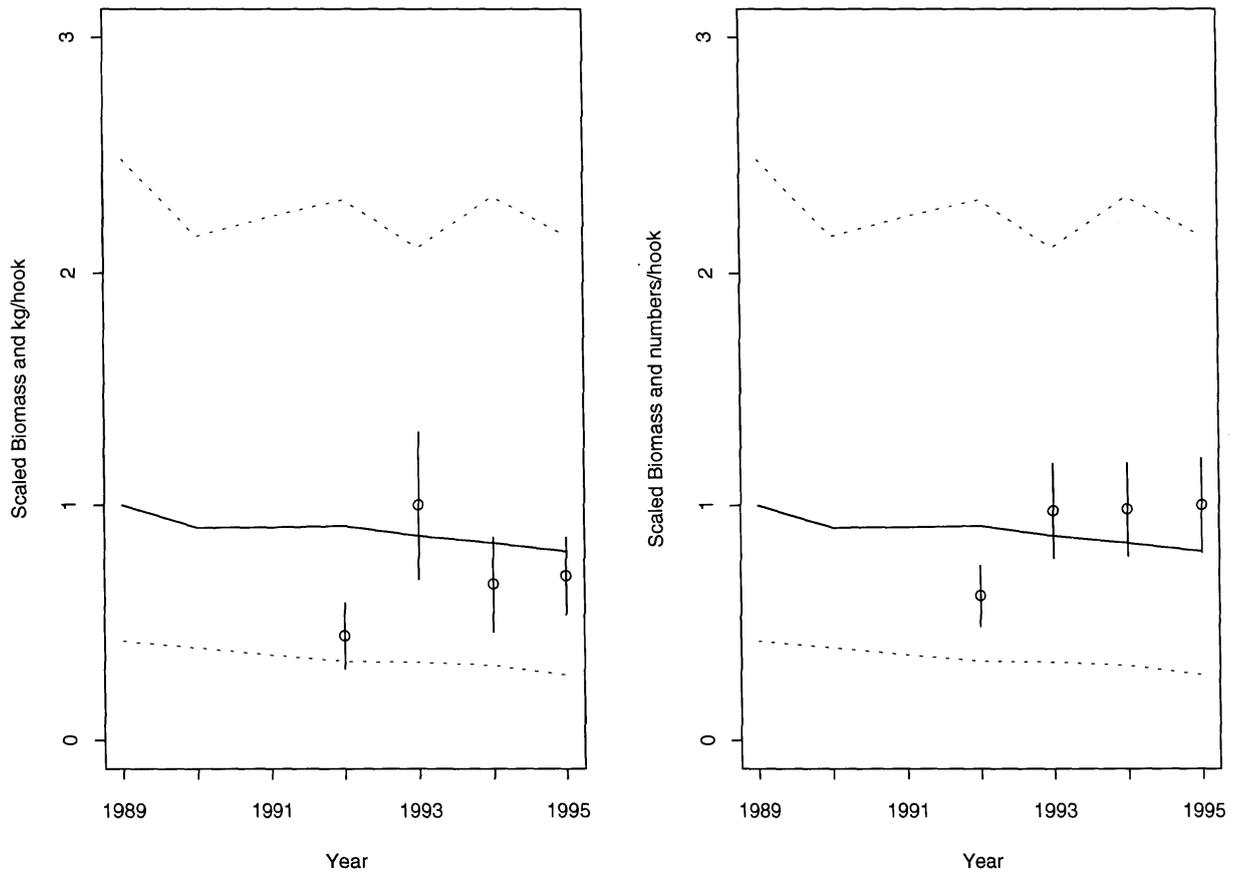


Figure 7: Standardised CPUE (kilogram/hook and numbers/hook scaled to 1) and estimated spawning stock biomass (scaled to 1) over the period 1989 to 1995. The solid line shows the trend in median spawning stock biomass projected with the yield model. Dashed lines indicate the 5 and 95% quantities for the spawning stock biomass. Open circles are the CPUE from the GLM analysis, vertical lines are ± 2 SD.

Table 17: Assumptions made in the assessment of *D. eleginoides* in Subarea 48.3.

Assumption	Potential Effect on the Result
<p>q for the survey is unknown, but is assumed to be 1.</p>	<p>If q were less than 1, estimates of abundance, and therefore recruitment, based on the survey results would increase. The level of catch consistent with the γ_1 decision rule would increase.</p>
<p>Recruitment is a log-normally distributed random variable with variance equal to that estimated from the bottom trawl surveys and mean with a normally distributed sampling error.</p>	<p>Conduct and analysis of additional surveys will reduce the uncertainty in recruitment. This will have the effect of increasing the level of catch which can be taken without violating the γ_1 decision rule (see paragraph 5.67).</p>
<p>The mean recruitment estimated from the surveys applies to the <i>D. eleginoides</i> population around Shag Rocks and South Georgia (Subarea 48.3).</p>	<p>If the recruitment was made to a larger area, then the catch limit should be applied to that larger area and not just to Subarea 48.3.</p>
<p>The estimated total catches shown in Table 6 apply only to Subarea 48.3.</p>	<p>If the catch applies to a larger area (i.e., the catches taken from Subarea 48.3 are lower) the level of catch in the assessment consistent with the γ_1 decision rule would increase.</p>
<p>The allowable catches will be the only removals from the population by fishing (i.e. there is no significant illegal fishing) and that only longline fishing will occur.</p>	<p>If significant illegal fishing occurred over and above the catch limit consistent with γ_1, the stock could become depleted.</p>
<p>Estimated total catches (paragraph 5.11) accurately reflect total removals from the stock over the period.</p>	<p>If the total removals from the stock were higher than those used in the projections, the level of catch consistent with γ_1 would decrease.</p>

Future Work

5.75 The Working Group recommended that future work be undertaken in an attempt to refine information on which the assumptions in Table 17 were based. Several specific recommendations were made for additional sensitivity analyses (paragraph 5.72).

5.76 The Working Group considered a number of other areas of future work on stock assessment of *D. eleginoides*, following on from the work undertaken at this year's meeting:

- (i) work on refining the standardised time series of CPUE should continue. This process will develop as more haul-by-haul data are supplied from the commercial fishery in due course;
- (ii) the development of length and/or age specific standardised indices of CPUE might provide more information on trends in abundance;

- (iii) further work to investigate the relationship between CPUE and abundance and the sensitivity of CPUE to declines in abundance;
- (iv) more trawl survey data should be made available for analysis using the length-density approach. This would increase the amount of information on which to base estimates of recruitment which are fed into the projections using the yield model. The technical problems encountered when accessing the trawl survey data stored in the CCAMLR database should be addressed during the intersessional period;
- (v) several areas for future work on methodologies which will improve the level of information on which the assessment of *D. eleginoides* is based were identified by WS-MAD (Appendix E, paragraph 2.72). The Working Group endorsed these recommendations, drawing particular attention to the need for tagging studies to study movement and migration;
- (vi) the computer programs used for the assessment of *D. eleginoides* at this year's meeting (length-density analysis (de la Mare, 1994a¹¹) and the generalised yield model (WG-FSA-95/41)) should be formally validated by the Secretariat during the intersessional period; and
- (vii) the Working Group also considered some practical measures to enhance the Secretariat's capability to undertake assessment work (e.g., improved computing power). These are taken up under Agenda Item 11 (paragraph 11.5).

5.77 The Working Group agreed that the assessment of *D. eleginoides* in Subarea 48.3 carried out at this meeting is far superior to any it has conducted previously for this species. In particular, it noted that:

- (i) previous assessments have relied on applying deterministic yield-per-recruit analyses to abundance estimates calculated by extrapolation of estimates of local densities. The local density estimates were based on analysis of short- to medium-term trends in CPUE. At best, this technique produces indirect estimates of density, and in practice the failure to observe consistent depletion (paragraphs 5.17 and 5.18) has often meant that no such estimates can be calculated;
- (ii) in contrast, in this assessment, direct estimates of absolute recruitment have been obtained from fishery independent scientific survey results. These are not only likely to

¹¹ de la Mare, W.K. 1994a, op. cit. p. 289.

be much more reliable than those based on CPUE analyses, but also it has been possible to quantify both estimation uncertainty and interannual variability in recruitment; and

- (iii) use of the generalised yield model has allowed specific account to be taken of these sources of uncertainty and variability. Furthermore, this model also provides a future means for quantitatively evaluating the possible effects of failure in assumptions listed in Table 17.

5.78 The Working Group noted that the use of the generalised yield model to make stochastic projections to test the effect of different harvesting strategies had revealed that an $F_{0.1}$ harvesting strategy was not appropriate for this fishery, due to the uncertainty and variability in recruitment. Harvesting at $F_{0.1}$ over the period of the projection had in fact resulted in considerable depletion of the spawning stock (Table 13).

5.79 The Working Group recognised the potential value of this new assessment method for *D. eleginoides* in the analysis of similar fisheries in other areas.

5.80 The Working Group considered that the results of the projections using the yield model with the γ_1 decision rule was a reasonable basis for setting guidelines for the limits on total removals of *D. eleginoides* in Subarea 48.3 during the 1995/96 season. The projection run which fulfilled the γ_1 decision rule criteria and included uncertainty in recruitment gave a constant catch of 4 000 tonnes.

Management Advice

5.81 The Working Group welcomed the significant progress which had been made at this meeting in developing a new approach to the assessment of the *D. eleginoides* fishery in Subarea 48.3. A program of future work was identified to refine this approach.

5.82 The Working Group noted with concern the apparent high level of unreported fishing for *D. eleginoides* in Subarea 48.3. At this year's meeting an attempt had been made to estimate total removals and to take these into account in the assessment. However, the Working Group noted that future illegal catches would continue to hinder severely attempts to make reliable stock assessments and requested that the problem be addressed as a high priority.

5.83 The Working Group also noted that since catches of *D. eleginoides* are also taken outside the Convention Area in waters adjacent to Subarea 48.3, it constituted a straddling stock. Issues

relating to conservation and management of straddling stocks are addressed in paragraphs 10.10 to 10.14.

5.84 The Working Group noted that the assessment of yield was based on the expectation that future catches will be taken only by longline vessels. Use of other types of fishing gear, such as trawls, would change the age structure of the catch. The Working Group made no assessment of the effects of such catches at this meeting. The Working Group therefore recommended that the directed fishery for *D. eleginoides* in Subarea 48.3 should be restricted to longliners during the 1995/96 season. (See other advice on trawling in Subarea 48.3 in paragraphs 5.113 and 6.27 to 6.29.)

5.85 The results of the projections using the generalised yield model indicated that an annual catch of 4 000 tonnes applied over a period of 35 years resulted in a probability of stock depletion (the spawning stock biomass falling to below 20% of its unexploited level) of about 10%. At this level of catch the ratio of median spawning stock biomass at the end of the projection period to the pre-exploitation level was about 74%. These criteria have been used in the past as a basis for setting catch limits. However, the Working Group noted that this assumed that the actual removals of fish would be no greater than the catch limit. Total annual removals exceeding 4000 tonnes would increase the probability of stock depletion (Table 14).

5.86 The analysis of CPUE data highlighted the importance of collecting catch and effort information on as fine a scale as possible. The Working Group recommended the continuation of the current procedures for reporting haul-by-haul and biological information from the fishery, and strongly encouraged the reporting of existing haul-by-haul data from the longline fishery prior to 1992.

5.87 The Working Group also recognised the importance for the assessment work of the biological data and information collected by scientific observers. The Working Group recommended that the 100% observer coverage applied to this fishery over the past two seasons be maintained.

5.88 The technical problems encountered when accessing the trawl survey data stored in the CCAMLR database will require some attention during the intersessional period. The Working Group recommended that Members with relevant data be requested to assist the Secretariat by submitting those data in the required format at the earliest opportunity.

Champscephalus gunnari (Subarea 48.3)

Commercial Catch

5.89 The fishery for *C. gunnari* was closed for the 1994/95 fishing season in accordance with Conservation Measure 86/XIII. There has now been no substantial reported commercial catch of *C. gunnari* in Subarea 48.3 since March 1990. A total of 8 027 tonnes was reported in that season.

Research Surveys

5.90 A research survey was conducted in Subarea 48.3 in February 1995 by the *Dr Eduardo L. Holmberg*. The methods and results of this survey are reported in WG-FSA-95/34 and 35.

5.91 The main aim of the survey was to investigate the variability in the spatial distribution of *C. gunnari* in Subarea 48.3. The methodology was similar to that used for the 1994 survey and involved sampling clusters of stations (i.e., stations which were spatially correlated). This enabled a measure of the relative importance of within and between-cluster variability to be determined. Thirty-one stations (27 from the South Georgia shelf and 4 from Shag Rocks) were in the same position, to within 1 n mile, as sites sampled during the 1994 survey. An additional 17 new stations were surveyed.

5.92 Because of differences in survey design, sampling equipment and estimation methods the data could not be used in the time series of relative abundance indices obtained from previous surveys of this area (see SC-CAMLR-XIII, Annex 4, paragraphs 3.17 to 3.20). It was felt, however, that a comparison of the difference in catch rates between the replicate stations might yield some qualitative information on the status of the stock compared to the previous year.

5.93 Analysis of the data from the replicated stations on the South Georgia shelf ($n = 27$ stations) using parametric and non-parametric tests indicated that there had been a significant increase in fish density since the 1994 survey ($P < 0.01$).

5.94 The length and age composition data collected during the 1994 and 1995 Argentinian surveys from South Georgia were compared. The 1995 survey was dominated by small fish mainly less than 30 cm, and contained two modes, one at 14 cm (1-year-old fish) and one at 27 cm (2- and 3-year-old fish) (WG-FSA-95/37). In contrast, the 1994 survey had a much greater proportion of fish larger than 30 cm, and a dominant mode at about 24 cm (2-year-old fish). The change in the size of

the dominant mode from 24 to 27 cm could be explained by growth of the fish in the intervening year. The relative paucity of larger fish could not be explained.

5.95 There were too few data to draw conclusions on fish density differences in the Shag Rocks area. A single mode was present in the size distribution in both surveys. The mode increased from about 25/26 cm in 1994 to 29 cm in 1995, probably representing one year's growth.

5.96 Lic. Marschoff stated the analysis of the between site variability as proposed in WG-FSA-95/34 has the potential to be used in studies of patchiness in the spatial distribution of *C. gunnari*, but fuller application of the model will require verification of the assumptions of the statistical model.

5.97 Other members felt that the sampling design offered no advantages and was less efficient than that recommended by WG-FSA in 1992.

Population Status and Mechanism for Providing Advice on Catch Limits

5.98 Problems with determining the population status and establishing a TAC for *C. gunnari* were discussed in WG-FSA-95/24. The paper put forward four recommendations; two with respect to future research and two with respect to management advice.

5.99 The first two recommendations concerned methods for the use of acoustics, and bottom and midwater trawling, to determine the distribution of the fish in the water column. Research surveys in recent years were conducted during only daylight hours, when most fish are likely to be close to the bottom. The Working Group agreed that it would be very useful to use acoustics and midwater trawls in addition to bottom trawls in order to obtain a better understanding of the vertical distribution of the fish both during the day and at night.

5.100 The third recommendation was to allocate a TAC for the fishery, even when the biomass was low, so that the population could be observed and VPAs conducted. The fourth recommendation was that a scientific observer be put on board commercial vessels conducting trawling to collect samples and data from the commercial catch. Both of these recommendations have been incorporated into option (ii) of the management advice.

Alternative Assessment Methods

5.101 An alternative way of formulating ADAPT to analyse the catch-at-age and trawl survey data has been proposed by Dr P. Gasiukov (Russia). In earlier assessments using ADAPT the estimated F on the terminal age in each year was assumed to equal the mean of the F on the previous three ages for that year. The alternative approach involves a model which treats the F s on the terminal age as unknown parameters. When this approach was used a plot of the log catchability coefficients by age show a dome shaped pattern, rather than the flat-topped pattern shown in earlier assessments. This difference has quite a large impact on the estimated numbers of fish surviving at the terminal age and hence on stock abundance.

5.102 The Working Group considers that it would be useful to explore alternative assumptions concerning some of the parameters such as selectivity-at-age when analysing data using ADAPT.

5.103 To do this most effectively, data from as many surveys as possible will be required. The Working Group felt it would be useful to review historical research and commercial trawl data on *C. gunnari* with a view both to the above, and also to help define the optimum timing of trawl surveys in this area and to standardise the research surveys. The Working Group recommended that these data be submitted to the Secretariat in the appropriate format and reviewed by an intersessional group convened by Dr Holt.

5.104 There are no new estimates of abundance for this stock. The most recent reliable estimate of abundance is from the 1994 UK survey. The stock abundance appears to have increased since then but the magnitude of this increase is unknown. The stock is currently dominated by 1- to 3-year-old fish.

Development of a Long-term Management Approach

5.105 The Working Group reiterated the need for a long-term management plan for the fishery which accounts for the high interannual recruitment variability, the uncertainty in biomass estimates and potential variability in M with age and between years. Any estimates of yield should be carried out using stochastic projections and will need to incorporate the possibility of major mortality events occurring every few years.

Management Advice

5.106 Given the difficulties associated with using estimates of relative abundance from the two Argentinian surveys in 1994 and 1995 (see paragraph 5.92), the Working Group felt that the most reliable estimate of abundance for *C. gunnari* around South Georgia and Shag Rocks was that from the 1994 UK survey (see SC-CAMLR-XIII, Annex 4, Table 3). Given the uncertainty associated with the state of this stock, the Working Group recommended that the lower confidence interval of that estimate be used if TACs are considered. The lower 95% confidence interval estimate equalled 13 295 tonnes.

5.107 For setting a TAC for *C. gunnari*, the Working Group considered two options:

- (i) no TAC should be set until a new research survey to assess the status of the stock has been conducted. This new estimate would then be considered by WG-FSA as a basis for providing new management advice; and
- (ii) a TAC be set (at some proportion of the lower confidence interval of the 1994 UK survey estimate), but this TAC being dependent on two things; a research survey being carried out before the commercial operation, and an international scientific observer being on board each vessel fishing commercially.

5.108 The Working Group recommended option (i). If the Commission were to consider re-opening the fishery then the Working Group recommended that a TAC be set at a level which is considerably below the lower 95% confidence limit of the 1994 UK survey estimate (13 295 tonnes), a research survey should be carried out in accordance with the design recommended by WG-FSA in 1992, and an international scientific observer be on board all commercial fishing vessels.

5.109 The Working Group reiterated its advice from last year that a long-term management plan be developed for this fishery and noted that this remains a high priority.

Chaenocephalus aceratus, *Gobionotothen gibberifrons*¹², *Notothenia rossii*,
Pseudochaenichthys georgianus, *Lepidonotothen squamifrons* and
Patagonotothen guntheri (Subarea 48.3)

5.110 Estimates of fish density and size composition were available from the Argentinian bottom trawl survey around South Georgia (WG-FSA-95/34 and 35).

¹² Formerly known as *Notothenia gibberifrons*

5.111 Because of differences in survey design, sampling equipment and estimation methods the data could not be used in the time series of relative abundance obtained from previous surveys of this area. However, it was felt that a comparison of the difference in catch rates between the replicate stations might yield some qualitative information on the status of the stocks compared to the previous year.

5.112 Analysis of the South Georgia data (n = 27 stations) showed that there were no significant differences in the density of all six species between 1994 and 1995 ($P > 0.05$). The size composition data were not analysed because the sample sizes and numbers of fish measured in the 1994 survey were too small to compare with earlier surveys.

Management Advice

5.113 The Working Group reiterated its advice from previous years concerning these species (SC-CAMLR-XIII, Annex 4, paragraphs 4.98, 4.102 and 4.103). In the absence of any new information on these species the Working Group recommended that a directed fishery of these species should remain prohibited (Conservation Measures 2/III, 3/IV, 76/XIII and 85/XIII).

Electrona carlsbergi (Subarea 48.3)

5.114 The only new information on *E. carlsbergi* was on the abundance of larvae and juvenile fish in the South Atlantic submitted in WG-FSA-95/7. These data could not be used to revise the precautionary TACs proposed by the Working Group last year (SC-CAMLR-XIII, Annex 4, paragraphs 4.91 to 4.93) because there was no clear relationship between this survey and the stocks observed in Subarea 48.3.

5.115 The Working Group agreed that the precautionary yields based on the revised krill yield model are appropriate estimates of yield for this species pending a revision of the biological parameters. The Working Group noted that the calculations of long-term yield using this method do not require updated estimates of stock biomass because the estimate of yield obtained from the projections is based on estimates of pre-exploitation biomass and the biological parameters. The estimate of yield (as a proportion of the estimated pre-exploitation biomass) is dependent on the uncertainties in the estimates, with a smaller yield arising from greater uncertainty in the estimates (SC-CAMLR-XIII, paragraphs 5.18 to 5.26).

Management Advice

5.116 Consequently, the Working Group recommends that a TAC for *E. carlsbergi* should be 14 500 tonnes for the region around Shag Rocks and 109 000 tonnes for all of Subarea 48.3 (see SC-CAMLR-XIII, Annex 4, paragraphs 4.91 to 4.93). A consequence of this recommendation is that any potential by-catch of other pelagic species taken by the *E. carlsbergi* fishery is likely to be reduced proportionately to the reduction of the precautionary limit from the 200 000 tonnes set by Conservation Measure 84/XIII.

5.117 In addition, the Working Group agreed that the conservation measure pertaining to the collection of biological information on *E. carlsbergi* from the commercial fishery (Conservation Measure 54/XI) should contain requirements equivalent to those regarding the reporting of this information from other fisheries, including monthly reporting of by-catch and biological information on all species found in the catch. In addition, the Working Group noted that this fishery may take other pelagic species. The Working Group recommended that if Conservation Measure 84/XIII is continued, then it should reference Conservation Measure 52/XI instead of Conservation Measure 54/XI, with the following provisions for setting a TAC and reporting conditions on this fishery:

- the target species is designated as *E. carlsbergi*;
- by-catch species are all other species caught during the fishing operations;
- the relative densities of each species of fish within catches from each fishing ground should be reported; and
- length composition data of 500 specimens of each species taken randomly from catches in this fishery from each fishing ground should be reported.

Historical Commercial Catch Data for *Notothenia rossii* in Subarea 48.3

5.118 Early landings data for *N. rossii* in Subarea 48.3 were reviewed in WG-FSA-95/17. It was concluded that a proportion of the *N. rossii* landings reported in 1969 and 1970 may have been other species including *C. gunnari* (see also paragraphs 3.3. to 3.11).

Crabs (*Paralomis spinosissima* and *P. formosa*) (Subarea 48.3)

5.119 On 1 September 1995, the US fishing vessel *American Champion* began fishing for Antarctic crabs in Subarea 48.3. The vessel is targeting *Paralomis spinosissima* with *P. formosa* being returned to the sea. Fishing operations were conducted in accordance with requirements of Phase I of Conservation Measure 75/XII. Provisions of Phase I require a vessel entering the fishery for the first time to expend its first 200 000 pot hours of effort within a series of 0.5° latitude by 1° longitude blocks. The vessel is limited to expending a maximum of 30 000 pot hours in any single block. To date, fishing effort of the *American Champion* has been mostly conducted to satisfy Phase I requirements. After finishing Phase 1 operations, the vessel began standard commercial operations.

5.120 Conservation Measure 79/XIII requires the reporting to CCAMLR of catch and biological data for all catches taken prior to 31 August 1995; however, no fishing occurred prior to this date. Data for 1 September to 10 October have been submitted in accordance with the 10-day Catch and Effort Reporting System set out in Conservation Measure 61/XII (Table 18). By-catch of *D. eleginoides* during these periods is given in Table 19. *N. rossii* and *G. gibberifrons* were also caught as by-catch, but the total amount of by-catch for these species was low (237 kg for *N. rossii* and 84 kg for *G. gibberifrons*).

Table 18: Catch of *P. spinosissima* (KCS) in crab fishery.

Start of 10-day Period	Catch KCS (numbers)	Catch KCS (kg)	Pots Fished	Hours Fished	CPUE numbers/pot
1 September	3198	2677	847	84	3.8
11 September	2827	2541	960	125	2.9
21 September	36398	32125	2220	240	16.4
1 October	50114	41985	2040	240	24.6
Totals	92537	79328	6067	689	15.3

Table 19: By-catch of *D. eleginoides* (TOP) in crab fishery.

Start of 10-day Period	Catch TOP (numbers)	Catch TOP (kg)	Numbers of TOP/pot	Catch TOP/pot (kg)	kg TOP/kg KCS
1 September	77	196	0.09	0.23	0.07
11 September	133	418	0.14	0.44	0.16
21 September	1039	4291	0.47	1.93	0.13
1 October	460	2090	0.23	1.02	0.05
TOTALS	1709	6995	0.28	1.15	0.09

5.121 Although the 10-day Catch and Effort Reporting System of Conservation Measure 61/XII does not include position data, Dr Watters (the US scientist aboard the vessel at the beginning of the fishing season) noted that data for the first 10-day period was for effort off the southeast coast of

South Georgia. Dr Watters also noted that effort for remaining 10-day periods was expended as the vessel worked its way northwest along the eastern side of the island.

5.122 The Working Group noted that catch rates (crabs/pot) increased with time as the vessel moved along the eastern side of South Georgia. Dr Watters noted that the increased catch rates may have been realised, as it participated in Phase I, because the vessel appeared to change and improve its fishing strategy and methods as the season progressed, but he also thought it likely that crab density is higher in the northwest area.

5.123 The Working Group was concerned that the crabs seemed to be concentrated off the northwest coast of South Georgia and that few crabs were available in other areas. Future assessments may need to consider that the area containing fishable concentrations of crab may not include all of the areas around South Georgia.

5.124 The Working Group recognised that additional information regarding geographical differences in crab density would be very valuable. It noted that during the 1995/96 season, the vessel will be required to conduct Phases 2 and 3 of Conservation Measure 75/XII. Fishing effort during these phases must be expended in three small squares, each measuring approximately 26 n miles² in area, until there is a decline in catch rates. The vessel operator has the option of choosing which squares to fish. The Working Group thought that it would be better for all of the squares occupied during Phases 2 and 3 to be in an area of high density. The area with high densities would also have the greatest variation in catch rates and would be a good area to test whether depletion experiments are likely to work for these species.

5.125 The Working Group noted the presence of finfish by-catch associated with the fishery. The amount appeared to be larger than had previously been observed in the 1991/92 crab fishery. Dr Watters noted that the current fishery uses pots with different opening configurations than those used in 1991/92, and fish may be more susceptible to the current pots. However, insufficient data were available to complete an appropriate analysis of this topic. Members were informed that the presence of scientific observers on the crab vessel would ensure that data on finfish by-catch would be available at the next meeting of the Working Group.

5.126 The Working Group was concerned about the high by-catch rates of *D. eleginoides* from the pots used in the current fishery and recommended that the variability in by-catch rates between different types of pots be investigated further. It also noted that this might be a useful source of live *D. eleginoides* for tagging studies. The study of methods to control by-catch should be undertaken independently of the experimental fishing regime described under Conservation Measure 75/XII.

5.127 Dr Watters reminded the Working Group that Conservation Measure 79/XIII set minimum carapace widths of 102 mm and 90 mm for male *P. spinosissima* and *P. formosa* respectively. The minimum width for *P. spinosissima* was determined using the limited data collected during the 1991/92 fishery; however, because catches of *P. formosa* were not retained during the initial season, the minimum size limit for this species was chosen arbitrarily. Data collected aboard the *American Champion* indicated that a minimum carapace width of 102 mm was appropriate for male *P. spinosissima*; however, observations of *P. formosa* indicate that approximately 75% of the male crabs retained in pots were below the minimum carapace width of 90 mm. It would be unlikely that this large percentage of harvestable male crabs would be sexually immature. The Working Group agreed that the minimum size limit for *P. formosa* should be based upon better data and encouraged the collection of additional measurements for this purpose during the course of the current fishery.

Management Advice

5.128 Since data were not available to make a re-assessment of the crab stock, the Working Group recognised that a conservative management scheme is still appropriate for this fishery. In particular, the Working Group noted that the fishery should be controlled by direct limitations on catch and effort, as well as by limitations on the size and sex of individual crabs which may be retained in the catch. The Working Group agreed that Conservation Measure 79/XIII contains such limitations, and that it should continue to be applied in the management of the crab fishery.

5.129 The Working Group again recalled the Commission's view that an exploratory fishery should not be allowed to expand faster than the acquisition of information necessary to ensure that the fishery can and will be conducted in accordance with the principles in Article II of the Convention. Given this view, the Working Group agreed that Conservation Measure 75/XII could provide valuable information about the crab stock and should continue to be applied in the management of the fishery.

5.130 The Working Group also noted that Conservation Measure 75/XII was in force during the 1993/94, 1994/95 and 1995/96 fishing seasons. However, no fishing had occurred during the 1993/94 season and only limited effort occurred during the 1994/95 season. The Working Group agreed that management of the fishery would benefit from additional data as required by Conservation Measure 75/XII and recommended that this measure remain in force for at least the 1995/96, 1996/97 and 1997/98 fishing seasons.

Other Subareas in Area 48

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

5.131 In the absence of new information on stocks in these areas, the Working Group reiterated its advice of last year that fisheries in Subareas 48.1 and 48.2 should remain closed until a survey is conducted to provide more accurate estimates of the status of these stocks (SC-CAMLR-XIII, Annex 4, paragraph 4.116).

South Sandwich Islands (Subarea 48.4)

5.132 Although a small fishery for *D. eleginoides* was open in this area, no catches were reported. In the absence of further information, the Working Group could not update its advice from 1993 when a TAC of 28 tonnes was recommended (SC-CAMLR-XII, Annex 5, paragraph 6.4).

Statistical Area 58

5.133 Catches in the 1995 season are shown in Table 20. Catches of *D. eleginoides* in Division 58.5.1 were taken in the French trawl fishery and the Ukrainian longline fishery. A fishery for *C. gunnari* was conducted for the first time since the 1991 season, most of the catch being taken by Ukrainian trawlers in Division 58.5.1.

5.134 Catches in Subarea 58.6 (Crozet Island) were taken during French exploratory fishing reported in WG-FSA-95/10, the most recent part of a series extending back to 1983. The results are discussed in paragraphs 3.16 to 3.18.

Kerguelen Islands (Division 58.5.1)

Notothenia rossii (Division 58.5.1)

5.135 At its 1994 meeting the Working Group considered that although there was some evidence for a recovery of this stock, no recent and relevant data were available on the biomass of this species, and so advised that the fishery remain closed until a biomass survey demonstrates that the stock has recovered to a level that will support a fishery (SC-CAMLR-XIII, Annex 4, paragraphs 4.120 to 4.123). No new data are available this year.

Management Advice

5.136 The Working Group again recommended that the fishery for *N. rossii* remain closed until a biomass survey demonstrates that the stock has recovered to a level that will support a fishery.

Lepidonotothen squamifrons (Division 58.5.1)

5.137 As no new data have been received on this species, no new assessment can be made.

5.138 Prof. Duhamel advised that in the 1996 season, the two French vessels trawling for *D. eleginoides* will be required to conduct an exploratory fishery for *L. squamifrons* on the traditional grounds for this species southeast of the Kerguelen shelf. These surveys will take place between 15 October and 31 December 1995, and each of the two trawlers will survey for up to 10 days to obtain data on CPUE and length frequency. This fishery will attempt to cover all of the new fishing grounds, but for operational reasons will not be a systematic survey. Scientific observers will be aboard the vessels. These data will be presented at next year's meeting.

Table 20: Total catches by species and subarea in Statistical Area 58. Species are designated by abbreviations as follows: ANI (*Champocephalus gunnari*), LIC (*Channichthys rhinoceratus*), TOP (*Dissostichus eleginoides*), NOR (*Notothenia rossii*), NOS (*Lepidonotothen squamifrons*), ANS (*Pleuragramma antarcticum*), MZZ (Unknown), SRX (*Rajiformes spp.*), WIC (*Chaenodraco wilsoni*).

Split- Year	ANI		LIC	WIC	TOP				NOR			NOS			ANS		MZZ			SRX
	58	58.5	58.5	58.4	58	58.4	58.5	58.6	58	58.4	58.5	58	58.4	58.5	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			6	6061			12200							548	
1977	10450				XX			-	97			308							11	
1978	72643	250	82		196	-	2	370	46155			31582	6023	98	234				261	
1979				101	3	-	-	-				1307	2096						1218	
1980		1631	8	14		56	138	-			1742		3035	11308					239	
1981		1122	2			16	40	-		217	7924		4865	6239					375	21
1982		16083				83	121	-		237	9812		1594	4038	50				364	7
1983		25852				4	128	14			1829		733	1832	229				4	17
1984		7127				1	145	-		50	744		1175	3794					611 ¹	17
1985		8253		279		8	6677	-		34	1707		570	7394	966				11	7
1986		17137		757		8	459	-		-	801		11283	2464	692					4
1987		2625		1099		34	3144	-		2	482		1963	1641	28					3
1988		159		1816		4	554	491		-	21		5002	41	66					

Split- Year	ANI		WIC	TOP		NOR	NOS		ANS		
	58.5.1	58.5.2	58.4.2	58.4.4	58.5.1	58.6	58.5.1	58.4.4	58.5.1	58.4.2	58.4.4
1989	23628	-	306	35	1630	21	245	4016	1553	30	17
1990	226	-	339	5	1062	-	155	1463	-	-	-
1991	13283 ²	-	-	-	1944	-	287	1000	-	-	-
1992	44	3	-	-	7492 ³	13	-	-	1	-	-
1993	-	-	-	-	2722	-	-	-	-	-	-
1994	12	3	-	-	5083	56	-	-	-	-	-
1995	3936	-			5534	114					

¹ Mainly *Rajiformes spp.*

² There are some discrepancies between the French statistics for the Soviet fishery under licence in Division 58.5.1 (12 644 tonnes) and the STATLANT A data provided by the USSR (13 268 tonnes). It may be explained by the inclusion of 826 tonnes of by-catch (mainly *Rajiformes*) in this total.

³ 1 589 tonnes - France; 5 903 tonnes - Ukraine, of which 705 tonnes were caught by longline.

NB: Before 1979/80 catches reported in Statistical Area 58 mainly concern Division 58.5.1 (Kerguelen subarea). Catch reporting was not divided into Divisions 58.5.1 and 58.5.2 until the 1989 season.

Management Advice

5.139 In the absence of new data and assessments, the Working Group recommended that the Kerguelen shelf fishery should remain closed.

Champtocephalus gunnari (Division 58.5.1)

Catch History Before 1979

5.140 New information provided by Dr V. Gherasimchok in WG-FSA-95/15 Rev. 1 on the Soviet fishery for *C. gunnari* in Subarea 58.5 between 1970 and 1978, before the establishment of the French and Australian Exclusive Economic Zones (EEZs), provides an opportunity to re-assess the early history of this fishery.

5.141 There are large differences between catches reported in WG-FSA-95/15 Rev. 1 and the CCAMLR catch statistics published in the 1990 edition of the *Statistical Bulletin*¹³ (Table 21). Dr Gherasimchok's data from Ukrainian records only account for 65% of the total catches in the *Statistical Bulletin*. In addition, only 69% of the catches reported by Dr Gherasimchok were taken in Division 58.5.1 (Kerguelen Plateau, Skif Bank and Zapadnaya (west) Bank), whereas it had previously been assumed that all reported catches were from this division. The remaining 31% was from Pike Bank (Shchuchya Bank), which is now astride the boundary between the Australian and French EEZs, being mostly within Division 58.5.2.

Table 21: Catches of *C. gunnari* from various locations in Subarea 58.5 reported from the Soviet fishery between 1970 and 1978 in WG-FSA-95/15 Rev. 1, compared to the equivalent data in the *Statistical Bulletin*.

Year	Division 58.5.1				Division 58.5.2	
	Kerguelen Shelf	Skif Bank	Zapadnaya (west) Bank	Total	Shchuchya Bank (Pike Bank)	Total
1969/70	5			5		
1970/71	380			380		
1971/72	33578	1990		35568	5860	5860
1972/73	45			45		
1973/74	25			25		
1974/75	1737			1737	14572	14572
1975/76	11324		253	11577	2663	2663
1976/77	32766		346	33112	4201	4201
1977/78	11220	3520	1841	16581	16166	16166
Total	91080	5510	2440	99030	43462	43462

¹³ CCAMLR. 1990. *Statistical Bulletin*, Vol. 1 (1970-1979). CCAMLR, Hobart, Australia: 61 pp.

Year	Total in WG-FSA-95/15	Total from Area 58 in <i>Statistical Bulletin</i>
1969/70	5	0
1970/71	380	10231
1971/72	41428	53857
1972/73	45	
1973/74	25	7392
1974/75	16309	47784
1975/76	14240	10424
1976/77	37313	10714
1977/78	32747	72939
Total	142492	219853

5.142 In view of these differences, it is recommended that the Data Manager verify the accuracy and completeness of the data reported in WG-FSA-95/15 Rev. 1, and if appropriate check with Russian authorities to see if additional catch data from this fishery are stored there. If he is satisfied that the new data are correct, the *Statistical Bulletin* should be updated.

5.143 Analysis of length frequency distributions given in WG-FSA-95/15 Rev. 1 shows that:

- the three-year cycle of cohort strength was already in place at the beginning of the fishery in 1970 for the Kerguelen shelf stock;
- the first large catches in the 1971/72 season (35 578 tonnes) were taken mainly from the 1+ age group of the 1970 cohort;
- catches on the Kerguelen shelf between 1974/75 and 1977/78 seasons are mainly from the 1973 cohort, exploited from age 1+ to 4+. More than 50 000 tonnes were taken from this cohort during these seasons;
- the 1976 cohort was also heavily exploited at age 1+. In the 1977/78 season 11 220 tonnes were taken from the 1973 cohort at age 4+ and the 1976 cohort at age 1+, and about 75% of fish by number were age 1+; and
- catches on Skif, Pike and other banks outside the Kerguelen shelf were of adult fish, ages 2+ and greater.

5.144 A map of the various banks in the subarea with their English and Russian language names is given in Figure 8.

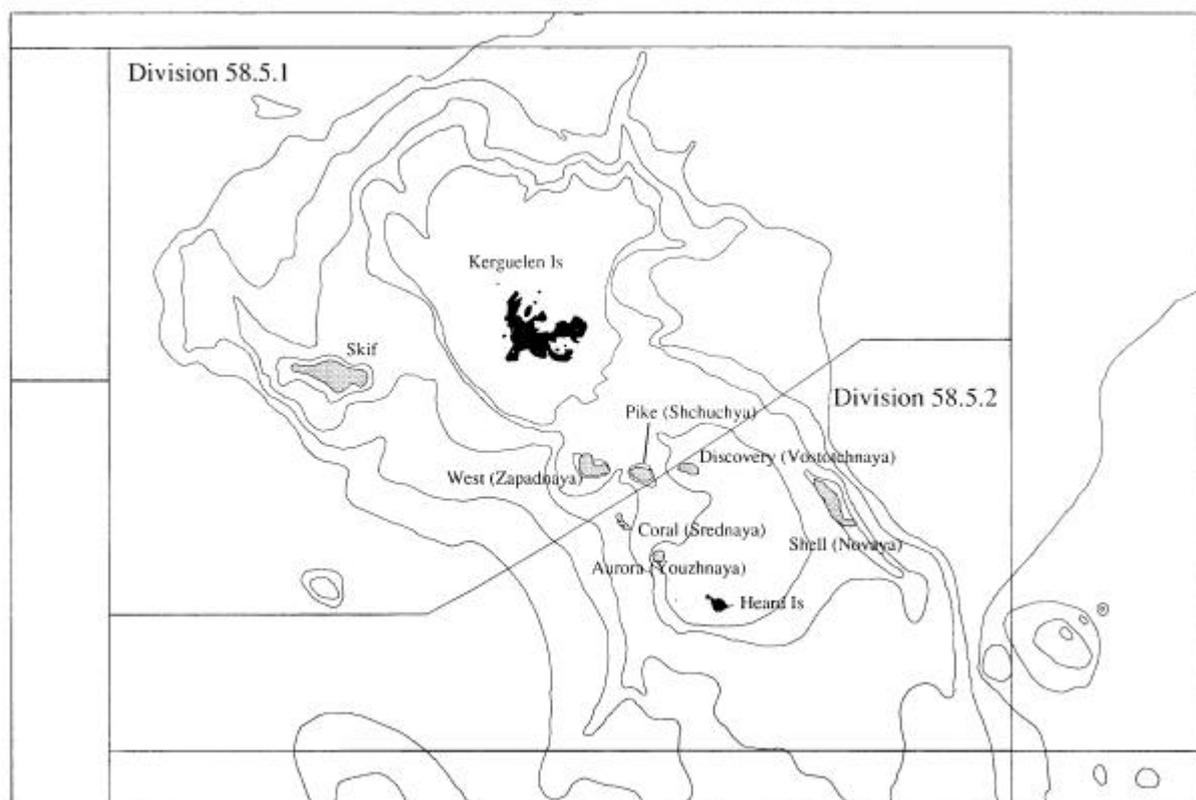


Figure 8: A map of the various banks in the subarea with their English and Russian language names.

5.145 Since this phase of the Soviet fishery ended with the creation of the EEZs, French, Soviet and Australian surveys or exploratory fishing have failed to find concentrations of *C. gunnari* on Pike or the other banks on the Heard shelf. This may be the result of heavy exploitation before 1978, especially of young age classes.

The Current Fishery

5.146 *C. gunnari* was fished for the first time since the 1991 season. Three Ukrainian trawlers took 3 852 tonnes from the traditional grounds on the northeastern Kerguelen plateau, and a French trawler took 84 tonnes. The 1991 cohort, now at age 3+, was exploited, with a mean total length in February 1995 of 31.1 cm (WG-FSA-95/13 Rev. 1). This catch was low compared to other seasons when a strong year class has been fished (Table 20).

5.147 This was in accord with the management advice in the 1994 report (SC-CAMLR-XIII, Annex 4, paragraphs 4.129 and 4.130). This stated that although a strong year class was expected to be present in the 1995 season, only restricted fishing should be allowed on it in order to enable sufficient escapement of fish to spawn a second time. This was because a declining trend in strength of previous strong cohorts had been detected, and it was hoped this strategy would contribute to establishing a population with more than one strong cohort and reduce variability in biomass.

5.148 The Working Group calculated an abundance index based on CPUE for this cohort, as used for previous cohorts in WG-FSA-90/17¹⁴, which gave a value of 0.68×10^4 fish per fishing hour, much lower than for the three previous cohorts at the same age (Figure 9).

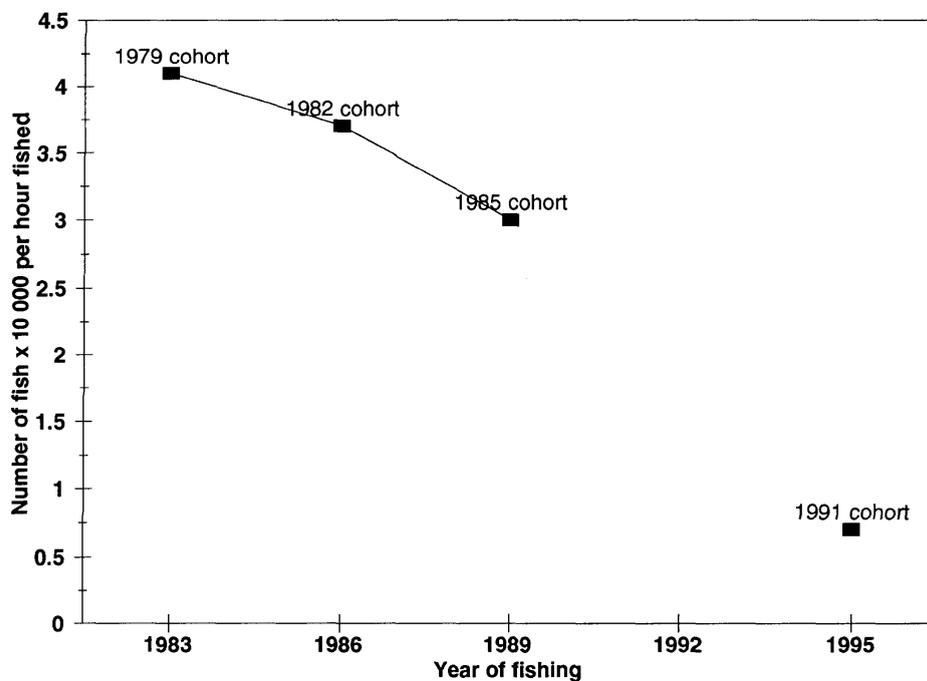


Figure 9: Abundance index of successive cohorts of *C. gunnari* at age 3+ in Division 58.5.1.

5.149 CPUE for all three trawlers in the fishery also declined markedly through the season, from about 2 tonnes/hour in November 1994 to less than 0.3 tonnes/hour in March (Figure 10), which indicates that stock abundance was affected even by this relatively low level of fishing. This phenomenon has not been observed over one season in fisheries targeting previous cohorts.

¹⁴ Duhamel, G. and D.J. Agnew. 1990. A re-analysis of the Kerguelen shelf stock and Skif Bank stocks of *Champsocephalus gunnari*. Document WG-FSA-90/17. CCAMLR, Hobart, Australia.

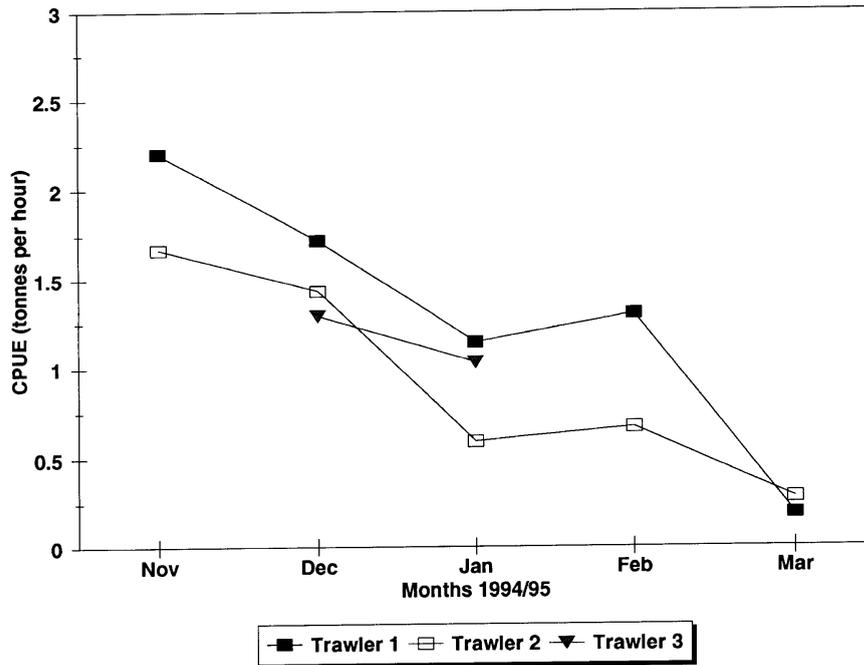


Figure 10: Trends in CPUE of trawlers fishing for *C. gunnari* in Division 58.5.1 during the 1995 season.

5.150 This continues the trend of decline in cohort strength even though no fishing had taken place since the present cohort was born in 1991. The previous 1988 cohort, however, had been heavily fished (13 283 tonnes were taken in the 1990/91 season when these fish were 2+ years old) and before most of them had spawned. This may explain the low abundance of its daughter cohort. More encouraging is that Dr L. Pshenichnov (Ukraine) in WG-FSA-95/13 Rev. 1 notes that many 0+ age fingerlings of *C. gunnari*, 25 mm to 60 mm long, were observed in the by-catch during the fishery last season. This suggests that the first spawning of the 1991 cohort in July 1994 was successful, even though the cohort abundance was low.

Management Advice

5.151 The Working Group advised in its 1993 and 1994 reports that because of the consistent decline in abundance of the strong cohorts appearing every three years, fishing of them should be delayed until they have had at least one opportunity to spawn and, thereafter, fishing should be kept to a low level to allow sufficient escapement of fish to spawn a second time.

5.152 Given the continuation of this decline, the Working Group recommended that this policy be continued. It therefore recommended that the fishery for *C. gunnari* in Division 58.5.1 be closed until at least the 1997/98 season, when the cohort born in 1994 will have had an opportunity to

spawn. Before this cohort is fished, it is recommended that a pre-recruit biomass survey be conducted in the 1996/97 season to evaluate the strength of the cohort at age 2+. These data should be evaluated at the 1997 meeting of WG-FSA, and an appropriate level of catch recommended.

Dissostichus eleginoides (Division 58.5.1)

5.153 Fishing for this species continued in the 1994/95 season in the two traditional areas, a longline fishery on the western slope and a trawl fishery on the northern shelf. The most recently discovered ground on the eastern part of the shelf (WG-FSA-93/15¹⁵) was also exploited by one trawler for one cruise.

5.154 On the western slope of the plateau, 1 432 tonnes were caught by three Ukrainian longliners. The catches were in accordance with the 1 400 tonnes recommended in the 1993 report (SC-CAMLR-XII, Annex 5, paragraph 6.129).

5.155 There was a substantial decrease in catches in the northern area, from 4 141 tonnes during the 1994 season (SC-CAMLR-XIII, Annex 4, paragraph 4.132) to 3 164 tonnes caught by two French trawlers in the 1995 season. This slightly exceeded the 3 000 tonne limit set for this zone by French authorities. One of the two trawlers also took 810 tonnes from the new fishing zone on the eastern edge of the plateau, and 128 tonnes were taken as a by-catch of the *C. gunnari* bottom trawl fishery on the northeastern shallow shelf.

Standardisation of CPUE Indices from *D. eleginoides* Fisheries in Division 58.5.1 (Kerguelen)

5.156 Since the results of standardising CPUE data from the *D. eleginoides* fishery in Subarea 48.3 were useful, the Working Group decided that it would be valuable to conduct similar analyses for the fisheries in Division 58.5.1.

5.157 Two separate GLM analyses were conducted on CPUE data from the fisheries for *D. eleginoides* around Kerguelen. The first was an analysis of CPUE data from the French trawl fishery operating off the northern and eastern coasts of Kerguelen. The second analysis was

¹⁵ Duhamel, G. 1993. The *Dissostichus eleginoides* fishery in Division 58.5.1 (Kerguelen Islands). Document WG-FSA-93/15. CCAMLR, Hobart, Australia.

conducted on CPUE data from the Ukrainian longline fishery operating off the western coast of the island. The French trawl data and the Ukrainian longline data could not be simultaneously analysed in a single GLM because there is no spatial overlap between these two fisheries.

Analysis of French Trawl Data

5.158 Five variables were selected as predictors for standardisation of the trawl CPUE data: vessel, year, month, area and depth. These predictors were used to model one CPUE index: kilograms per trawl hour.

5.159 The GLMs were fit to haul-by-haul data from 1994 and 1995, and the Working Group thanked Prof. Duhamel for providing these data.

5.160 The predictor effects were considered to be multiplicative, and the modelling strategy followed the methods previously outlined for the *D. eleginoides* fishery in Subarea 48.3. (paragraphs 5.22 to 5.43).

5.161 Year, vessel and depth were significant components of the variance in CPUE from the French trawl fishery (Table 22). There were not enough data to estimate month or area effects. The trawl GLM did not fit as well as those estimated for the longline fishery in Subarea 48.3; the reduction in deviance was only 4%.

5.162 Depth was the most significant component of the variance in trawl CPUE (Table 22). Kilograms per trawl-hour declined with increasing depth (Figure 11).

Table 22: Analysis of deviance table from GLM fit to French trawl data (1994-1995, northern and western sectors).

Factor/Covariate	Residual df*	Residual Deviance	p
NULL	957	602.4	
Year	956	596.1	0.0117
Vessel	955	590.5	0.0180
Depth	954	577.5	0.0003

* degrees of freedom

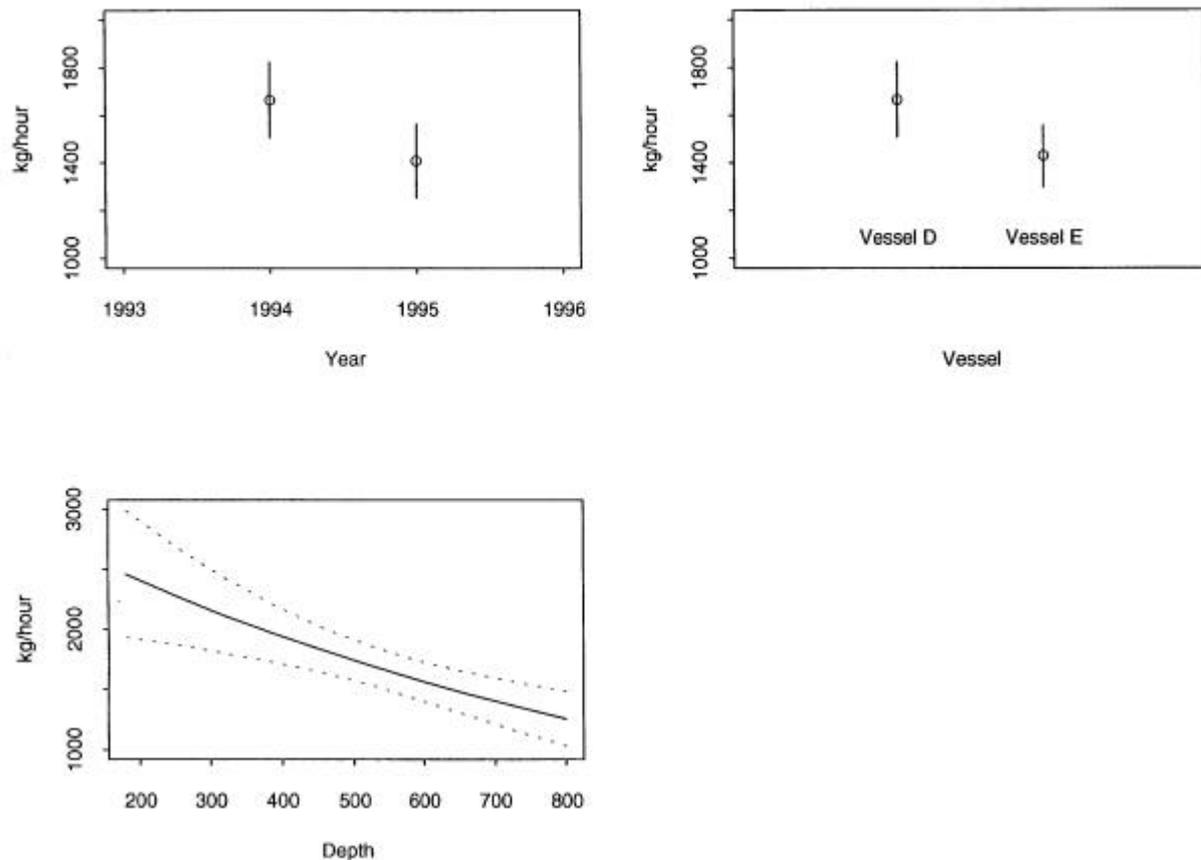


Figure 11: Estimated year, vessel and depth effects from a GLM fit to CPUE data from the *D. eleginoides* trawl fishery in the northern and eastern sectors of Division 58.5.1 (French fishing fleet). Circles are predicted area responses in the year and vessel plots and lines in these plots represent approximate 95% confidence limits. In the depth plot, the solid line is the estimated area response, and the dotted lines are the approximate 95% confidence limits on the predicted area response.

5.163 The year and vessel factors were about equally significant components of the variance in trawl CPUE. Kilograms per hour decreased between 1994 and 1995, and vessel 'D' had higher catch rates than vessel 'E' (Figure 11). Prof. Duhamel noted that the difference in catch rates between the two vessels was a result of differences in the type of factory production on each vessel. Vessel 'E' targets larger fish for the fillet market, while vessel 'D' targets smaller fish to produce headed and gutted product.

5.164 The Working Group noted that since the residual deviance from the trawl GLM was relatively large when compared to the null deviance, there are probably variables contributing to variation in CPUE that were not considered in the GLM. For this reason, the Working Group recommended that

during the intersessional period the haul-by-haul data from the trawl fishery be explored to identify additional predictor variables.

Analysis of Ukrainian Longline Data

5.165 Five variables were selected as predictors for standardisation of the Ukrainian CPUE data: vessel, year, month, soak time and depth. These predictors were used to model one CPUE index: kilograms per hook.

5.166 Unfortunately, haul-by-haul data from the Ukrainian fishery were not available to the Working Group, but Prof. Duhamel provided vessel-specific catch and effort data that was averaged over 5-day intervals.

5.167 Year was the only significant component in the variance of the Ukrainian CPUE data; none of the other predictors contributed to a significant reduction in residual deviance (Table 23). The predicted year effects for kilograms per hook (averaged over 5-day intervals) are plotted in Figure 12. The standardised CPUEs differ between years, but there is no apparent trend over time.

Table 23: Analysis of deviance table from GLM fit to Ukrainian longline data (1991 to 1995, eastern sector).

Factor/Covariate	Residual df	Residual Deviance	p
NULL	172	44.5	
Year	168	35.4	0.0573

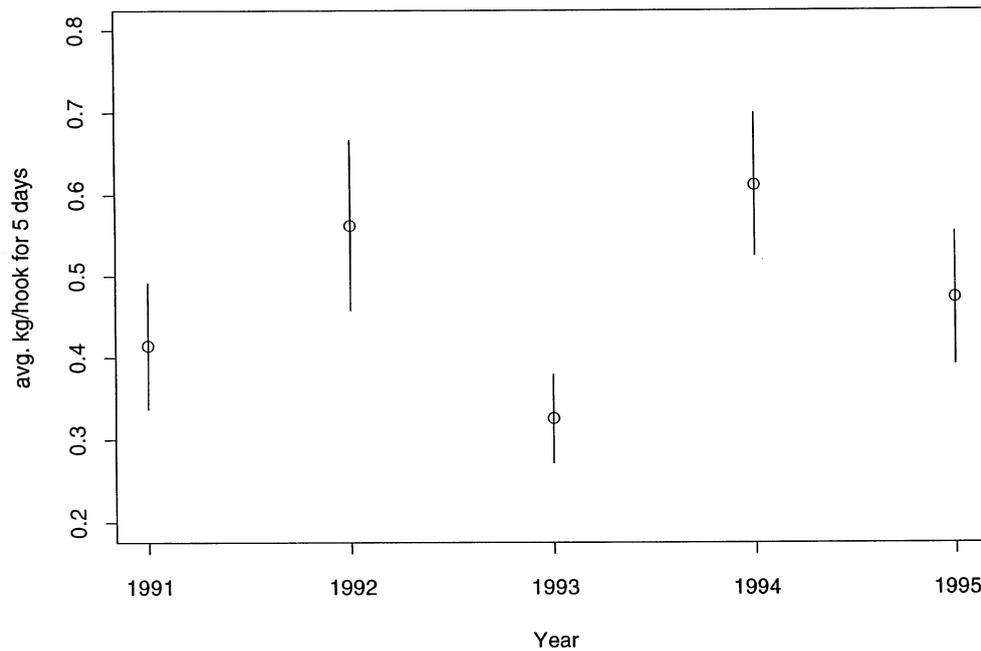


Figure 12: Estimated year effects from a GLM fit to CPUE data from the *D. eleginoides* longline fishery in the western sector of Division 58.5.1 (Ukraine fishing fleet). Circles are predicted area responses and lines represent approximate 95% confidence intervals for the predictions.

5.168 The Working Group was concerned about the lack of significance of factors in the GLM that are known to be significant for the fishery in Subarea 48.3 (i.e., month, soak time and depth). The Working Group noted that haul-by-haul data are critical for proper standardisation of CPUE data and recommended that every effort should be given to providing these data to future meetings of the Working Group.

Management Advice

5.169 French authorities have already set TACs for the three sectors fished for the 1995/96 season. These are 2 800 tonnes for the trawl fishery in the northern sector, 1 000 tonnes for the trawl fishery in the eastern sector, and 500 tonnes until the end of 1995 for the longline fishery in the western sector.

5.170 For the western sector longline fishery, there has been no decline in the trend of CPUE in recent years (WG-FSA-93/15 and subsequent data), so the Working Group recommended that the value of the longterm sustainable yield estimated at the 1994 meeting (SC-CAMLR-XIII, Annex 4, paragraph 4.134) of 1 400 tonnes per split-year be continued. As a 500 tonne catch has already been authorised for the first half of the split year, this would imply a catch limit for the January to

June 1996 period of 900 tonnes. The Working Group recommended, however, that further analysis of the *D. eleginoides* stocks exploited by the longline and trawl fisheries should be undertaken at the next meeting using the improved techniques recently established at WS-MAD.

5.171 At its 1993 meeting, the Working Group recorded that CPUE in the trawl fishery in the northern sector had fallen from 3.4 tonnes/hour in 1990/91, the first season of exploitation, to about 1 tonne/hour in the 1991/92 season (SC-CAMLR-XIII, Annex 5, paragraph 6.211). Since then the CPUE has stabilised at about 1.5 tonnes/hour. The Working Group therefore recommended that the TAC set by French authorities, which is a slight decrease from the 3 000 tonnes set in the previous year, be endorsed.

5.172 The eastern sector has only been fished in the 1995 season, when 810 tonnes were caught. The limit of 1 000 tonnes set by French authorities is considered appropriate as a precautionary approach.

5.173 The Working Group felt that the GLM analysis of factors affecting CPUE in longline and trawl fisheries is a potentially useful technique to improve its assessments. However, the analyses described in paragraphs 5.157 to 5.169 were limited by the lack of data on a haul-by-haul basis for the longline fishery, and by lack of data prior to 1994 for the trawl fisheries. The Working Group recommended therefore, that in future, catch and effort data be collected and reported to CCAMLR on a haul-by-haul basis for the longline fishery. In addition, efforts should be made to acquire haul-by-haul data from Ukrainian authorities for the fisheries in previous years. Prof. Duhamel will bring to next year's meeting the haul-by-haul data for the French trawl fishery prior to 1994. This will enable a more thorough GLM analysis to be performed in subsequent years.

Ob and Lena Banks (Division 58.4.4)

5.174 At CCAMLR-XIII, a conservation measure to allow a commercial catch of 1 150 tonnes of *L. squamifrons* to be taken over a two-year period (Conservation Measure 87/XIII) was approved at the request of Ukraine, provided a biomass survey was undertaken. Despite this, no fishing took place during the 1994/95 season, and so no new data are available.

5.175 Revised catch figures for both banks submitted to last year's meeting too late to be used in assessments (SC-CAMLR-XIII/BG/13¹⁶) were verified intersessionally by the Data Manager. These differ little from the previously accepted data set (Table 24), and it was felt that the differences did

¹⁶ Ukraine. 1994. Ob and Lena Banks: Report of Observer. Document SC-CAMLR-XIII/BG/13. CCAMLR, Hobart, Australia.

not warrant a re-assessment of the stocks. As these data now describe catches for Ob and Lena Banks separately, it is recommended that separate statistical subdivisions be made for each bank and that in future catch and effort data be continued to be reported separately for each bank.

Management Advice

5.176 The Working Group reiterated its opinion held for the past few years that a biomass survey is necessary to provide a valid assessment of the fish stocks on the two banks.

5.177 As Conservation Measure 87/XIII, allowing a catch of 1 150 tonnes of *L. squamifrons* on the two banks provided an approved biomass survey is undertaken, is still valid until the end of the 1995/96 season, the Working Group encouraged this option to be taken up. This should provide data on which a new assessment can be based.

Heard and McDonald Islands (Division 58.5.2)

5.178 Dr Gherasimchuk's re-analysis of fisheries statistics held by Ukraine (WG-FSA-95/15 Rev. 1) reveals for the first time that catches of *C. gunnari* had been taken from the Heard Island shelf and associated banks between 1970 and 1978 (Table 21 and paragraphs 5.141 to 5.145).

5.179 No fishery has been reported in recent times, but Conservation Measure 78/XIII set precautionary TACs of 311 tonnes and 297 tonnes for *C. gunnari* and *D. eleginoides* respectively on the basis of results from Australian biomass surveys (Williams and de la Mare, 1995¹⁷).

¹⁷ Williams, R. and W.K. de la Mare. 1995. Fish distribution and biomass in the Heard Island zone (Division 58.5.2). *CCAMLR Science*, Vol. 2: 1-20.

Table 24: Reported catches of *L. squamifrons* from Ob and Lena Banks.

Year	1977 /78	1978 /79	1979 /80	1980 /81	1981 /82	1982 /83	1983 /84	1984 /85	1985 /86	1986 /87	1987 /88	1988 /89	1989 /90	1990 /91	Total 1977/78 to 1990/91	Reference
Ob	4952	1511	2831	1645	114	307	341	513	4999	1683	2989	850	867	-	22735	New data reported to CCAMLR
Ob	4952	1511	2830	1586	70	313	341	513	4999	1457	2989	850	867	-	22411	WG-FSA-92/5
Ob	4821	234	4167	41	56	588	40	1023	9531	1601	1971	913	-	-	24986	WG-FSA-90/37
Lena	1071	585	204	3220	1480	426	834	57	6284	280	2013	3166	596	1000	19620	New data reported to CCAMLR
Lena	1071	585	201	3073	514	426	822	57	6284	506	2013	3166	596	-	18718	WG-FSA-92/5
Lena	1592	267	2616	1934	59	840	397	87	1977	441	2399	3003	-	-	15612	WG-FSA-90/37
Ob and Lena	6023	2096	3035	4865	1594	733	1175	570	11283	1963	5002	4016	1463	1000	42355	New data reported to CCAMLR
Ob and Lena	6023	2096	3031	4659	584	739	1163	570	11283	1963	5002	4016	1463	-	41129	WG-FSA-92/5
Ob and Lena	6413	501	6783	1975	115	1428	437	1107	11508	2045	4370	3916	-	-	40598	WG-FSA-90/37

5.180 At the 1994 meeting, TACs for *D. eleginoides* and *C. gunnari* were estimated using the revised form of the krill yield model (SC-CAMLR-XIII, Annex 4, paragraphs 4.153 to 4.159). The Scientific Committee agreed that the TAC should be revised when better estimates of the biological parameters became available.

5.181 The estimates of biological parameters for *D. eleginoides* established at WS-MAD this year were used as the basis for a revised assessment. However, the estimates of M are still uncertain, and a range of values of M between 0.1 and 0.2 were used in the model. Table 25 shows the γ_1 estimated using the generalised yield model (paragraphs 3.44 to 3.47) and γ_2 calculated using 50% escapement from the fishery. The program was run for each of the CVs derived from the two valid biomass surveys, as in WG-FSA-94 (SC-CAMLR-XIII, Annex 4, paragraph 4.150). Estimates of yield for these runs are shown in Table 25. γ_2 remains the most conservative approach and its value is identical with that obtained last year (0.025). The TAC does not change.

Table 25: Values of γ calculated from the general yield model for each of the CVs derived from the two biomass surveys reported in Williams and de la Mare, 1995.

Survey	CV%	Biomass Estimate	γ_1	γ_2	TAC (using γ_2)
Autumn 1990	25.2	17714	0.028	0.025	443
Spring 1993	18.6	11880	0.0295	0.025	297

5.182 No other new data were available, but an Australian vessel plans to fish both *C. gunnari* and *D. eleginoides* in the division in the 1996 season. There is also an application to attempt a new fishery on *D. eleginoides* in Division 58.4.3 which adjoins Division 58.5.1 (paragraphs 5.1 to 5.7).

Management Advice

5.183 Conservation Measure 78/XIII established a TAC of 311 tonnes for *C. gunnari* in Division 58.5.2. In the light of experience with the fishery for this species in Division 58.5.1 (paragraphs 5.146 to 5.152), it is recommended that the fishery for *C. gunnari* in Division 58.5.2 also avoid the taking of fish smaller than the size at first spawning (about 28 cm total length).

5.184 The revised assessments given in paragraph 5.181 did not suggest that any revision of the TAC of 297 tonnes was necessary. Information from the fishery in the coming season may enable new assessments to be made at next year's meeting. Improved techniques developed in WS-MAD should be used with biological parameters derived from data on fish from this area.

Pacific Ocean Sector (Area 88)

5.185 No information was available to make any assessment of this area.

CONSIDERATIONS OF ECOSYSTEM MANAGEMENT

Interactions with WG-EMM

6.1 At its first meeting, WG-EMM had developed a plan for providing an ecosystem assessment and had concluded that such an assessment should consist of:

Part 1: an analysis of the status of key biotic components of the ecosystem; and

Part 2: a prediction of the likely consequences of alternative management actions for the future status of these components.

6.2 WG-EMM concluded that 'status' should include not only the points necessary for a single-species assessment, which are:

current abundance and productivity of the harvested species, with abundance related to some level prior to the onset of exploitation; and

if possible, the relationships between these quantities and the state of the environment;

but also points related to dependent species which may be summarised as:

current abundance of dependent species (usually expressed as breeding population size or an index thereof) in relation to previous values, where possible in conjunction with data on current and recent adult survival and recruitment rates.

6.3 Historical developments have been towards assessments of the status of krill, as the key harvested species, and selected krill-dependent bird and mammal species. It was, however, recognised that other animals, such as fish and squid, are also dependent on krill and also that there are other food chains containing harvested species that do not directly include krill.

6.4 The icefish *C. gunnari* is a good example of a harvested species that is, in part, dependent on krill and is also predated by fur seals and some species of birds. Myctophids are an example of a group which had been harvested previously and which are a primary source of food of birds and seals.

6.5 The common interests of WG-FSA and WG-EMM concerning various aspects of the interactions, clearly indicate that there is a need for the two working groups to work together. In developing this work it is important that the focus of attention of each working group is aimed at avoiding duplication and also ensuring that the work of one group supports and extends the work of the other, thus improving the quality of advice being brought forward to the Scientific Committee.

6.6 The Working Group agreed that WG-EMM might provide information on harvested finfish species present in the diet of predators to be used in determining functional relationships between harvested fish and their predators. The types of information which WG-FSA could utilise would include: species taken, amount eaten, size and age composition of the prey, distribution and density of foraging activity.

6.7 WG-FSA felt that WG-EMM might benefit from information on the status of harvested species and specifically on the subjects of distribution, abundance and production.

6.8 It was noted that there are some fields where the same approaches are used by both working groups. One example is the use of acoustics for estimating the abundance and distribution of pelagic resources; this is a topic that receives much attention at WG-EMM from experts in the field. Clearly WG-EMM is the best forum for this topic to be developed for the time being. Another area of interest is statistical analyses, where both working groups have specific requirements; where the statistical problems were similar for the two groups there would be advantages in combining some of this work.

6.9 The Working Group discussed how best to achieve close liaison between the working groups and provide the best advice to the Scientific Committee. The advice from WG-FSA to the Scientific Committee is generally targetted towards developing a management plan on a season-by-season basis whereas WG-EMM is looking to drawing together information for ecosystem assessment over a longer time-scale. It was felt that because some Members participate in both working group meetings, requests from one group could be more easily understood by the other. The other approach was to formulate specific questions, examples of which are set out below.

6.10 The Working Group considered specific interactions for which advice might be sought from WG-EMM.

6.11 The recent history of the *C. gunnari* fishery in Subarea 48.3 has included periods when the stock has declined in the absence of commercial harvesting. This topic has been discussed at WG-FSA and raised at WG-EMM. It is thought that the decline is in some way related to the availability of krill, either directly as food for icefish, or else as a result of predators feeding more intensively on fish when krill are scarce. The Working Group therefore proposed the following questions for consideration by WG-EMM:

- (i) How much *C. gunnari* is eaten by major predators in Area 48 and particularly in Subarea 48.3?
- (ii) How does this impact vary within and between seasons?
- (iii) Under what circumstances does the diet of individual predator species feeding on *C. gunnari* vary?

6.12 It was noted that the overlap between the distributions of krill and myctophids is being considered by WG-EMM. Studies in this field may provide information of value to WG-FSA in providing advice on the status of myctophids. In the event that a fishery recommences on Myctophidae, WG-FSA will be required to reconsider previous assessments. An abundance survey of myctophids in Subarea 48.3 was requested by WG-FSA at its 1992 meeting (SC-CAMLR-XI, paragraph 6.107). Estimates of annual production of myctophids would be enhanced by taking note of consumption rates by predators as had been done in the early krill assessments. WG-FSA therefore puts the following question to WG-EMM:

What is the estimated consumption by predators of Myctophidae in the Convention Area and adjacent waters?

6.13 The Working Group considered that this question should have a lower priority than those related to *C. gunnari* in paragraph 6.11 above.

6.14 WG-CEMP initially, and also WG-EMM, have considered *P. antarcticum* as a species for study within the Ecosystem Monitoring Program. No proposals for monitoring studies have been received and, accordingly, research activities on this species were given a low priority. It was noted that the biology and ecology of *P. antarcticum* were discussed at some length during a meeting of the Antarctic Fish Network of the European Science Foundation and that Dr G. Hubold (Germany) is preparing a review paper on the subject. The Working Group looked forward to receiving this review.

6.15 WG-FSA considered a proposal which had been put to WG-EMM on the use of blue-eyed shags (*Phalacrocorax atriceps*) as indicators of the status of some coastal fish species. The proposal had been brought forward for consideration in WG-EMM-95/84. The Working Group felt that the study might provide useful indices for *N. rossii* and *G. gibberifrons*, particularly since it had not been possible to provide resources for direct estimation of the status of these species.

By-catch of Fish in the Krill Fishery

6.16 Two papers reporting on the by-catch of fish in the krill fishery had been tabled at WG-EMM. One (WG-EMM-95/56) assessed the by-catch in the Japanese krill fishery off the South Shetland Islands (Subarea 48.1) from 30 January to 18 February 1995, the other (SC-CAMLR-XIV/BG/10) the occurrence of fish in commercial krill catches taken by a Japanese trawler off Wilkes Land (Division 58.4.1) from 19 January to 2 March 1995.

6.17 A detailed examination of these papers was prepared by WG-EMM for submission to WG-FSA and is included below.

6.18 The study conducted in the South Shetland Island region used the subsample size of 50 kg recommended in the *Scientific Observers Manual* as suggested by WG-Krill and WG-FSA last year (SC-CAMLR-XIII, Annex 5, paragraph 3.15; SC-CAMLR-XIII, Annex 4, paragraph 5.6). However, the by-catch (in numbers and weight of fish) was only extrapolated to 100 kg of krill and not standardised to numbers per tonne krill caught and numbers per tonne/hour as recommended in the *Scientific Observers Manual*. As a consequence, the findings are not directly comparable to previous studies. The study off Wilkes Land was the first study carried out by an international scientific observer. Most (88.8%) of the 169 hauls were made in a narrow band between 63 to 64°S latitude and 103 to 104°E longitude. Twenty-one hauls (12.4%) were sampled for finfish by-catch. With a few exceptions, the crew of the trawler surveyed the entire catch as the fish passed on a conveyor belt through the processing deck and as fish were gathered. Subsamples from hauls only partially surveyed were extrapolated to the entire catch. Subsamples of 25 to 50 kg krill from a number of hauls in the second part of the cruise (from station 70 onwards) were investigated more thoroughly for the presence of larval fish.

6.19 Twenty (25.6%) out of 78 hauls investigated in WG-EMM-95/56 contained fish. The area of operation is clearly reflected in the species composition of the fish incidentally caught. They were all mesopelagic species with the myctophid *Electrona antarctica* being the most abundant both in terms of numbers (85.6%) and weight (64.7%). However, no larval fish were observed. The

author concluded that there is evidence that the by-catch of fish is greater when catch rates of krill are lower.

6.20 The Working Group noted that based on information provided by Japanese scientists during the meeting, it became obvious that the study in the South Shetland Islands was only representative, if at all, for the first part of the fishing season when Japanese trawlers were operating offshore over the deeper slope and in oceanic waters. The amount of by-catch extrapolated to 1 tonne of krill varied between 10 and 500 fish and is comparable to the level of by-catch of young notothenioids reported for Japanese trawlers operating in the shelf and upper slope waters of the South Shetland Islands in the previous season by the same author (WG-Krill-94/25¹⁸). The author's conclusion that the by-catch of fish tended to be greater at lower catch rates of krill agreed with earlier conclusions by the Scientific Committee. However, the Working Group noted that plots of the krill/fish catch ratio (as shown in Figure 1 of WG-EMM-95/56) can be misleading because they impose an implicit negative correlation (krill catch at the y-axis and fish/krill catch at the x-axis). The appropriate manner in which to investigate the hypothesis is to consider plots of fish catch rates versus krill catch rates. Given the limited amount of data available from one cruise this may best be achieved by pooling data from several cruises in the same region and period.

6.21 The observations off Wilkes Land represented the first study of that kind in this region. Twenty out of the 21 hauls surveyed contained fish. No larval fish were observed. The by-catch composition was different to the one observed off the South Shetland Islands. The most abundant species were the mesopelagic *Notolepis coatsi* and *Xenocyttus nemotoi* and juveniles of the giant nototheniid *D. mawsoni*. On five occasions, squid (*Psychroteuthis glacialis* and unidentified species) were found. The Working Group noted that, given the different way the data had been obtained and presented, it was impossible to compare by-catch levels with those provided in WG-EMM-95/56.

6.22 Subsequent to WG-EMM, a further analysis of the data in SC-CAMLR-XIV/BG/10 had been undertaken by Dr Watters and presented as WG-FSA-95/40. The author concluded that there was a great deal of uncertainty in the estimates of mean and total by-catch. It was suggested that one way of improving this situation would be by increasing the sampling effort, however, since this topic had been assigned a low priority in the list of sampling procedures in the *Scientific Observers Manual*, it was felt that this situation was unlikely to improve in the near future.

6.23 The Working Group was concerned that in spite of requests for this work to be undertaken it was still unable to provide a clear indication of the likely impact of krill harvesting on juvenile fish.

¹⁸ Iwami, T. 1994. Fishes caught along with the Antarctic krill in the vicinity of the South Shetland Islands during the austral summer months of 1994. Document WG-Krill-94/25. CCAMLR, Hobart, Australia.

Two approaches were considered, a thorough examination of current data leading to a revision of the sampling requirements and an increase in sampling effort.

6.24 It was noted that work is in progress on reviewing current information through a group which includes T. Iwami (Japan), Z. Cielniaszek (Poland) and E. Pakhomov (Ukraine). It was recommended that this group be augmented by inclusion of Dr Watters for statistical advice and Dr M. White (UK) for information on larval distribution. In the first instance the group would operate by correspondence and be coordinated by Dr E. Sabourenkov (Secretariat).

6.25 The Working Group agreed that the topic should have a higher priority and be discussed under a single agenda item at its next meeting. The Secretariat was requested to develop a format for reporting of historical data and thereby encourage Members to submit further data.

6.26 One additional scientific observer's report was received too late to be considered by the Working Group (SC-CAMLR-XIV/BG/20). The Working Group recommended that WG-EMM consider this paper in more detail at its 1996 meeting.

Ecological Interactions

6.27 When considering trawl fisheries, the Working Group had previously advised that, due to the likely slow regeneration times for benthos, and the lack of any firm information on the effects of trawling on benthic communities, bottom trawling should be banned. The topic of ecological interactions is currently being investigated in other fisheries, for example, by the ICES Study Group on Unaccounted Mortality (ICES CM 1995/B:1 Ref. Assess) under the heading 'habitat degradation mortality', and further information is likely to accrue from that source. In the meantime, the Working Group agreed that bottom trawling should continue to be prohibited in Area 48. Midwater trawling could be permitted because the gear is likely to have minimal impact on benthos even when conducted close to the bottom.

6.28 The Working Group considered conservation measures which apply to finfish. In general, conservation measures specify target species but not the fishing method. For example, Conservation Measure 80/XIII is drafted on the assumption that the only method of fishing will be longlining even though it is clear that, based on historical catches and survey information, the target species *D. eleginoides* can be caught in trawls. The Working Group noted that the trawl fishery in Patagonia for *D. eleginoides* had been closed and that there were concerns that trawlers might move to parts of the CCAMLR Convention Area where this species is found. Providing part of a TAC was still available and the season was still open, such trawlers could legitimately target *D. eleginoides*. The

Working Group emphasised that its advice in paragraph 5.86 was based on the assumption that longlining would be the only fishing method employed in Subarea 48.3.

Experimental Fishing

6.29 The crab fishery in Subarea 48.3 was an example of a predetermined sampling design being incorporated into a conservation measure (Conservation Measure 75/XII). The first results of this study were available to the Working Group and are reported in paragraphs 5.119 to 5.122. The Working Group noted with pleasure that much useful information from this fishery was becoming available from the outset and as the fishery develops. This in turn would aid the Working Group in providing good advice for management of the resource. The Working Group considered that this approach might be applied to other fisheries within the Convention Area.

RESEARCH SURVEYS

Simulation Studies

7.1 The Working Group endorsed the use of simulation studies in tackling specific survey design questions. It also recognised that simulation studies need to be developed in conjunction with experimental surveys in an iterative manner. For example, the survey design simulation described in Everson et al. (1992)¹⁹ addressed the specific problem of assessing the abundance of aggregating fish such as *C. gunnari*. Although the 1994 UK cruise tried to implement this approach, aggregations of *C. gunnari* were not found (WG-FSA-94/18²⁰).

7.2 The Working Group identified a number of other fields in which simulation studies could be applied:

- surveys aimed at obtaining simultaneous estimates of the abundances of *C. gunnari* and *D. eleginoides*;
- the design of experiments in the *D. eleginoides* fishery; and

¹⁹ Everson, I., M. Bravington and C. Goss. 1992. Trawl survey design: results from a simulation study of the mackerel icefish, *Champscephalus gunnari* at South Georgia. Document for the CCAMLR Workshop on Bottom Trawl Survey Design, Hamburg, Germany, 16-19 September, 1992.

²⁰ Everson, I., G. Parkes, K.-H. Kock, C. Goss, D. Cielniaszek, J. Szlakowski, H. Daly, L. Allcock and G. Pilling. 1994. Fish stock assessment survey in Subarea 48.3. Document WG-FSA-94/18. CCAMLR, Hobart, Australia.

- determination of sample sizes for the calculation of representative length distributions from survey data.

Notification of Intended Surveys

7.3 Last year, some concern was raised that the six-month lead-in time, required by Conservation Measure 64/XII (paragraph 3a) for the notification of research surveys in cases where the catch in surveys is expected to be greater than 50 tonnes, was too long (SC-CAMLR-XIII, paragraph 11.4). After considerable discussion, the Working Group confirmed that this provision is appropriate, since it ensures that there are sufficient opportunities for review of proposals by working groups and the Scientific Committee before those research plans can proceed.

INCIDENTAL MORTALITY ARISING FROM LONGLINE FISHING

Intersessional Work on Seabird Incidental Mortality in Longline Fisheries

8.1 In 1993 the Scientific Committee established an ad hoc working group to consider Incidental Mortality Arising from Longline Fishing (WG-IMALF). This met in Hobart in 1994 (SC-CAMLR-XIII, Annex 8). Although there was no meeting of the ad hoc working group in 1995, a coordinating group convened by Prof. Moreno and the Secretariat worked during the intersessional period in accordance with the plan of work outlined in last year's paper 'Intersessional work on longline incidental mortality, 1994/95' (CCAMLR-XIII/BG/30).

8.2 A summary of work undertaken by the Secretariat during the 1994/95 intersessional period is given below. Items are listed in the same order as in the program of work recommended in CCAMLR-XIII/BG/30.

8.3 As required, all members of the coordinating group were provided with a set of working documents at the beginning of the intersessional period.

8.4 The following additional documents were distributed to the coordinating group during the intersessional period:

- two reports of observations of seabirds conducted on board a Korean longliner in 1995 and a Bulgarian/Ukrainian longliner in 1994 by Russian scientific observers designated in accordance with the Scheme of International Scientific Observation; and

- a paper by Dr M. Hall of the Inter-American Tropical Tuna Commission (IATTC), received via Dr Croxall, entitled 'Strategies to reduce the incidental capture of marine mammals and other species in fisheries'.

8.5 The Secretariat has informed the following international organisations of CCAMLR initiatives on the prevention of incidental mortality of seabirds in longline fisheries:

- International Commission for the Conservation of Atlantic Tunas (ICCAT);
- Indian Ocean Fisheries Commission (IOFC);
- South Pacific Commission (SPC);
- South Pacific Fisheries Forum Agency (FFA);
- Commission for the Conservation of the Southern Bluefin Tuna (CCSBT);
- UN Food and Agriculture Organisation (FAO); and
- UN Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks.

8.6 This information was also provided to all CCAMLR scientific observers nominated by the Commission to meetings of the international organisations listed above and the XIX Antarctic Treaty Consultative Meeting (ATCM) (CCAMLR-XIII, paragraph 12.16). FAO and IWC were also consulted on possible means of reducing interactions between cetaceans and longline fishing in the Convention Area (SC-CAMLR-XIII, paragraph 9.60).

8.7 The Secretariat had received reports from CCAMLR scientific observers at meetings of the ATCP, FAO and ICCAT, which contain references to information presented on behalf of CCAMLR. Other reports are expected to be available during CCAMLR-XIV.

8.8 The Secretariat had also received letters from IATTC, ICCAT, FFA and IWC acknowledging the receipt of information and indicating steps being taken or planned by these organisations to deal with the problem of incidental mortality of seabirds in longline fisheries. Copies of this correspondence were passed to the convener of the coordinating group, Prof. Moreno.

8.9 The Secretariat was asked to arrange for two documents, originally produced by Mr N. Brothers (Australia), on the prevention of incidental mortality of seabirds during longline fishing and on the principles of bird-line construction, to be suitably revised to apply to CCAMLR fisheries, published and widely circulated in all languages of the Commission, as well as other languages of Members currently fishing in the Convention Area. Australia contributed A\$20 000 to a special fund to assist in the drafting of text, design, translation and printing of these documents (SC-CAMLR-XIII, paragraphs 9.30 and 9.39; CCAMLR-XIII, paragraphs 4.28 to 4.32).

8.10 Both documents have been carefully studied by the Secretariat in order to determine the extent of revision required to ensure their applicability to longline fisheries in the Convention Area and adjacent waters. It was found that the first document requires extensive revision because, in its present form, it deals mainly with pelagic longline fisheries and, as such, most of its conclusions and recommendations may not necessarily be valid for bottom longline fisheries. The recommendations contained in the second document were, however, found to be in agreement with the current CCAMLR strategies on the reduction of incidental mortality of seabirds.

8.11 In order to ensure completeness and a high level of applicability of both documents, the Secretariat asked Mr Brothers to assist with the revision of the documents. Mr Brothers suggested that it would be useful if both documents were combined into a longline fishery/seabird handbook for vessels fishing in the CCAMLR Convention Area. He also suggested that the required completeness and applicability of this handbook would best be achieved if the author were able to have first-hand experience in studying incidental mortality of seabirds on board longline vessels fishing for *D. eleginoides* in the Southern Ocean. Mr Brothers therefore strongly recommended that CCAMLR delay proceeding with the preparation of the book until the information that will be obtained during the current 1995 fishing season is incorporated.

8.12 The coordinating group was consulted and the responses received showed agreement with the recommendations of the Secretariat and Mr Brothers.

8.13 Mr Brothers consequently continued his research program and conducted observations in May and June 1995 on board a longliner fishing for *D. eleginoides* in the waters around the Falkland/Malvinas Islands. In accordance with a tentative agreement with Mr Brothers, the Secretariat plans to prepare a draft handbook and distribute it to the coordinating group for comments by early March next year.

8.14 The Secretariat drafted data sheets for reporting scientific observations of incidental mortality of seabirds aboard longline vessels and sent them to the coordinating group for comments. The comments received were incorporated into the revised versions of the data sheets. With the assistance of Mr Brothers and Dr R. Gales (Australia), the Secretariat has also prepared guidelines for observations of incidental mortality of seabirds and marine mammals on board longline fishing vessels. The data sheets and guidelines are submitted to WG-FSA for consideration in the document SC-CAMLR-XIV/BG/13.

8.15 The Secretariat suggested that in addition to publishing data sheets and guidelines in a book format for distribution to scientific observers, as recommended by the Scientific Committee (SC-

CAMLR-XIII, paragraph 9.28), both documents should also be appended to the revised edition of the *Scientific Observers Manual*. A draft of the revised manual was prepared by the Secretariat (SC-CAMLR-XIV/6).

8.16 In order to ensure that data and samples collected by scientific observers are analysed and reported to CCAMLR in a timely fashion, Members were reminded that, at the initiation of observer arrangements, agreement should be reached on the fate of such data and samples, and on their analyses (COMM CIRC 95/5 of 20 February 1995) (see paragraph 8.76 and Appendix H).

8.17 The Secretariat consulted with Dr S. Bartle (New Zealand) regarding New Zealand plans to produce a seabird identification manual for scientific observers on fishing vessels. Some work on the identification manual was started this year. It is expected that the delegation of New Zealand will submit an official proposal to the Scientific Committee regarding the preparation of the manual and funding of its publication.

8.18 A presentation on 'CCAMLR Initiatives on the Prevention of Incidental Mortality of Seabirds in Longline Fisheries' was given to the First International Conference on the Biology and Conservation of Albatrosses (28 to 30 August 1995, Hobart, Tasmania, Australia) by the CCAMLR Executive Secretary. The Secretariat's Data Manager and Science Officer participated in the conference workshop on albatross-fisheries interactions.

Matters Arising from Intersessional Work

8.19 The Secretariat was thanked for its efficient conduct of the considerable volume of intersessional business.

8.20 The responses from organisations listed in paragraphs 8.5 to 8.7, in respect of the request for information on the steps they have taken and are planning to address the topic of incidental mortality of seabirds associated with fisheries, especially longline fisheries, and details of current and forthcoming meetings at which input from CCAMLR might be particularly relevant, were not available at the meeting. They were expected to be available for the meeting of the Scientific Committee and would need evaluation at that time.

8.21 It was agreed that it would be very useful to request similar information from Members with respect to fisheries under their control in waters adjacent to the Convention Area and in other regions where seabirds from the Convention Area might be affected.

8.22 It was agreed that the proposed handbook on ‘Catching fish not birds: a guide to improving longline fishing efficiency’ (including the details of the principles of streamer line construction) should be produced as soon as possible on the basis of the best information currently available on both Spanish and autoliner methods. A draft version should be available for circulation by March 1996.

8.23 The need for a seabird identification manual for scientific observers on fishing vessels was re-emphasised (see also paragraph 8.42(i)). New Zealand was encouraged to continue its work on this and the Scientific Committee was requested to support proposals that would assist in its publication.

8.24 The Working Group commended CCAMLR staff for their role in the recent International Albatross Conference, particularly in publicising the activities of CCAMLR in addressing the topic of incidental mortality of seabirds. The conference, which attracted 120 people from 11 nations, was presented with some 20 papers and 13 posters on topics of direct relevance to incidental mortality of albatrosses (see WG-FSA-95/19), and most of the conference workshop was devoted to consideration of this topic.

8.25 As WG-FSA-95/59 notes, much of the success of the conference was due to the diversity of participants. Especially important for making progress on key issues was the participation of fishery managers, fishing industry representatives (from Australia, Japan and New Zealand) and scientists active in seabird by-catch research from Argentina, Brazil and Uruguay.

8.26 The Working Group noted some of the workshop interim conclusions, that:

- there was unanimity in the concern for albatross conservation due to longline fishing;
- the recognition that probably all albatross species are currently affected by longline fishing for tuna, broadbill, hake and toothfish;
- the extent and severity of albatross by-catch is poorly documented in most areas;
- except for black-browed, grey-headed and wandering albatrosses there are few studies of albatross demography adequate to understand the effect of incidental mortality at the population level; and
- the need to implement mitigating measures to reduce seabird by-catch in most current longline fisheries.’

8.27 In respect of these conclusions, the Working Group noted that CCAMLR could take considerable credit for its prompt action in requiring mitigating measures to be used on all vessels and in developing a comprehensive scientific observer program.

8.28 CCAMLR was fortunate that several of the major current long-term population studies of albatrosses are at sites within the Convention Area. Nevertheless, the Working Group also noted the workshop conclusions that:

- (i) similar studies on additional populations are needed. Members (particularly Chile, South Africa and New Zealand) were encouraged to initiate and maintain such research; and
- (ii) albatross banding programs should be initiated, particularly in order to help determine the provenance of birds caught in longlines at sea. Members were encouraged to undertake this work. It was recognised that there was potential scope for collaboration with SCAR, particularly as the SCAR Bird Biology Subcommittee had organised large-scale banding studies (of giant petrels and penguins) in the past.

8.29 The Working Group noted that CCAMLR would be very interested in the full report of the workshop (and in due course the conference proceedings) and looked forward to receiving it. It congratulated the organisers on holding such a timely and productive conference.

8.30 The Working Group noted that the IMALF coordinating group had received no reports from Members on existing or projected monitoring studies on albatrosses, giant petrels and white-chinned petrels (as requested in CCAMLR-XIII/BG/30). One report was tabled at the meeting.

8.31 The UK reported that:

- monitoring of population size and breeding success, together with adult survival and juvenile recruitment rates of black-browed, grey-headed and wandering albatrosses at Bird Island, South Georgia had been carried out annually since 1976 (see Croxall et al., 1990²¹; Prince et al., 1994²²; black-browed albatross data are submitted annually to CEMP);

²¹ Croxall, J.P., P. Rothery, S.P. Pickering and P.A. Prince. 1990. Reproductive performance, recruitment and survival of wandering albatrosses *Diomedea exulans* at Bird Island, South Georgia. *Journal of Animal Ecology*, 59: 775-796.

²² Prince, P.A., P. Rothery, J.P. Croxall and A.G. Wood. 1994. Population dynamics of black-browed and grey-headed albatrosses *Diomedea melanophris* and *D. chrysostoma* at Bird Island, South Georgia. *Ibis*, 136: 50-71.

- a census of breeding population size of northern and southern giant petrels at Bird Island, South Georgia is being undertaken in 1996 and 1997 for comparison with similar data collected there from 1979 to 1981; and
- a census of the breeding population of white-chinned petrels at Bird Island, South Georgia is to be undertaken in 1997 and 1998 for comparison with similar data collected there in 1980 and 1981.

8.32 Other Members of CCAMLR and the IMALF coordinating group were requested to make reports as soon as possible. Such information is important in assessing the likelihood and/or time-scale of detecting population changes of the species known to be the ones most affected by longline fishing.

8.33 Chile stated it had not submitted a report because it was unable to carry out any work on the only available site (Diego Ramirez - a globally important breeding site for black-browed and grey-headed albatrosses). Other Members known to be carrying out appropriate work or having the potential to do so include Argentina, Australia, France, New Zealand and South Africa.

8.34 The Working Group looked forward to advice from SCAR (and Members) on establishing a research program on albatross population genetics to identify the origin of birds caught in longline vessels (CCAMLR-XIII/BG/30).

Reports on Incidental Mortality of Seabirds During Longline Fishing

Data from the Convention Area

Observations for 1994

8.35 The remaining report for the 1994 season (WG-FSA-95/4) (see SC-CAMLR-XIII, paragraph 9.9) was circulated intersessionally.

8.36 This report, which provided detailed information on fish, fishing operations and fish by-catch, indicated that three to eight short longlines (1 250 to 2 500 hooks, 60 to 70% baited, setting time 20 to 30 minutes) per day were set using a Mustad autoliner. Spaced weights were used on the line, thawed bait was used and a streamer line modified from the CCAMLR design deployed. Sixteen seabirds were recovered dead, but because the report does not specify what proportion of hooks were monitored, an overall catch rate of seabirds cannot be calculated. The 16 specimens were

examined in Stanley by Dr Croxall; all black-browed albatrosses were adult and the unidentified petrel turned out to be a white-chinned petrel.

Observations for 1995

8.37 Observation programs carried out in the 1995 season are summarised in Table 26 (SC-CAMLR-XIV/BG/16 Rev. 1). All except the vessels of Argentina observed by Chile had one scientific observer on board. The ability to use two scientific observers on each Argentinian vessel (one local (from Argentina) and one international (from Chile)) reflected significant assistance from the fishing industry, which is acknowledged.

8.38 The Working Group noted that the quality of information provided clearly relates closely to the degree of observer coverage. Thus, for some Chilean-observed vessels, 100% of every haul was monitored. The reports from most other vessels state, or suggest, incomplete coverage and do not specify the proportion of hooks observed. It is essential to have this information in order to make an estimate of overall by-catch.

8.39 The report on the *Ihn Sung* (WG-FSA-95/5 Rev. 1) contains considerable valuable information on seabird by-catch and the scientific observer was commended for the detail on this topic. Important points from the report are:

- only 72% of sets were made at night;
- offal was discharged on the same side as, and only 2 m away from, hauling operations;
- a CCAMLR-designed streamer line was not very effective (WG-FSA-95/58 suggests it was probably incorrectly rigged) and was replaced by a streamer line with bags attached;
- one of the two albatrosses recovered dead was caught during a daylight set;
- the other albatross and one of the two white-chinned petrels were caught on a longline deployed without a streamer line;
- although observations of sperm whales were frequent, only one potential interaction involving the removal of fish from the line occurred; and
- lack of data on the proportion of hooks observed precludes any estimate of overall seabird mortality.

8.40 The report of the *Itkul* (WG-FSA-95/56) is very brief. Important points include: a Mustad autoliner with squid bait was used; and 12.5% of the 24 sets took place during daylight. There was no reported incidental mortality but without any information on scientific observer effort or viewing position it would seem prudent to treat the report with caution.

Table 26: Summary of observation programs on longline fisheries conducted in the 1994/95 season, in accordance with Conservation Measure 80/XIII, by scientific observers designated under the CCAMLR Scheme of International Scientific Observation.

Flag State	Vessel	Observer	Report	Subarea/ Fishery	Period of Observation	Data Reported
Republic of Korea	<i>Ihn Sung 66</i>	Russia	WG-FSA-95/16 Rev. 1	48.3 <i>D. eleginoides</i>	3/3 - 8/4/95	Fish catch and biological data; seabird incidental mortality and marine mammal interaction data
Chile	<i>Magallanes III</i> <i>Isla Sofia</i> <i>Cisne Verde</i> <i>Puerto Ballena</i> <i>Isla Isabel</i>	Argentina	WG-FSA-95/49 - 55	48.3 <i>D. eleginoides</i>	5/3 - 29/5/95	Fish catch and biological data; seabird incidental mortality and marine mammal interaction data
	<i>Isla Camila</i>	Spain	WG-FSA-95/46			
Argentina	<i>Arbumasa XX</i> <i>Arbumasa XXII</i> <i>Arbumasa XXIII</i> <i>Marunaka</i> <i>Estela</i>	Chile	SC-CAMLR-XIV/BG/23 - 27	48.3 <i>D. eleginoides</i>	1/3 - 12/5/95	Fish catch and biological data; seabird incidental mortality and marine mammal interaction data
Russia	<i>Itkul</i>	Ukraine	WG-FSA-95/56	48.3 <i>D. eleginoides</i>	4/5 - 20/5/95	Fish catch and biological data; seabird incidental mortality and marine mammal interaction data

8.41 Many aspects of the results of the remaining observations are summarised in WG-FSA-95/42. In this paper, of 537 birds reported caught and released alive, 61% were white-chinned petrels (though mainly identified as sooty albatrosses - see below), 18% giant petrels and 17% black-browed albatrosses. Of 956 birds reported captured dead, the overall catch rate (hereafter referred to as birds-per-unit-effort (BPUE)) was 0.175 birds per thousand hooks, being 0.115 and 0.215 for the Argentinian and Chilean vessels respectively. Of this total, 82% were white-chinned petrels, 9% giant petrels, 4% black-browed albatrosses, 3% wandering albatrosses and 1% grey-headed albatrosses. Interactions with killer and sperm whales were reported as being common.

8.42 The authors of WG-FSA-95/42 drew attention to certain problems noted by the scientific observers:

- (i) difficulties that some scientific observers (particularly those inexperienced with seabird work) had in species identification. In particular, most identifications of sooty albatrosses almost certainly refer to white-chinned petrels; records of royal albatrosses probably all relate to wandering albatrosses; gulls were likely to be black-browed albatrosses;
- (ii) although on leaving port all vessels were provided with streamer lines constructed to CCAMLR specifications, these were not used by the *Estela*, *Marunaka*, *Mar del Sur II*, *Puerto Ballena*, *Isla Camila* (first leg) (i.e., at least 36% of the vessels involved in the fishery); and
- (iii) offal was usually being discharged during hauling. This sometimes resulted in a substantial number of birds (e.g., 325 white-chinned petrels, 86 black-browed albatrosses and 72 giant petrels by *Isla Camila* (first leg)) being caught while hauling, necessitating considerable work in releasing them alive.

8.43 The data on incidental mortality of seabirds reported by the scientific observers were analysed in WG-FSA-95/42 in relation to distance from South Georgia (the nearest breeding colonies of the seabirds involved), the lunar cycle, hook size and the presence/absence of streamer lines.

8.44 There was a statistically significant trend ($P < 0.001$) for more birds to be caught by vessels fishing closer to South Georgia.

8.45 The Working Group noted that there was the potential in this analysis for a confounding effect of the presence/absence of streamer lines, although it did note that the authors of WG-FSA-95/42 stated that one vessel which fished at three different distances from South Georgia also showed a trend of more birds being caught closer to the island. The Working Group suggested that it might be

useful to look for temporal effects, particularly in relation to the timing of fledging of white-chinned petrels, whose abundance in the area would be expected to decline substantially after their chicks fledge (mean date 21 April, SD 6.4 days, range 9 April to 9 May; Hall, 1987²³).

8.46 Paper WG-FSA-95/42 indicated a significantly ($P < 0.001$) higher catch rate for white-chinned petrels at the time of full moon.

8.47 Smaller hooks were significantly ($P < 0.001$) associated with higher capture rates of birds, though this requires further work because the smallest hooks were used only by one vessel although these were, however, of similar shape to the other hooks used.

8.48 After restricting the data set in terms of the phase of moon and distance from South Georgia, the catch rates of birds by vessels without streamer lines were significantly greater (by a factor of at least two) than for vessels using streamer lines.

8.49 The Working Group congratulated the authors on their work, which provided CCAMLR with by far the most detailed examination so far of the nature of interactions between seabirds and longline vessels in the Convention Area.

8.50 The Working Group particularly noted:

- (i) the indication of lower overall catch rates (BPUE of around 0.15 to 0.20) of seabirds than in previous data for Subarea 48.3 (0.47 BPUE), which it inferred was probably due to a combination of night-time setting, fishing later in the breeding season of the most potentially vulnerable seabird species and more extensive use of streamer lines;
- (ii) the dramatic reduction in seabird by-catch of albatrosses - 9% of the total catch as opposed to 50% in previous years. This was attributed almost exclusively to the use of night-time setting. Indeed the Working Group noted that of the 23 albatrosses caught by Argentinian vessels, 18 (78%) were in fact caught on sets in the daylight or extending into dusk/dawn (when albatrosses are particularly active); and
- (iii) the increase in the number and proportion of white-chinned petrels caught, forming over 80% of the seabird by-catch. This had been recognised as a likely consequence of night-time setting. The Working Group noted that to reduce this catch level it was essential to use streamer lines at all times; further investigation of other ways of reducing the by-catch of this species was also requested (see paragraph 8.64 below).

²³ Hall, A.J. 1987. The breeding biology of the white-chinned petrel, *Procellaria aequinoctialis*, at South Georgia. *J. Zool., Lond.*, 212: 605-617.

8.51 The Working Group noted that despite the value and importance of the analyses in WG-FSA-95/42, it provided insufficient information for a comprehensive assessment of the data on incidental mortality from individual vessels. This was of particular importance given the great variation between vessels in reported seabird by-catch, which in some cases did not appear to relate to the presence/absence of streamer lines.

8.52 The Working Group welcomed the provision of more detailed reports from scientific observers on individual vessels, many of which provided most of the data needed for a comprehensive assessment. The main data required for even a general assessment are, for each set/haul:

- timing and duration of set and haul;
- number of hooks deployed and, if possible, the proportion of hooks baited;
- number of hooks observed for seabird by-catch during set and/or haul;
- number and specific identity (with age and sex if known) of birds caught;
- whether streamer lines were used (and the type of line, particularly whether conforming to CCAMLR specification or not); and
- whether or not offal was discharged during set/haul and location of discharge (e.g., side of vessel, distance from haul point).

8.53 The Working Group used such data as were available in scientific observers' reports to undertake a preliminary assessment (Tables 27 and 28). This analysis should be repeated intersessionally, once certain aspects of the data have been validated (see below).

Table 27: Summarised data on incidental mortality of seabirds in longline fisheries for *D. eleginoides* in Subarea 48.3 (South Georgia) and adjacent areas in 1995.

Vessel	Dates of Fishing	Method ¹	Sets ²			No. of Hooks (thousands)		Proportion (%) of Hooks Observed	No. of Birds Killed		Catch Rates		Streamer Line in Use	Offal Discharge at Haul ³	Reference
			N	D	Total	Obs	Total		Obs	Total	Obs	Total			
Subarea 48.3															
<i>Itkul</i>	4/5 - 20/5	Auto	21	3	24	94?	94		0				Y	?	WG-FSA-95/6
<i>Ihn Sung 66</i>	4/3 - 17/7	Sp	31	33	64	679?	679		1				N/Y	YS	WG-FSA-95/5
									3		0.006		N/Y	YS	Rev. 1
									4				N/Y	YS	“
<i>Estela</i>	13/3 - 29/3	Sp	14	1	15	200?	200		1		0.005	-	N	YO	WG-FSA-95/52
<i>Estela</i>	14/4 - 17/5	Sp	31	0	31	c 310?	c 310?		3		0.010	-	N	YO	WG-FSA-95/50
<i>Marunaka</i>	7/3 - 20/4	Sp	31			411	411	100	84	84	0.204	0.204	N	YO	WG-FSA-95/51
				10		125	125	100	29	29	0.232	0.232	N	YO	“
					41	536	536	100	113	113	0.21	0.211	N	YO	“
<i>Arbumasa XXII</i>	29/3 - 5/5	Sp			39	326?	326		44		0.135		Y	Y?	WG-FSA-95/49
			35			2905	2905		11		0.038		Y	Y?	“
				4		355?	355		23		0.648		Y	Y?	“
<i>Arbumasa XXIII</i>	1/4 - 16/5	Sp			42	424?	424		70		0.165		Y	YO	WG-FSA-95/55
				2			11		0		0.0		Y	YO	“
			40			403?	403		70		0.174		Y	YO	“
<i>Mar del Sur II</i>	27/4 - 16/5	Sp	16			246?	246		0		0.0		N	Y?	WG-FSA-95/53
				3		36?	36		19		0.528		N	Y?	“
					19	282?	282		19		0.067		N	Y?	“
<i>Arbumasa XX</i>	13/4 - 17/5	Auto	31	5	36	?	c 360		0		0		Y	YS	WG-FSA-95/54
<i>Puerto Ballena</i>	6/3 - 25/4	Sp	56		56	757?	757	100	346	346	0.457	0.457	N	YS	
<i>Cisne Verde</i>	4/3 - 14/4	Sp	30		20	593?	593		134		0.226		Y	Y?	
<i>Isla Camila</i> ⁴	3/3 - 2/5	Sp	90		90	827?	827		210		0.254		N	Y?	WG-FSA-95/57
<i>Isla Sofia</i>	26/3 - 15/5	Sp	39	4	43	421?	421		14	14?	0.033		Y?	Y?	Database
<i>Isla Isabel</i>	8/3 - 18/4	Sp	21	14	35	306?	306		0		0		Y?	Y?	Database
<i>Magellanes III</i>	1/3 - 2/4	Sp	30	0	30	288?	288		0		0		Y?	Y?	Database
Falklands/Malvinas															
<i>Mar del Sur I</i>	?	Sp			?		c 740		319		0.431		N	?	WG-FSA-95/58
<i>Mar del Sur I</i>	?	Sp			?		c 320		90		0.281		N	?	“
<i>Isla Guafo</i>	6/5 - 7/6	Sp			?	c 380	c 380	100	43	43	0.113	0.113	Y	YO	“

¹ Sp = Spanish method; Auto = Mustad autoliner

² N = night-time; D = daytime (including dawn and dusk)

³ O = opposite side to hauling; S = same side as hauling; ? unknown

⁴ See comments in paragraph 8.55

Table 28: Summary of the species composition of birds killed in longline fisheries in Subarea 48.3 and adjacent areas in 1994 and 1995.

Vessel	Method	Dates of Fishing	Area	No. of Killed Birds Identified ¹	Composition by Species ² (%)							Reference
					DIX	DIM	DIC	MA	PRO	DAP	Other	
1994:												
<i>RK-1</i>	Auto	1/6 - 9/9	48.3	16		44				6	5	WG-FSA-95/4
1995:												
<i>Itkul</i>	Auto	4/5 - 20/5	48.3	0								WG-FSA-95/56
<i>Ihn Sung 66</i>	Sp	3/3 - 30/4	48.3	4	25	25				50		WG-FSA-95/5 Rev. 1
<i>Estela</i>	Sp	13/3 - 29/3	48.3	1		100						WG-FSA-95/52
<i>Estela</i>	Sp	14/4 - 17/5	48.3	3					100			WG-FSA-95/50
<i>Marunaka</i>	Sp	7/3 - 20/4	48.3	113	1	5	1	92				WG-FSA-95/51
<i>Arbumasa XXII</i>	Sp	29/3 - 5/5	48.3	44			2	2	95			WG-FSA-95/49
<i>Arbumasa XXIII</i>	Sp	1/4 - 16/5	48.3	70	3			9	89			WG-FSA-95/55
<i>Mar del Sur II</i>	Sp	27/4 - 16/5	48.3	19	11		47	42				WG-FSA-95/53
<i>Arbumasa XX</i>	Auto	13/4 - 17/5	48.3	0								WG-FSA-95/54
<i>Puerto Ballena</i>	Sp	6/3 - 25/4	48.3	346	7				93			WG-FSA-95/42
<i>Cisne Verde</i>	Sp	4/3 - 14/4	48.3	133		2			98			WG-FSA-95/42
<i>Isla Camila</i>	Sp	3/3 - 2/5	48.3	213		28		13	58		1 ³	WG-FSA-95/42
<i>Isla Sofia</i>	Sp	c 2/4 - c 12/5	48.3	14		36		36			29 ³	WG-FSA-95/42
<i>Isla Isabel</i>	Sp		48.3	0								
<i>Magellanes III</i>	Sp		48.3	0								
<i>Mar del Sur I</i>	Sp	?	Falk/Malv	319		93			6	<1		WG-FSA-95/58
<i>Mar del Sur I</i>	Sp	?	Falk/Malv	90		100						WG-FSA-95/58
<i>Isla Guafo</i>	Sp	6/5 - 7/6	Falk/Malv	43		12	77	5		7		WG-FSA-95/58

¹ Identification corrected, where appropriate, as indicated in paragraph 8.42(i)

² DIX = wandering albatross; DIM = black-browed albatross; DIC = grey-headed albatross; MA = giant petrel; PRO = white-chinned petrel; DAP = cape petrel

³ Albatross nei

8.54 The results provided in Tables 27 and 28 indicate that data in scientific observers' reports for Argentinian vessels, adequate for assessments of seabird by-catch, were available only from *Estela*, *Arbumasa XXII*, *Arbumasa XXIII*, *Marunaka* and *Mar del Sur II*. The report on *Arbumasa XX* clearly indicates that only partial observation was achieved.

8.55 Some data from Chilean vessels are more difficult to interpret.

- (i) Except for the *Isla Camila*, the scientific observer reports contain no data on incidental mortality nor any indication of observer effort. Reports of zero incidental mortality from *Isla Isabel* and *Magallanes III* should, therefore, be regarded with caution.
- (ii) The data submitted to CCAMLR for *Cisne Verde* are entirely plausible, though the complete absence of daytime hauls is perhaps unexpected.
- (iii) The extensive data submitted to CCAMLR from *Puerto Ballena* suggest particularly comprehensive scientific observer coverage. The data revealed plausible, if somewhat high catch rates (the vessel did not use streamer lines). However, all hauls are reported to be restricted to night-time yet 24 wandering albatrosses were caught on five hauls, a most surprising result in these circumstances.
- (iv) Data submitted to CCAMLR from the master of the *Isla Camila* give a total of 117 black-browed albatrosses, 2 macaroni penguins, 132 giant petrels and 450 white-chinned petrels caught. The timing of all sets is reported as restricted to night-time. Paper WG-FSA-95/42, based on these data, reports identical totals of giant petrels (72 released alive, 60 dead), macaroni penguins (two released alive), and white-chinned petrels (325 released alive, 125 dead) but slightly different numbers of black-browed albatrosses (86 released alive, 27 dead). However, the scientific observer's report (WG-FSA-95/57), which was not available to the authors of WG-FSA-95/42, tabulates 2 macaroni penguins, 1 gentoo penguin and 2 giant petrels released alive and 133 giant petrels, 100 black-browed albatrosses and 452 white-chinned petrels recovered dead. The similarity of the overall totals from the two sources suggests errors in classification in data originally reported to CCAMLR. In addition, WG-FSA-95/57 reports that 98 giant petrels (73%), 84 black-browed albatrosses (84%) and 31 white-chinned petrels (6%) were captured in daytime. This is a much more realistic situation. Further clarification of the data submitted to CCAMLR will be required during the intersessional period.

The difficulties with some of these data illustrate the importance of the detailed reports from independent scientific observers. Without WG-FSA-95/57, substantially erroneous conclusions might have been drawn from the data submitted to CCAMLR.

8.56 Further analyses of data on seabird by-catch at this meeting were not possible; there was also insufficient time for any review of the data on interactions with cetaceans beyond that reported in Table 2 and paragraph 3.13. Further assessment of these interactions might be desirable intersessionally. From the vessels with apparently unambiguous detailed information, however, it was confirmed that a disproportionate amount of seabird mortality occurred:

- (i) on the daytime sets (which formed 5 to 24% of sets), especially in the case of albatrosses; and
- (ii) on one or two specific sets. Thus 52% of the bird by-catch on the *Arbumasa XXII* occurred on set 6 (BPUE 2.875), the remaining sets having a low rate (BPUE 0.066). Similarly, three sets (17, 21 and 41) on the *Marunaka* contributed 42% of the mortality (BPUE 1.205), the rest having a low rate (BPUE 0.133).

8.57 The Working Group reiterated the importance of detailed reports, even where these included data on apparently high catch rates of birds. Only with such complete records could problems be recognised and solutions devised and it commended the vessels and scientific observers who had collaborated in producing such good reports. By contrast, reports of zero by-catch with inadequate supporting details were inherently suspect, given the known difficulties, even in ideal conditions, of avoiding any by-catch of seabirds. Furthermore, it was recognised (e.g., in WG-FSA-95/58) that scientific observers unable to watch the line from a close vantage point were liable significantly to underestimate the seabird by-catch; this may be exacerbated if only partial coverage can be achieved.

8.58 Paper SC-CAMLR-XIV/BG/12 reported on mortality of seabirds associated with the longline fishery around Kerguelen (Division 58.5.1) in November/December 1994. A scientific observer was present on one of the three vessels in the area and observation of hauls was believed to be comprehensive. The overall observed mortality rate of 26 birds on 437 lines was 0.059 birds per line (or 0.025 birds per thousand hooks). However, for 42 lines observed in detail the catch rate was 0.28 birds per line (0.117 per thousand hooks). White-chinned petrels (65%) were the main species killed, followed by black-browed albatrosses (19%), grey-headed albatrosses (12%) and wandering albatrosses (4%). This mortality rate is lower than observed in the previous year (0.50 birds per line in February), which may reflect the difference between mortality during incubation and

chick-rearing periods. Streamer lines are not used in this fishery, nor is setting restricted to night-time. However, the use of offal to distract birds from the set results in significantly lower capture rates (0.02 birds per line compared to 1.19 per line without offal discharge), suggesting that this method may be useful in this fishery, for which setting times are very short.

Information from Outside the Convention Area

8.59 Paper WG-FSA-95/45 provides a preliminary assessment of the fishing effort in longline fisheries for *D. eleginoides* in Patagonian waters (i.e., adjacent to the Convention Area), based on a survey of 74 fishing trips from December 1993 to July 1995 involving 12 of the 19 vessels presently operating in Patagonian waters. Of the ships studied, 10 used manual and 2 used autoline systems.

8.60 Most of the fishing takes place in two areas, the Patagonian shelf north of the Falklands/Malvinas and around Islas de los Estados and Cape Horn, although some setting takes place around seamounts between the latter area and Subarea 48.3. During 1994, effort was fairly constant, but increased throughout 1995. The total effort in 1994 and 1995 was 20.164 million hooks.

8.61 The Working Group noted the report with interest. At current by-catch rates for seabirds in Subarea 48.3 (say 0.2 BPUE) this represents a mortality of 4 000 birds. However, noting that the fishery is not restricted to night-time setting, nor are mitigating measures in use, the mortality of seabirds could easily reach 1.0 BPUE (and, not impossibly, rates like 5.0 BPUE as reported last year from Uruguay), giving a potential mortality of 20 000 birds over two years, possibly 30 to 50% of which could be albatrosses. This is a situation of great concern, indicating the importance of using appropriate mitigating measures in regions outside the Convention Area.

8.62 Paper WG-FSA-95/21 provides data on seabird mortality in an experimental longline fishery for hake off South Africa. Seabird mortality rates observed during the set of the two vessels observed were 0.435 and 0.534 BPUE, extrapolating to a total of 1 505 and 1 170 birds killed per vessel. Over the total fleet of 61 vessels, this would sum to an estimated mortality of 58 800 birds. All birds observed killed were white-chinned petrels. The fishery currently uses no mitigating measures and the report recommends that these should be adopted as a matter of urgency.

8.63 Mortality of white-chinned petrels on this scale is of great concern to CCAMLR because South African waters are probably an important wintering ground for birds from two of the main world population centres of this species - South Georgia in the South Atlantic Ocean and Kerguelen

and Crozet in the Southern Indian Ocean. The Working Group wished to see South Africa encouraged to use appropriate mitigating measures in this longline fishery.

8.64 Paper WG-FSA-95/21 also indicates that the capture of white-chinned petrels was strongly related to the time of the set and the diel activity patterns of the birds. Thus, white-chinned petrels showed much increased activity from 0300 to dawn (c. 0600) and were much more susceptible to capture between these times. This activity pattern should be investigated in the CCAMLR area but, even as an interim measure, it would seem sensible to suggest that longline setting in the Convention Area should try to start soon after complete darkness and end at least three hours before dawn.

8.65 Paper WG-FSA-95/58 presents a comprehensive evaluation of the causes of and potential solutions to mortality of seabirds associated with the use of the Spanish system of longlining, as practiced in the Falklands/Malvinas fishery in the 1995 season. This clearly has substantial implications for the use of similar fishing methods in the Convention Area.

8.66 Attention was drawn primarily to the detailed recommendations in the report in order to evaluate their applicability to fishing in the Convention Area.

8.67 Rec. 1 - single fishing line. Longline fishing using the Spanish method in the Convention Area only uses a single line and thereby already conforms to this recommendation.

Rec. 2 - line setting confined to night-time. Conservation Measure 29/XIII already requires this.

Rec. 3 - the release of weights before line tension occurs. The reduction in availability of baited hooks to birds would clearly also be true for the Convention Area. Consideration should be given to highlighting this, perhaps even in advisory text to Conservation Measure 29/XIII.

Rec. 4 - construction of line-setting boxes. Improved construction to reduce loss of boxes and hook-ups will reduce bird catch and increase fishing efficiency. This would apply equally to the fishery in the Convention Area and should be highlighted as appropriate.

Rec. 5 - discharge of offal. Conservation Measure 29/XIII prohibits discharge of offal on the same side as hauling and thereby already conforms to this recommendation. (However, there is a clear need for greater compliance with this element of Conservation Measure 29/XIII.)

Rec. 6 - discharge of homogenised offal. This is likely to be a useful technological development but probably not feasible for the fishery to implement at this stage. Its desirability should certainly be indicated in the forthcoming handbook.

Rec. 7 - hook recovery. Better hook recovery would reduce opportunities for birds to swallow hooks and reduce costs to the fishery. This is equally applicable in the Convention Area and the suggestions for future work on snood breaking strain should be followed up.

Rec. 8 - bird scaring lines. These devices are mandatory under Conservation Measure 29/XIII. (However, scientific observer reports suggest that fishing masters would benefit from help and advice in rigging these lines to achieve maximum benefit.)

Recs 9/10 - stone weight and spacing. The recommendation of 6 kg mass stones (compared to current mean of 3.9 kg) and 20 m spacing (against current 30 m) may need further investigation (given the considerable mass of stones this would represent). The attention of investigators (and the fisheries generally) should be drawn to the study in WG-FSA-95/58 of sinking rates for different combinations of stone weight and spacing.

8.68 Additional recommendations (B1 to B9 in WG-FSA-95/58):

B1 - scientific observers

The existing CCAMLR recommendations are designed to try to obtain accurate estimates of seabird mortality but, as noted previously, there are some clear improvements (e.g., in documenting numbers of hooks observed) that need implementing. The new logbook design and instructions are intended to help address these and related issues. The Working Group noted particularly the advice in B(ii)c that scientific observers be aware of the importance of a vantage point allowing them to observe birds on the line as it is hauled on board to ensure that birds are not knocked off at this time. A modification to the reporting code may be necessary to accommodate such records.

B2 - policy with respect to vessel track record

The Working Group endorsed the importance of working with vessels to assist them in overcoming problems of high by-catch of seabirds, rather than discriminating against such vessels. Indeed the Working Group, as noted earlier, would wish to encourage vessels providing comprehensive and accurate scientific observer reports.

B3 to B9

The Working Group noted these general recommendations, mainly concerning the investigation and promotion of desirable technological developments. A particularly

important development is that of longline systems which release the baited line under water. This has great potential for reducing, if not eliminating, most seabird by-catch; the Working Group encouraged the rapid development and deployment of such systems.

8.69 The author of the report, Mr Brothers, the manager of Consolidated Fisheries Limited (Martin Cox) and the Australian Government were thanked for their contributions to this most valuable study and report.

Information Relevant to Fishery Management

8.70 Paper WG-FSA-95/43 used data on distribution at sea (derived from satellite tracking studies) of wandering albatrosses breeding at South Georgia to investigate the potential risk from the longline fishery to *D. eleginoides* in the waters around South Georgia. The report concluded that for most of the breeding cycle, wandering albatrosses are at limited risk from fisheries at South Georgia (though at substantial risk from fisheries around the Patagonian shelf). However, during the chick-brooding period (March through mid-May) adults of both sexes forage mainly over waters of the South Georgia shelf (including Shag Rocks), thereby being almost exactly coextensive with the distribution of the local longline fishery. The paper suggested prohibiting longline fishing in Subarea 48.3 during March and April.

8.71 The Working Group welcomed the fact that data on seabird behaviour and distribution is now used to assess risks of interactions with fisheries. It was noted, however, that delaying the start of the fishery for *D. eleginoides* in Subarea 48.3 until May might risk causing the fishery to operate during the *D. eleginoides* spawning season (July/August). There was some feeling that the current use of night-time setting and streamer lines gives albatrosses (including wandering albatross) adequate protection. On the other hand, an absolute minimum of 29 wandering albatrosses were killed in Subarea 48.3 in 1995, so some restriction on the timing of the fishery, at least until more vessels are complying in full with Conservation Measure 29/XIII, might still be appropriate.

8.72 Dr Croxall was asked whether the at-sea distribution of black-browed and grey-headed albatrosses indicated any opportunity for managing the longline fishery in such a way as to avoid critical periods of high risk of albatross mortality. He replied that from September through April black-browed albatrosses foraged widely over the whole South Georgia shelf and were therefore at relatively high risk at all times, at least until most of the adult population moved towards South African waters in winter. Grey-headed albatrosses feed less extensively over the shelf and are more concentrated around the Antarctic Polar Frontal Zone to the north and west of South Georgia. This and their more localised breeding distribution at South Georgia might offer some prospect of

reducing potential interactions by restricting the location of longline fishing in the area; this is being investigated currently.

Conservation Measure 29/XIII

8.73 Appendix 2 of WG-FSA-95/58 is an appraisal of Conservation Measure 29/XIII based on Mr Brothers' experience aboard a longline fishing vessel using the Spanish system around the Falklands/Malvinas in 1995. The numbered items below refer to the numbered sub-items in the conservation measure.

1. It was agreed that it would be desirable to specify minimum mass of weights and distance between these on the line; however, it was clear that further research was needed before advice suitable for a mandatory measure could be framed. Similarly, further work on the condition (thawed or not) of bait might be required but it would be inappropriate to change the measure now.
2. Contrary to the statement in WG-FSA-95/58, night setting in the Convention Area does cause an increase in catch rates of white-chinned petrels. Therefore, while night setting is very effective at avoiding albatross mortality, the problem it continues to pose for white-chinned petrels needs urgent investigation.
3. The incorporation of two options for the disposal of offal reflects the inability of some fishing operations to avoid discharge of offal during processing. Ways of avoiding offal discharge or discharging homogeneous offal under water need to be explored with the fishing industry.
4. Conservation Measure 29/XIII is not an appropriate way to deal with hooks being retained in discarded by-catch fish and heads of processed fish; further research is needed on snood breaking strain.
5. The Working Group noted the emphasis on correct operation of the CCAMLR-prescribed line; existing difficulties may indicate a need for expert practical assistance.

8.74 In all other respects Conservation Measure 29/XIII was deemed still to be appropriate, though earlier comments (paragraphs 8.64 and 8.67) might need reflecting upon, at least in footnotes to the measure, until the handbook is available.

Data Collection and Reporting

8.75 The Working Group welcomed the draft data sheets and accompanying guidelines for reporting scientific observations of seabird incidental mortality aboard longline vessels (SC-CAMLR-XIV/BG/13). It recommended that the Scientific Committee endorse the production and circulation of these and their attachment to the revised edition of the *Scientific Observers Manual*.

8.76 Two suggestions were made for further modifications to the forms. First, to allocate space to indicate where specimens and samples were lodged; second, to add extra pages to the G5 fish form (see also the comment in paragraph 8.68).

8.77 The Working Group noted that the work outlined in SC-CAMLR-XIV/BG/13 represents an ideal program for an experienced scientific observer dedicated to recording seabird and marine mammal incidental mortality and interactions.

8.78 The main problem, indicated in many of the scientific observers reports, was the difficulty that a single observer faced in apportioning time to the different tasks. This required some advice on priorities.

8.79 The highest priorities for a single scientific observer with regard to seabird data are as follows:

- (i) observation of the whole of any set (or part thereof) carried out in daylight, dusk or dawn, together with the appropriate complete records of the number and species of seabirds caught;
- (ii) observation of at least 50% of the haul, ideally divided into periods covering the early, middle and late stages, with a record of the times and numbers of hooks observed and the appropriate complete record of the species of seabirds caught;
- (iii) the retention and labelling of specimens from the by-catch (albatrosses, giant petrels, white-chinned petrels in priority order for retention as whole specimens);
- (iv) documentation of the streamer line used; and
- (v) documentation of the location and timing of offal discharge.

8.80 In attempting to assign priorities within the collection and processing of fish data and specimens, and between fish and seabird work, it was recognised that it was necessary to have more detailed information on the time taken to perform the various tasks.

8.81 It was agreed to ask scientific observers to estimate the time taken to undertake each of their currently specified tasks, and to provide additional appropriate information on their overall daily time-budget.

8.82 The idea of incorporating the data forms into a scientific observer logbook was commended. It was also suggested that space be allocated in this logbook for recording the daily work schedule of the observer.

8.83 The Working Group encouraged work to ensure the easy conversion of logbook data into electronic formats appropriate for data analysis.

8.84 It was noted that there were potential complications as regards access to data provided under bilateral agreements between Members, especially when not all data were formally requested by CCAMLR.

Advice to the Scientific Committee

8.85 The Scheme of International Scientific Observation has developed in a most successful way. Despite some problems of meeting appropriate reporting standards (hopefully to be rectified with new data sheets and logbooks) and the need to reconcile and validate some data (to be tackled intersessionally), many reports are comprehensive and of a high standard (see also paragraph 8.27).

8.86 The reports enable the first systematic analyses of incidental mortality of seabirds in the Convention Area to be undertaken (see especially WG-FSA-95/42).

8.87 The results of this and the assessments performed at the Working Group meeting indicate that:

- (i) the specification in Conservation Measure 29/XIII of restricting setting to night-time has reduced by-catch of albatrosses by four-fifths (and would nearly have eliminated it if all vessels had complied with all parts of the conservation measure); and

- (ii) streamer lines are highly effective in reducing (by at least half) seabird by-catch. The conservation measure is therefore having a very significant effect in reducing seabird by-catch in general and that of albatrosses in particular. However, especially when streamer lines are not used, captures of white-chinned petrels are increasing and further work on appropriate mitigating measures for this species is needed.

8.88 The reports and assessments do, however, indicate widespread lack of compliance with some elements of Conservation Measure 29/XIII. In particular:

- (i) many of the vessels are not using streamer lines, even though lines of appropriate specification were given to them;
- (ii) most vessels continue to discharge offal during the haul and some do so on the same side of the vessel as hauling activities, thereby greatly increasing by-catch of seabirds and decreasing fishing efficiency; and
- (iii) many vessels are carrying out some setting during hours of daylight, dawn or dusk.

The Scientific Committee should ask the Commission to request Members to ensure compliance with all aspects of the conservation measure, thereby achieving further reduction in seabird by-catch and also considerably more cost-effective fishing.

8.89 Data from outside the Convention Area indicate that many more birds of species breeding in the Convention Area are probably killed by longline fisheries in adjacent waters and, for some species, also in their more distant wintering grounds. This re-emphasises the high priority of developing and maintaining close liaison with international organisations in order to tackle the whole problem worldwide. The Scientific Committee should ask the Commission to encourage Members to be especially active in drawing CCAMLR's concerns to the attention of appropriate national authorities and organisations and in implementing the type of measures developed by CCAMLR in waters under their control (see also paragraphs 8.21, 8.61 and 8.63).

8.90 There are a number of additional points which should be drawn to the attention of the Scientific Committee, i.e.:

- (i) the need to evaluate responses from international organisations to the questions posed by CCAMLR relating to work on longline fishing and incidental mortality of seabirds (paragraph 8.20) and the need to direct similar requests to Members (paragraph 8.21);

- (ii) production of educational materials (paragraphs 8.22 and 8.23);
- (iii) population studies of vulnerable species:
 - long-term population studies of albatrosses (paragraph 8.28(i));
 - banding programs for albatrosses (paragraph 8.28(ii));
 - information on monitoring/demographic studies of albatrosses, giant petrels and white-chinned petrels (paragraphs 8.32 and 8.33);
- (iv) improvements in reporting (paragraphs 8.51, 8.52 and 8.75);
- (v) intersessional work on submitted data (paragraphs 8.53 to 8.56);
- (vi) utility of Conservation Measure 29/XIII and potential modifications to it (paragraphs 8.64, 8.67, 8.68, 8.73 and 8.74);
- (vii) potential modifications to the management of the *D. eleginoides* fishery in Subarea 48.3 (paragraphs 8.70 and 8.71);
- (viii) acquisition of information on observer time-budgets in order to help prioritise observer tasks (paragraph 8.81);
- (ix) production of logbooks (paragraphs 8.75 and 8.82); and
- (x) suggested revised arrangements for the consideration of IMALF items intersessionally and at next year's meeting of WG-FSA (paragraphs 8.92 and 8.93).

Future Work

8.91 The Convener noted the difficulty in devoting adequate time to IMALF in a single day towards the end of the main WG-FSA meeting. He also noted that this timing had apparently not assisted attendance of members of the IMALF coordinating group.

8.92 Therefore, the Convener proposed that IMALF issues be treated in a similar fashion to other elements of the WG-FSA agenda. Thus, appropriate assessments of data and reports would

commence at the start of the WG-FSA meeting. It was agreed to recommend this to the Scientific Committee.

8.93 It was recommended that the ad hoc WG-IMALF coordinating group should continue during the intersessional period. Its work would be coordinated by the Secretariat. Prof. Moreno was thanked for his work as coordinator during 1995.

OTHER INCIDENTAL MORTALITY

9.1 Paper SC-CAMLR-XIV/BG/12 noted some mortality of seabirds associated with the *C. gunnari* trawl fishery in the Kerguelen area (Division 58.5.1). This mortality was of two kinds. First, mortality of white-chinned petrels (10 individuals reported) killed by warps and/or in attempting to take fish from the net. Second, mortality of three white-chinned petrels, three black-browed and one grey-headed albatross killed by collision with the net-sonde cable of Ukrainian fishing vessels. The *D. eleginoides* trawl fishery appears to have minimum mortality impact on seabirds.

9.2 The paper noted that French trawlers (which do not use net-sonde cables) operate outside the breeding season of white-chinned petrels, which may reduce impact. The mortality associated with the net-sonde cable would be eliminated by banning the use of such equipment, as provided for in Conservation Measure 30/X.

9.3 The Working Group encouraged the French authorities to extend the provisions of Conservation Measure 30/X to the Crozet and Kerguelen area.

9.4 The capture of a southern elephant seal in a trawl was reported in SC-CAMLR-XIV/BG/12. This was an exceptional event. (Another elephant seal was reported as killed by a longline vessel in Subarea 48.3 in WG-FSA-95/57.)

9.5 Paper SC-CAMLR-XIV/BG/6 reported on detailed observations of seabird interactions with trawling operations near Macquarie Island. Although numerous seabirds were attracted to the vessel (which did not use net-sonde cables), no incidental mortality was reported. This was probably due to the location and configuration of the vessels gear, in particular that of the trawl warps. This is an encouraging report because the gear configuration used is common amongst factory vessels.

9.6 The Working Group noted that Conservation Measure 63/XII, prohibiting the use of plastic packaging bands to secure bait boxes, comes into force after the 1995/96 season.

Advice to the Scientific Committee

9.7 The Scientific Committee should request the Commission to encourage the French authorities to extend the provisions of Conservation Measure 30/X to the Crozet and Kerguelen area.

INTERNATIONAL DEVELOPMENTS IN FISHERIES MANAGEMENT

Precautionary Approach to Fisheries Management

10.1 The Government of Sweden in conjunction with FAO held a technical consultation on the precautionary approach to fisheries management at Lysekil in Sweden in June 1995. The consultation highlighted the nature of precaution in fisheries management, clarified the concept of 'burden of proof' and provided specific guidelines for management, research, technology development and transfer, and species introduction.

10.2 The consultation, working within the framework outlined in Article 15 of the Rio Declaration, considered that the precautionary approach involves the application of prudent foresight, taking into account the uncertainties in fisheries systems and the need to take action with incomplete knowledge. The precautionary approach requires, *inter alia*:

- (i) consideration of the needs of future generations and the avoidance of changes which are not potentially reversible;
- (ii) prior identification of undesirable outcomes and of measures which will avoid them or correct them promptly;
- (iii) that any necessary corrective measures are initiated without delay and that they achieve their purpose promptly, on a time-scale not exceeding two or three decades;
- (iv) that where the likely impact of resource use is uncertain, priority should be given to conserving the productive capacity of the resource;
- (v) that harvesting and processing capacity should be commensurate with estimated sustainable levels of resource, and that increase in capacity should be further constrained when resource productivity is highly uncertain;
- (vi) all fishing activities must have prior management authorisation and be subject to periodic review;

- (vii) an established legal and institutional framework for fisheries management, within which management plans that implement the above points are instituted for each fishery; and
- (viii) appropriate placement of the burden of proof by adhering to the requirements above.

10.3 On the question of the burden of proof, the consultation recognised that:

- (i) all fishing activities have environmental impacts, and it is not appropriate to assume that these are negligible until proved otherwise;
- (ii) although the precautionary approach may require cessation of fishing activities that have potentially serious adverse impacts, it does not imply that no fishing can take place until all potential impacts have been assessed and found negligible;
- (iii) the precautionary approach to fisheries requires that all fishing activities be subject to prior review and authorisation; that a management plan be in place which clearly specifies management objectives and how impacts of fishing are to be assessed, monitored and addressed; and that specified interim management measures should apply to all fishing activities until such time as a management plan is in place; and
- (iv) the standard of proof to be used in decisions regarding authorisation of fishing activities should be commensurate with the potential risk to the resource, while also taking into account the expected benefits of the activities.

10.4 The consultation considered that a precautionary approach to managing a fishery involves, within management strategies and plans, explicit consideration of precautionary actions that will be taken to avoid undesirable outcomes. As over-development of harvesting capacity is a common cause of undesirable outcomes, a management plan should include mechanisms to monitor and control that capacity. Consideration needs to be given to how uncertainty and ignorance are to be taken into account in developing and varying management measures. For all fisheries, plans should be developed or revised to incorporate precautionary elements. The plans, even where no additional precautionary elements are considered necessary, should be re-evaluated in accordance with a specified approach to management planning. This approach requires several key elements:

- (i) specification of management objectives;
- (ii) specification of operational targets and constraints;

- (iii) specification of the procedure to apply and modification of management measures so as to meet operational targets and constraints;
- (iv) evaluation of the procedure to determine its reliability in meeting targets and constraints; and
- (v) revision of procedures until they are deemed to have adequate performance.

10.5 The consultation suggested a series of precautionary measures which should be considered for application in various types of fisheries at various stages of exploitation. For new and developing fisheries the consultation suggested a system of measures already instituted in CCAMLR as conservation measures for new and exploratory fisheries (Conservation Measures 31/X and 65/XII). For over-exploited fisheries, measures should include the development of a recovery plan for the fisheries, which would include the establishment of biological reference points to define stock recovery. Short-term action should be considered even on the basis of circumstantial evidence about the effectiveness of particular management measures. For fully utilised fisheries, regulatory agencies need to ensure that there are means to effectively keep fishing mortality rate and fishing capacity at the existing level and to implement interim management actions and undertake investigative action in response to early warning signs that the stocks are beginning to become over-utilised.

10.6 The consultation gave further advice on the role of fisheries research in:

- (i) the establishment of management objectives;
- (ii) the specification of the observations and information base needed for management; and
- (iii) precautionary assessment methods and analyses.

10.7 The consultation set out the following guidelines for the implementation of a precautionary approach to fisheries management:

- (i) take into account the best scientific evidence available when designing and adopting conservation measures;
- (ii) require a minimum level of information to be made available for any fishery to start or continue;

- (iii) ensure that the *‘lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures’*^o;
- (iv) reduce critical uncertainties in the management plan;
- (v) take measures aimed at eliminating or reducing non-reporting and mis-reporting of fisheries data;
- (vi) systematically analyse various possible management options;
- (vii) promote multidisciplinary research, including (a) social, economic and environmental sciences, and (b) research on management institutions and decision-making processes;
- (viii) develop scientific information on multi-species and ecosystem processes as a foundation for identifying acceptable degrees of disturbance;
- (ix) identify biological limit and target reference points for affected species and stocks, habitats and the ecosystem at large;
- (x) identify bioeconomic reference points to address the objectives of the fishery management plan;
- (xi) improve methods for quantification of direct and indirect impacts of fishing;
- (xii) improve understanding of the performance of different management structures in relation to precaution;
- (xiii) develop methods for optimising the monitoring system; and
- (xiv) set up research and development programs aimed at improving the performance of fishery technology in relation to environmental impacts and precautionary management.

10.8 The consultation also outlined guidelines for the precautionary approach to the development and introduction of fishing technologies, and guidelines to follow to reduce the likelihood of inadvertent species introductions.

Management Advice

10.9 The Working Group acknowledged that CCAMLR had acted as a pioneer for many of the approaches outlined in the Lysekil meeting. CCAMLR has already implemented, or was in the process of developing, many of the recommendations of the Lysekil meeting. These recommendations represent the latest thinking on what a precautionary approach entails. It considered, however, that some progress could still be made within CCAMLR in the evaluation of management procedures and their likely outcomes under conditions of uncertainty (10.4(iv) above). There was much still to be done in this area, and the Working Group considered it to be important that CCAMLR continue to work at the forefront of world development of precautionary approaches.

Conservation and Management of Straddling Stocks

10.10 WG-FSA reviewed the recent UNCLOS agreement on highly migratory fish stocks and straddling fish stocks²⁴. *D. eleginoides* is found within the Convention Area as well as in adjacent regions (see paragraph 5.83).

10.11 WG-FSA emphasised that the current *D. eleginoides* fishery operates both within the Convention Area and in neighbouring regions. The absence of information from the fishery across the Convention's boundaries makes it extremely difficult to assess the location and overall impact of the *D. eleginoides* fishery in Subarea 48.3 and adjacent areas.

10.12 WG-FSA therefore recommended that the Scientific Committee and Commission should seek to translate the intent of Resolution 10/XII into practical effect in order to ensure that approaches to managing the *D. eleginoides* fishery in Subarea 48.3 are more in keeping with the principles of the UNCLOS Agreement. Consequently, the 'Standard Provisions for Collection and Sharing of Data' contained in Annex 1 of the UNCLOS Agreement (especially Articles 3 to 6) offer a useful model for the development of a system to ensure the timely collection, compilation, verification and analysis of data essential for the management of *D. eleginoides* fisheries both within and outside the Convention Area. The types of data required include catch information and the location of catches (see paragraph 5.11).

10.13 WG-FSA also requested that the Scientific Committee consider establishing a system to ensure that data from the *D. eleginoides* fishery are freely exchanged between CCAMLR and operators fishing in regions adjacent to the Convention Area. In these terms, it would be

²⁴ Draft agreement for the implementation of the provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the conservation and management of straddling fish stocks and highly migratory fish stocks.

advantageous to extend the high level of scientific observer coverage aboard fishing vessels within the Convention Area to adjacent regions. Both the establishment of effective scientific observer schemes and vessel monitoring systems have been identified by the UNCLOS Agreement (Article 6 of the Standard Provisions) as important ways to verify fishery data for straddling stocks and highly migratory species.

10.14 Finally, WG-FSA agreed that although the UNCLOS Agreement applied to fish stocks only, many of its principles are relevant to other species which cross the Convention's boundaries and about which there is concern as to their conservation status (e.g., wandering albatross - see paragraph 8.70). As such, the need for information on these species when they are outside the Convention Area is crucial to the development of a comprehensive approach to their management.

FUTURE WORK

Data Requirements

11.1 As reported in paragraph 3.2, experience has shown that general requests for data do not always result in submission of information to the Working Group. Consequently, the Working Group attempted this year to identify data which could be acquired, and requested the Secretariat to pursue these requests with appropriate scientists or other authorities.

11.2 The following data were requested:

- *D. eleginoides*, Subarea 48.3: all data listed in Appendix D. Historical haul-by-haul data should be acquired to enable extended calculations of standardised CPUE (paragraph 5.43).
- *C. gunnari*, Subarea 48.3: all research and commercial data, previously the subject of working papers submitted to the Working Group, should be submitted in haul-by-haul format (paragraph 5.103).
- *P. formosa*, Subarea 48.3: data on size at sexual maturity should be collected from the current fishery (paragraph 5.127).

- *D. eleginoides*, Division 58.5.1: future and historical haul-by-haul data from longline fisheries should be reported (paragraph 5.173).
- Subarea 58.6: haul-by-haul data from French exploratory cruises should be submitted (paragraph 3.17).
- Area 58: the accuracy of data reported in WG-FSA-95/15 Rev. 1 should be verified (paragraph 5.142).
- Fish by-catch: historical data on fish by-catch in krill trawls should be acquired (paragraph 6.25).
- Research surveys: data should be resubmitted in a form to be circulated by the Secretariat for use in a new suite of research survey databases to be developed at the Secretariat (paragraph 5.88).

Future Work Required by WG-FSA

11.3 Stock assessment methodology has undergone considerable development over the last four years. The advent of computers with very high processing capacity, the availability of complex statistical and modelling software, and the demand for stochastic modelling particularly in response to uncertainty, has meant that much of the traditional analysis is no longer applicable. New methodologies rely on a stock-specific approach to specific assessment problems rather than creating standard assessments such as VPA.

11.4 An added problem of these analyses is the time required to perform them. Preparation of data and technical analysis by the Secretariat prior to the meeting of the Working Group would assist it in completing its work within the time-frame of its meeting.

11.5 The Secretariat is currently under-equipped to fully support or prepare for these new types of assessment. Considerable upgrading of hardware and software is required. As a first step, it is recommended that the Secretariat purchase a fast work station and analysis software in 1996.

11.6 The Working Group has identified a number of requirements in respect of the observer data and reports (paragraphs 11.9 to 11.11). The Working Group sets great importance by these data. It was recognised, however, that considerable processing and analysis of these data by the

Secretariat is required prior to the meeting of the Working Group if the group is to extract the full information from the observer program, to give them the justice they deserve.

11.7 The Secretariat is currently not equipped to process the volume (at least 20 000 records per year) of data arising from an observer program that demands 100% coverage (paragraph 3.5) and requires extra funding to deal with the problem. The Working Group recommended that this funding be specifically directed at:

- the employment of an extra person to deal with data arising from the observer program, covering all aspects of data acquisition, coding, and summary analysis;
- participation of this person in observation cruises to ensure a clear understanding of observer problems; and
- ensuring that this work is integrated with the existing data management structure in the Secretariat.

11.8 A number of other items of intersessional work were identified:

- the Data Manager should validate the new general yield model as a high priority (paragraph 3.47) and the trawl survey analysis program (de la Mare, 1994a²⁵);
- a correspondence group, coordinated by Dr Sabourenkov, should re-analyse data on fish by-catch in krill trawls (paragraph 6.24);
- stochastic projections with the general yield model should be applied to *C. gunnari* in Subarea 48.3 (paragraph 5.105);
- a review of historic research and commercial data on *C. gunnari* in Subarea 48.3 should be performed by a correspondence group (Drs Gasiukov, Holt, Agnew and Everson) coordinated by Dr Holt (paragraph 5.103);
- further work is required to define longline soak time for use in the standardisation of CPUE (paragraph 5.39);
- the handbook 'Catching fish not birds: a guide to improving longline fishing efficiency' should be drafted for circulation to WG-IMALF and WG-FSA by March. This work will be coordinated by Dr Sabourenkov (paragraph 8.22);

²⁵ de la Mare, W.K. 1994a, op. cit., p. 289.

- albatross population and banding studies should be initiated by Members not already performing them (paragraph 8.28);
- although intersessional work for IMALF will continue to be coordinated by the Secretariat, ad hoc WG-IMALF need not meet in 1996. Assessment of IMALF should be considered a part of the assessment work performed at WG-FSA (paragraphs 8.92 and 8.93);
- some changes to the formulation of the CCAMLR ADAPT program may be required at next year's meeting (paragraphs 5.101 and 5.102);
- incidental mortality data in scientific observer reports should be analysed intersessionally (paragraphs 8.53, 8.55 and 8.56) by the Secretariat;
- information on albatross monitoring and petrel demographic studies should be submitted (paragraphs 8.32 and 8.33);
- scientific observers should gather information on their overall daily time-budget (paragraph 8.81); and
- logbooks should be developed for other non-longline fisheries (paragraphs 8.75 and 8.82).

Work of Scientific Observers - Observer Data Handling and Future Work

Scientific Observer Reports to WG-FSA

11.9 Eighteen reports by scientific observers on fishing vessels were presented to WG-FSA. Most of these reports were from longliners operating in Subarea 48.3 with information coming from Russian (2), Ukrainian (3), Chilean (7) Argentinian and Spanish (1) scientific observers.

11.10 In reviewing scientific observers' reports, WG-FSA commended the observers concerned and noted the considerable range and detail of information presented in these reports. Given the volume of information, its extraction could be facilitated by presentation of the report in conformity with a standard format. WG-FSA therefore urged scientific observers to provide summaries of their work along the lines set out in Appendix H.

11.11 Scientific observer report summaries submitted in accordance with Appendix H are aimed at highlighting the scope of information available. WG-FSA endorsed the principle that submission of more data to CCAMLR should continue following the prescribed detailed formats.

Scientific Observers Manual

11.12 A number of scientific observer reports indicate that the various tasks outlined in the *Scientific Observers Manual* may on occasion be difficult to carry out. The Working Group agreed that in the interest of efficiency, scientific observers' tasks should be as simple as possible. There are two considerations in this context.

11.13 In the first instance, WG-FSA agreed that there would be merit in developing scientific observer logbooks for various types of fisheries which can be submitted to CCAMLR. The logbook would comprise a consolidated record of all the information required from scientific observers of the commercial finfish fishery as prescribed in the *Scientific Observers Manual*. It was agreed that the logbooks for longline fisheries should be a priority and should be developed for use in the 1996 season. It was also agreed that a small task group coordinated by the Secretariat and in consultation with potential users should develop draft scientific observer logbooks for use in other fisheries and would report to WG-FSA-96. The reports submitted in the form described in Appendix H should be submitted by every scientific observer and should accompany the logbook containing the raw data forms.

11.14 In the second instance, the actual tasks carried out by scientific observers can be simplified. WG-FSA agreed that techniques to facilitate scientific observer work should be investigated further during the forthcoming interseasonal period. Due consideration should also be given to ways in which scientific observers' tasks can be automated (e.g., by using length measuring boards linked directly to laptop computers).

ADVICE TO THE SCIENTIFIC COMMITTEE

Management Advice

12.1 Advice on the management of species and areas, including advice on catch limits, should be read in its entirety under the relevant sections of Agenda Item 5. Summaries of the status assessments are given in Appendix I.

Advice with Budgetary Implications

- A scientific observer logbook for longline fisheries should be printed and translated in 1996 (paragraph 11.13). This logbook should include data forms, instructions, space for comments and the report forms given in Appendix H (paragraph 8.80). Logbooks for other CCAMLR fisheries will be developed during the intersessional period.
- The IMALF brochure should be developed in draft (paragraph 8.13).
- An extra edition of the *Statistical Bulletin* containing revised historical data should be produced (paragraph 5.142).
- Funds should be provided to enable the Secretariat to employ staff with responsibility for scientific observer data (paragraph 11.7).
- Funds should be provided to enable the Secretariat to purchase new hardware and software for assessment purposes (paragraph 11.5).

Action Towards Improving Data Quality

- The Scientific Committee should consider mechanisms for identifying individual vessels within the CCAMLR database should they re-register (paragraph 3.7).
- Misunderstandings about data reporting requirements should be clarified (paragraph 3.8), particularly the reporting of live weight, reporting of zero catch hauls and not amalgamating hauls in reports (paragraph 3.10).
- Mechanisms for data exchange with management agencies and with operators fishing in areas adjacent to the Convention Area should be developed (paragraph 10.13) along the guidelines provided by the UNCLOS Agreement.
- Division 58.4.4 should be subdivided at 43°E longitude into subdivisions for Ob and Lena Banks (paragraph 5.175).

Scientific Observer System

- Summaries of scientific observer reports should be submitted in the draft standard format given in Appendix H and comments on the draft are solicited (paragraph 11.10).
- Scientific observer programs of a similar quality to CCAMLR's should be encouraged in areas adjacent to the Convention Area, in particular Subarea 48.3 (paragraph 10.13).
- Adjusted priorities for observers in the longline fishery are given in paragraph 8.79.
- Appropriately amended formats and instructions for scientific observers of the longline fishery should be appended to the *Scientific Observers Manual* (paragraphs 8.75 and 8.76).
- Time budget information requested from scientific observers (paragraph 8.81).

Interaction with WG-EMM

- What is the quantity, seasonal and other variability of *C. gunnari* in the diet of predators in Subarea 48.3 (paragraph 6.11)?
- What is the estimated consumption of myctophids in Subarea 48.3 (paragraph 6.12)?

OTHER BUSINESS

13.1 There was no other business.

ADOPTION OF THE REPORT

14.1 The report of the meeting was adopted.

CLOSE OF THE MEETING

15.1 In his closing comments, the Convener expressed his gratitude to the Secretariat, rapporteurs, conveners of subgroups and to all participants for their hard work during the meeting. A great deal of assessment work had been performed during the meeting with major progress being made in the assessment of *D. eleginoides*.

15.2 Dr Kock congratulated the Convener for conducting such a successful meeting, and extended his thanks to the Convener and participants on behalf of the Scientific Committee.

15.3 The Convener then closed the meeting.

AGENDA

Working Group on Fish Stock Assessment
(Hobart, Australia, 10 to 18 October 1995)

1. Opening of the Meeting
2. Organisation of the Meeting and Adoption of the Agenda
3. Review of Available Information
 - 3.1 Data Requirements Endorsed by the Commission in 1994
 - 3.2 Fisheries Information
 - (a) Catch, Effort, Length and Age Data
 - (b) Scientific Observer Information
 - (c) Research Surveys
 - (d) Mesh/Hook Selectivity and Related Experiments Affecting Catchability
 - 3.3 Fish and Crab Biology/Demography/Ecology
 - 3.4 Developments in Assessment Methods
4. Report of the Workshop on Methods for the Assessment of *Dissostichus eleginoides*
5. Assessments and Management Advice
 - 5.1 New Fisheries
 - 5.2 Antarctic Peninsula (Subarea 48.1)
 - 5.3 South Orkney Islands (Subarea 48.2)
 - 5.4 South Georgia (Subarea 48.3) - Finfish
 - 5.5 South Georgia (Subarea 48.3) - Crabs
 - 5.6 South Sandwich Islands (Subarea 48.4)
 - 5.7 Antarctic Coastal Areas (Subareas 58.4.1 and 58.4.2)
 - 5.8 Ob and Lena Banks (Subarea 58.4.4)
 - 5.9 Kerguelen Islands (Subarea 58.5.1)
 - 5.10 Heard Island (Subarea 58.5.2)
 - 5.11 Pacific Ocean Sector (Area 88)

6. Considerations of Ecosystem Management
 - 6.1 Interactions with WG-EMM
 - 6.2 Ecological Interactions (e.g., multi-species, benthos, etc.)
7. Research Surveys
 - 7.1 Simulation Studies
 - 7.2 Recent and Proposed Surveys
 - 7.3 Notification of Intended Research Activity
8. Incidental Mortality Arising from Longline Fishing
9. Other Incidental Mortality
10. International Developments in Fisheries Management
 - 10.1 Report from the FAO Technical Consultation on the Precautionary Approach to the Management of Capture Fisheries (including draft code)
 - 10.2 UN Convention on Straddling Stocks
11. Future Work
 - 11.1 Data Requirements
 - 11.2 Software and Analyses to be Prepared or Developed Prior to the Next Meeting
 - 11.3 Work of Scientific Observers - Observer Data Handling and Future Work
12. Advice to the Scientific Committee
13. Other Business
14. Adoption of the Report
15. Close of the Meeting.

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(Hobart, Australia, 10 to 18 October 1995)

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LIST OF DOCUMENTS

Working Group on Fish Stock Assessment
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WG-FSA-95/5 Rev. 1	REPORT OF THE FISHING CRUISE OF THE KOREAN VESSEL <i>IHN SUNG 66</i> IN STATISTICAL SUBAREA 48.3 (SOUTH GEORGIA) (SEABIRD OBSERVATIONS MARCH TO MAY 1995) A.N. Kozlov (Russia)
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Delegación de Argentina

DATA REQUIREMENTS FOR THE WORKING GROUP

I Data Required by WG-FSA-94	II Data Received by WG-FSA-95	III Data Requested by WG-FSA-95
1. <i>D. eleginoides</i> , Subarea 48.3: <ul style="list-style-type: none"> • studies on hook selection factors required; • studies on loss rates of fish. 	None Some information in WG-FSA-95/46	<i>D. eleginoides</i> , Subarea 48.3: Studies on hook selection factors required.
2. <i>D. eleginoides</i> , Subarea 48.3: <ul style="list-style-type: none"> • age and maturity determination required for an expanded range of lengths from historical and current commercial and research catches. 	Some information on maturity from observer reports.	<i>D. eleginoides</i> , Subarea 48.3: Age determination required (paragraph 3.38).
3. Representative length frequency from the commercial catch of <i>C. gunnari</i> in Subarea 48.3 should be reported for the most recent years of the fishery and required from historical fishery.	None	
4. Trawl fisheries in Subarea 48.3: <ul style="list-style-type: none"> • detailed data on the by-catch in pelagic (midwater) and demersal (bottom) trawl fisheries in Subarea 48.3 are urgently required to establish management advice ; • historical data required. 	None None	
5. <i>E. carlsbergi</i> : <ul style="list-style-type: none"> • clarification of position and time of catch of 1 518 tonnes reported for Subarea 48.2 in 1990/91; • clarification of position and time of catch of 50 tonnes in Subarea 48.1 in 1991/92. 	None None	

I Data Required by WG-FSA-94	II Data Received by WG-FSA-95	III Data Requested by WG-FSA-95
6. Call for historic information from surveys to assist the Workshop on the Design of Bottom Trawl Surveys in investigating the interannual variability in the occurrence of fish aggregations. Also required for validation of MVUE methods.	Data now being submitted in the required format.	
7. <i>D. eleginoides</i> , Subarea 48.3: <ul style="list-style-type: none"> • stock identification studies; • data on the position or bearing of each end of longlines especially in preparation for workshop. 	WG-FSA-95/28 provides information on parasite load. Now incorporated in CCAMLR database.	<i>D. eleginoides</i> , Subarea 48.3: Stock identification studies (Appendix E, paragraph 2.72).
8. Crab fishery, Subarea 48.3: Investigations on the use of time-release devices, escape ports and pot selectivity.	None, but expected to be forthcoming from the present fishery.	Crab fishery, Subarea 48.3: Investigations on the use of time-release devices, escape ports and pot selectivity.
9. Additional data from <i>D. eleginoides</i> fishery.	All now requested and most data being reported.	
10. All observer data should be reported if possible.	All data now reported.	
11. <i>D. eleginoides</i> : Data requested from outside CCAMLR Convention Area.	Data acquired (see paragraph 5.10).	

**REPORT OF THE WORKSHOP ON METHODS FOR THE
ASSESSMENT OF *DISSOSTICHUS ELEGINOIDES***

(Hobart, Australia, 5 to 9 October 1995)

**REPORT OF THE WORKSHOP ON METHODS FOR THE
ASSESSMENT OF *DISSOSTICHUS ELEGINOIDES*
(Hobart, Australia, 5 to 9 October 1995)**

INTRODUCTION

1.1 The Workshop on Methods for the Assessment of *Dissostichus eleginoides* (WS-MAD) was held at CCAMLR Headquarters, Hobart, Australia from 5 to 9 October 1995. The Convener, Dr W. de la Mare (Australia), chaired the Workshop. The terms of reference of the Workshop were agreed by the Scientific Committee at its 1994 meeting (SC-CAMLR-XIII, paragraph 2.17).

1.2 The Convener welcomed participants to the Workshop, noting with pleasure the presence of two invited experts, Mr D. Japp from the Sea Fisheries Research Institute, South Africa and Dr A. Zuleta from the Instituto de Fomento Pesquero, Chile.

1.3 The Provisional Agenda was adopted unchanged. The Agenda is included in this report as Attachment A and the List of Participants as Attachment B. Documents submitted to the 1995 Working Group on Fish Stock Assessment (WG-FSA) and referred to in this report are listed in Appendix C of this annex.

1.4 The report was prepared by Drs I. Everson, G. Kirkwood and G. Parkes (UK), K. Sullivan (New Zealand) and Mr R. Williams (Australia).

REVIEW OF POSSIBLE ASSESSMENT APPROACHES

2.1 Under this agenda item, the Workshop first carried out an initial review of the approaches taken in previous CCAMLR assessments of *D. eleginoides*, and of the approaches used in the assessments of the longline fishery for *D. eleginoides* in Chile and the trawl and longline fishery for hake in South Africa. Following this, key problem areas in CCAMLR assessments were identified and potential solutions were discussed in subgroups, drawing particularly on the experience in the Chilean and South African fisheries. Conclusions reached by the Workshop are recorded under this or subsequent agenda items.

Previous CCAMLR Assessments

2.2 The Workshop considered the current state of knowledge as reflected in previous CCAMLR assessments of *D. eleginoides* under four headings: biology and demography, stock identity, abundance and yield.

Biology and Demography

2.3 Discussion on biology and demography of *D. eleginoides* centred on the topics of growth, reproduction, diet and condition.

Growth

2.4 Otolith and scale readings have been used to determine the age of individual fish. Both these methods are widely used in fisheries biology. Shortcomings have been noticed with both methods for *D. eleginoides* which would affect the accuracy of age/length keys derived from them. Results from both methods have been used together in the past and it is therefore important to reconcile any systematic differences between the two methods.

2.5 In the case of otoliths, false checks are occasionally noted which, if not recognised, would cause the age of the individual fish to be overestimated.

2.6 In the case of scales, there is some uncertainty about the time taken for completion of the nucleus and hence the age at which the first annual ring appears. This effect could lead to the underestimation of the fish's age by one year (SC-CAMLR-XI, Annex 5, paragraph 6.124). The annual rings seen on scales tend to blend together towards the edge leading to an underestimation of the age of older, larger fish (SC-CAMLR-XI, Annex 5, paragraph 6.124).

2.7 The Workshop recommended that further efforts be made to improve age determination using otoliths and scales.

2.8 Length frequency distributions derived from samples of fish from trawl catches frequently contain modes at intervals equivalent to years of growth (WG-FSA-91/20¹). The modes are indistinguishable for fish older than five years; the method is therefore only applicable for juvenile fish.

¹ Everson, I. 1991. Stock assessment of the Patagonian toothfish (*Dissostichus eleginoides*) at South Georgia. Document WG-FSA-91/20. CCAMLR, Hobart, Australia.

2.9 There is evidence that longlining selects large fish (a key factor is the gear itself). Refinements in selectivity can be obtained through variations of both hook and bait. Rigorous trials have not been conducted for longlining of *D. eleginoides* with the result that age/length keys derived from longline data may be biased towards large fish for the younger age classes and smaller fish for the older age classes.

2.10 The Workshop recommended that experiments be designed using trawls and longlines, and be undertaken to determine the magnitude of biases in estimated age/length keys caused by the use of different gear types and sizes, and different bait sizes and species (trawls generally fish in shallower water than longlines).

2.11 Samples from commercial trawl and trawl survey catches may underestimate the proportion of larger and therefore older fish. This is further discussed in paragraph 3.10.

2.12 Given the possible biasing effects of size selectivities, the Workshop agreed that it would be useful to compare growth rates for young and old fish. To examine this, a table of estimates of size-at-age was prepared using data from both trawl catches and surveys and longline catches (Figure 1).

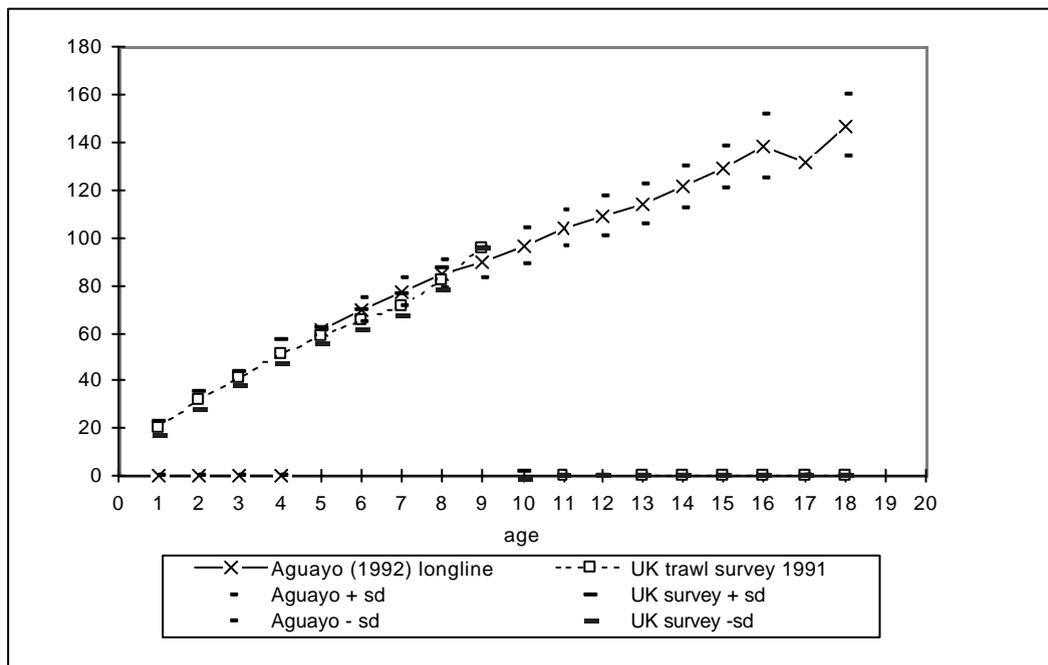


Figure 1: Estimates of size-at-age from both trawl catches and surveys and longline catches.

2.13 Lengths-at-age for *D. eleginoides* from longline fisheries on the Patagonian shelf, around Southern Chile and in the South Georgia and Kerguelen regions were reviewed in 1992 (SC-CAMLR-XI, Annex 5, paragraphs 6.122 to 6.129 and Appendix G). An age/length key not used in

this review is available in the CCAMLR database for pre-recruits from a UK trawl survey on the continental shelf around South Georgia in January 1991 (SC-CAMLR-XIII, Annex 5, paragraph 4.24).

2.14 No other age/length data are available.

2.15 A number of problems with the existing data were identified in the review of 1992:

- age/length keys from Kerguelen Island area were based on small numbers of fish from a limited size range;
- at South Georgia, ages were determined from scale readings (see discussion of problems in paragraph 2.6);
- generally, age/length characteristics of an entire stock are unlikely to be represented in the longline catches used to generate these keys (see SC-CAMLR-XI, paragraphs 6.125 and 6.126); and
- most estimates were derived using Ford-Walford plots, which are less reliable than non-linear regressions.

2.16 The available data, except those from the Kerguelen area, were used to generate estimates of the von Bertalanffy growth parameters. A non-linear estimation procedure based on the Levenberg-Marquardt method was used. In these analyses, mean length-at-age was not used; each length-at-age datum was weighted by the number of fish in the sample which were observed with that value. Exploratory analyses were undertaken to investigate the influence of a number of sampling problems on the estimation of the parameters. The analyses comprised the following:

- (i) estimation of L_8 , K and t_0 for all samples (males, females, combined);
- (ii) using all samples (combined sexes only), estimation of K in all samples with a fixed L_8 and t_0 , where L_8 was chosen as 170.8 (SC-CAMLR-XI, Annex 5, Appendix G, Table G.4) and $t_0 = 0$; and
- (iii) estimation of K as previously but removing size classes likely to be incompletely sampled. The size ranges used were:

UK 1991 trawl survey	all fish < 60 cm
longline catches	all fish > 100 cm.

2.17 The results are presented in Table 1.

Table 1: Estimates of von Bertalanffy growth parameters for *D. eleginoides* in Subarea 48.3 from age/length keys available in the CCAMLR database and in WG-FSA-92/30. See paragraph 2.16 for details. Var = variance; L/L = longline; T = trawl

South Georgia Samples	Sample Method	Estimates from All Data				FIX $L_{\infty} = 170.8; t_0 = 0$					
						All Data		Trawl: Length < 60		Longline: Length > 100	
		Linf	K	t_0	Var	K	Var	K	Var	K	Var
Aguayo (1992)*:											
1. Feb-May 1991 Males	L/L	170.3	0.086	-0.015	49						
2. Feb-May 1991 Females	L/L	177.5	0.082	+0.35	65						
3. Combined (1 + 2) Feb-May 1991	L/L	170.9	0.087	0.16	58	0.085	58.1			0.09	57.4
4. Apr-May 1991 Females	L/L	169.8	0.086	-0.01	59						
5. Apr-May 1991 Males	L/L	170.1	0.087	-0.02	54						
6. Combined (4 + 5) Apr-May 1991	L/L	171.0	0.087	-0.01	57	0.086	57.1			0.089	55.4
7. Feb-Mar 1991 Males	L/L	165.1	0.085	-0.61	42						
8. Feb-Mar 1991 Females	L/L	172.5	0.088	0.162	62						
9. Combined (7 + 8) Feb-Mar 1991	L/L	170.2	0.088	0.162	62	0.086	52.1			0.09	49.1
SUN 1986	T	182.3	0.074	0.819	9	0.074	11.5	n = 2			
UK trawl 1991: Female	T	159.9	0.081	-0.69	14						
Male	T	163.8	0.082	-0.51	19						
Combined sexes	T	162.0	0.081	-0.60	16	0.088	23.5	0.091	19.4		

* Aguayo, M. 1992. Preliminary analysis of the growth of *Dissostichus eleginoides* from the austral zone of Chile and South Georgia. Document WG-FSA-92/30. CCAMLR, Hobart, Australia.

Reproduction

2.18 Spawning generally occurs during winter although there are some references to spent fish being taken in December. This may indicate that the gonad maturation and recovery processes are prolonged.

2.19 There is no precise information on spawning location or whether the fish aggregate during the spawning season.

2.20 The few ova that have been found, have been near the surface in deep water. Post larvae and early juveniles spend at least one year in midwater before settling to the bottom. Juvenile fish tend to be found on the shelf and it is thought that they migrate into deeper water as they get older and become sexually mature.

2.21 The maturity scale developed for nototheniids (SC-CAMLR-VIII, Annex 6, Appendix 4) has been used by observers examining catches from the *D. eleginoides* fishery.

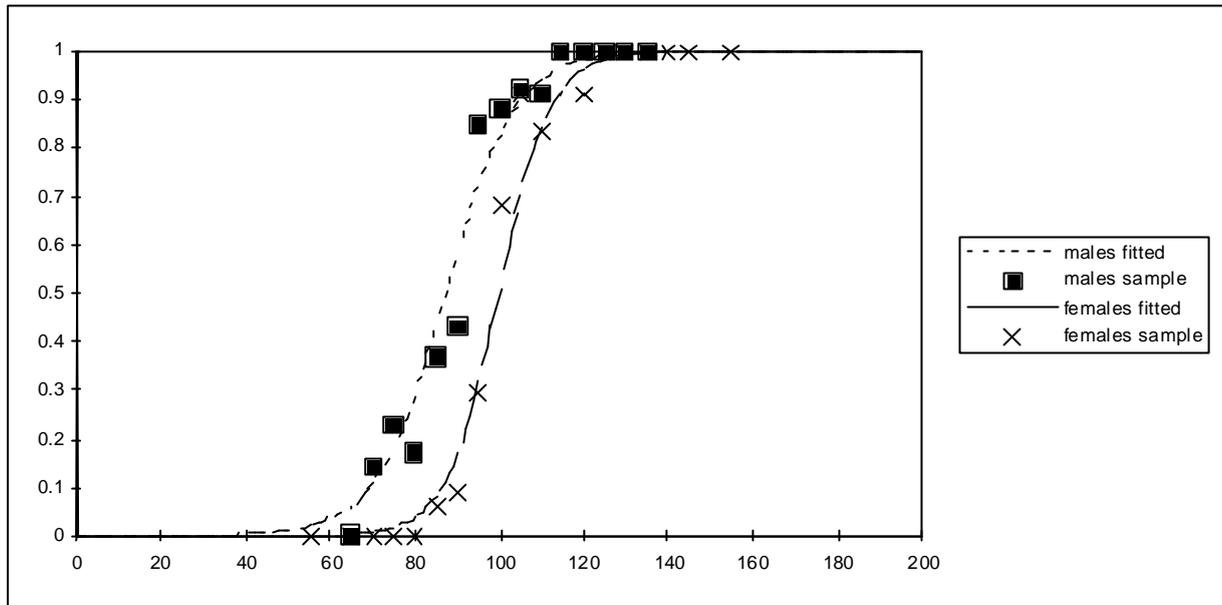
2.22 The results from observer reports available at the meeting were considered by the Workshop. There were major differences in the shape of maturity ogives and length at 50% maturity (L_{m50}) values derived from data from the different vessels.

2.23 From an examination of the data on maturity stages of female fish, the Workshop concluded that these data were inconsistent, indicating that there had been difficulties in recognising specific maturity stages. Examples of distributions are shown in Figure 2 and the results from all observer data are summarised in Table 2.

Table 2: Estimates of size at sexual maturity from data collected by observers working on different commercial longliners. (?, - = Insufficient or no data to provide an estimate.)

		Sample Size	Length-at-Sexual Maturity (cm) (Stages II to V)	Length-at- Spawning (cm) (Stages III to V)
<i>Estela</i> Cruise 1 March 1995	Males	135	90	100
	Females	265	75	105
<i>Estela</i> Cruise 2 April to May 1995	Males	106	70	85
	Females	168	?	95
<i>Marunaka</i> March to May 1995	Males	205	70	90
	Females	284	90	95
<i>Isla Camila</i> March to May 1995	Males	3272	75	90
	Females	353	95	?
<i>RK-1</i> June to September 1994	Males	815	-	75
	Females	864	-	95

Marunaka



Isla Camila

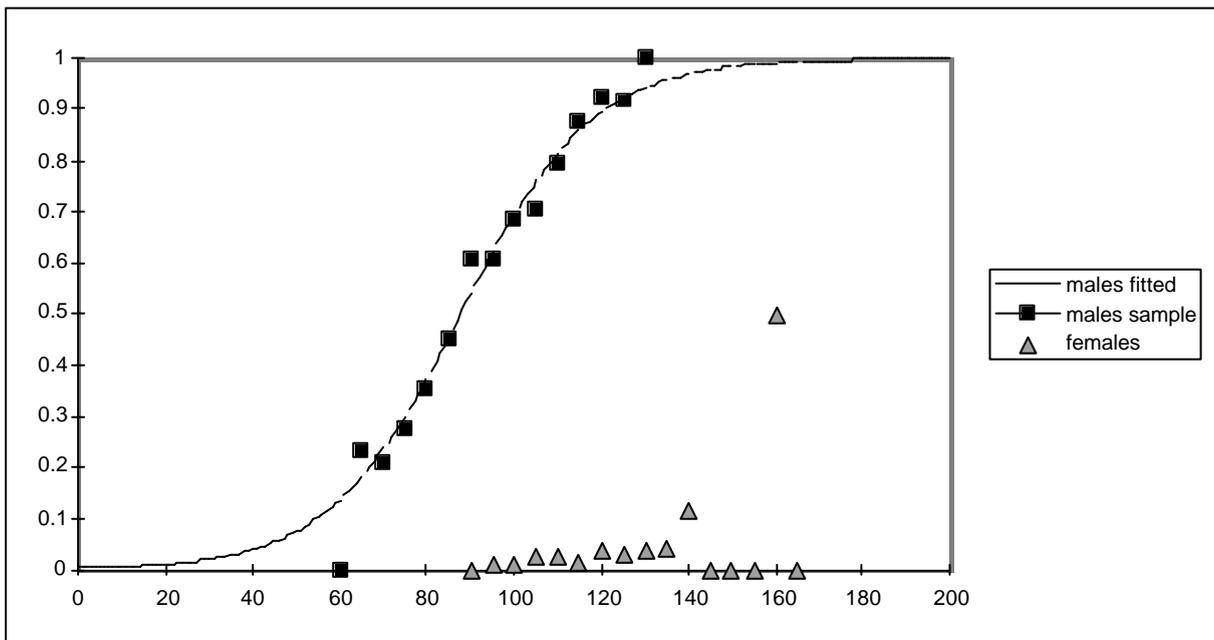


Figure 2: Length-at-first spawning derived from scientific observer data obtained during the 1994/95 season from two vessels, *Marunaka* and *Isla Camila*.

2.24 The Workshop recommended the following future work:

- clearer and more expansive description of the maturity stages augmented, if possible, by photographs;

- information should be collected on gonad maturity stages from as many months as possible in order to determine the spawning season more precisely;
- estimates of spawning stock biomass should be made based on the proportion of fish in stages III to V;
- L_{m50} should be estimated from data obtained during the month immediately prior to spawning; and
- determine locations of spawning.

2.25 It was agreed that refinement of estimates of age-at-maturity would arise from such detailed investigations and also in conjunction with improvements in methods for age determination.

Diet

2.26 The Workshop considered whether information on diet might provide indications of vertical movement based on the known distribution of the prey items. The Workshop agreed that at this stage there was insufficient information available on which to base firm conclusions.

Condition

2.27 A condition known as 'jellymeat' has been reported previously (SC-CAMLR-XIII, Annex 4, paragraph 4.28). No information was available to indicate the cause of this condition. Concern was expressed that fish with the jellymeat condition were being discarded and might not be included in the reported catch. It was unknown whether such finfish might have higher mortalities and/or reduced spawning success.

Stock Identity, Structure and Movements

2.28 Discussion on stock identity, structure and movements of *D. eleginoides* centred on the topics of distribution, extent and timing of movements, segregation by sex and age, aggregations and stock separation.

Distribution

2.29 The distribution of *D. eleginoides* is generally known on a broad scale. It is widespread in the sub-Antarctic zone, being found around the east and west coasts of South America, South Georgia and Shag Rocks, South Sandwich Islands, Kerguelen Plateau, Crozet Island, Ob and Lena Banks, and Macquarie Ridge.

2.30 There are, however, some areas of uncertainty, including the southern limit of distribution in the South Orkney/Antarctic Peninsula and southern Kerguelen Plateau areas, where the distribution may be confused with that of *Dissostichus mawsoni*. Recent findings of *D. eleginoides* on the South African shelf and the Campbell Plateau south of New Zealand, as well as a much larger population than previously thought on the Macquarie Ridge demonstrate that our knowledge of the distribution of this species is still imperfect (Figure 3). It is likely that fish occur in other areas which have not yet been investigated.

2.31 The Workshop noted that sperm whales are known to feed on both *Dissostichus* species, and that there is some information available on sperm whale stomach contents from Russian data. It was agreed that this information should be examined and a summary prepared for discussion at next year's meeting.

2.32 Information from the Chilean fishery demonstrates that catches have been made to 2 900 m depth off southern Chile (WG-FSA-95/29), so that *D. eleginoides* apparently can move in depths to around 3 000 m. Catch rates in terms of weight increase below 1 500 m in much of the Chilean fishery, however, little is known about the catch rates in numbers of fish. This does indicate that a significant proportion of the population, at least in the Chilean area, could live between 1 500 m and 3 000 m. Also, there is no information on the extent to which *D. eleginoides* is capable of movement over long distances in midwater.

2.33 No bathymetric maps of sufficient detail were available in the CCAMLR collection except for the South Georgia/Patagonian region. Given the uncertainty of present distribution and the capability of this fish to exist in waters around 3 000 m deep, the Workshop was unable to draw any conclusions on the likely extent of movement between populations in different areas.

Extent and Timing of Movements

2.34 Movements occur on several time and spatial scales.

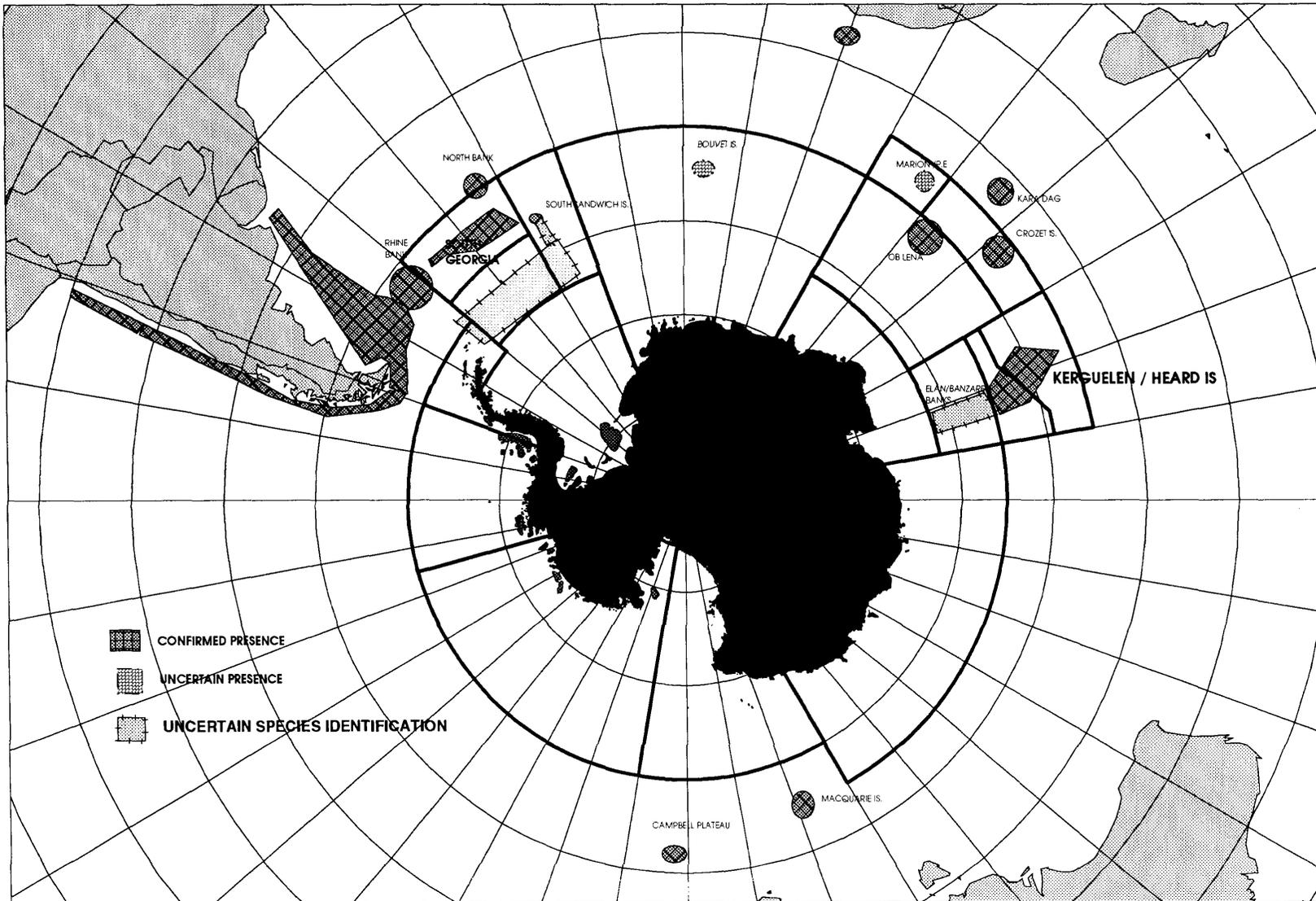


Figure 3: Known distribution of *D. eleginoides*.

2.35 There is some evidence for movements on the time scale of a few days. Data from the trawl fishery at Macquarie Island and the depletion experiments in Subarea 48.3 suggest that fish move into an area of localised harvesting to replenish stock removed by fishing. This will tend to reduce the usefulness of CPUE data on local scales.

2.36 Movements on a seasonal time scale of large numbers of fish will confound results of biomass surveys and analysis of catch and CPUE. There is very weak evidence for lunar cycles in CPUE which may involve migration or other activity patterns. Spawning is presumed to take place during winter in mid-slope depths. Some circumstantial evidence on migrations is available for the South Georgia/Shag Rocks area (WG-FSA-95/27).

2.37 As eggs, larvae and small juveniles are pelagic, egg and larval surveys could possibly provide information on the time and place of spawning as well as on the size of the spawning stock. However, the Workshop agreed that useful results from such surveys will take some time to collect given the potentially large geographic spawning area of *D. eleginoides* (paragraph 2.30).

2.38 The presence of larger fish in deeper water seems well established, but details may be different between areas. This may be mediated by temperature or some other factor(s). It is necessary to know that the depth distribution of fish by size, sex and spawning condition in survey results are representative and to ensure that the interpretation of fishery data is not biased. Therefore a description of distribution patterns by depth for each area is necessary, using fishery-independent surveys and haul-by-haul analysis of fishery data.

2.39 The Workshop noted that the different available length frequency distributions from shallow and deeper waters may be partially confounded by the different selectivity patterns of trawls and longlines. This has been further considered in section 3 of this report.

2.40 There is no direct information on movements over long distances between geographic areas (e.g., South Georgia to South America or Kerguelen Plateau to Macquarie Ridge). There is some indirect information from parasite loadings that the Chilean population is split at 47°S, and that fish from southern Chile to the southern Patagonian shelf have similar origins, whereas there are greater differences between the southern Patagonian shelf and South Georgia (WG-FSA-95/28). More data on egg and larval distribution and further studies on biochemical markers and parasite loadings may give indirect evidence on the extent of movement.

2.41 The Workshop agreed that the most promising method for obtaining direct observations on movements on all time and spatial scales was from tagging experiments in areas subject to fisheries, and it recommended that high priority be given to such studies in the future.

Segregation by Sex and Age

2.42 There is some direct evidence for segregation by sex and age from fishery experience; Chilean data indicate that in the deepest strata fished, down to 1 500 m, larger female fish predominate (WG-FSA-91/11²). This needs to be quantified and investigated to see whether it is consistent over all areas so that survey and fishery analysis are representative. Research data and any appropriate fishery data could be analysed for sex ratio by time, position and depth. Length frequency data could be analysed along the same lines for age segregation.

Aggregations

2.43 There do not appear to be any known spawning or feeding aggregations, but many fisheries exploit areas of consistent higher-than-average abundance, e.g. the two zones on the Kerguelen Plateau, and the Argentine fishery centres on an area southwest of the southern Patagonian shelf. It is not known whether aggregations are solely on the bottom, in midwater, or both. Feeding behaviour suggests both. Acoustic methods using deep-towed bodies may provide some information on this. These questions need to be answered so that appropriate survey methods can be applied in order to optimise biomass estimates.

Stock Separation

2.44 There is no information at present on the number of stocks of *D. eleginoides*. Direct investigation by analysis of mitochondrial DNA has encountered technical problems. Too little is known about other aspects of the biology and behaviour as described above to make any meaningful inferences. More information on oceanographic conditions would also help interpretation of biological data, e.g. how currents in the upper 200 m might affect drift of larvae and juveniles. Further work on parasite loadings, allozyme polymorphisms and otolith microchemistry may yield more information on this important subject. Conventional studies of meristic and otolith morphology were felt unlikely to shed much further light on stock separation.

² Moreno, C.A. Hook selectivity in the longline fishery of *Dissostichus eleginoides* (Nototheniidae) off the Chilean coast. Document WG-FSA-91/11. CCAMLR, Hobart, Australia.

Abundance

2.45 Discussion on methods for estimating abundance of *D. eleginoides* centred on the topics of local abundance, inter- and intra-seasonal depletion studies, commercial trawl data, trawl survey data, fishing radius of longlines and age-based methods. The Workshop also discussed the accuracy of the reported total catch data under this heading.

Local Abundance

2.46 At previous meetings, WG-FSA has made a number of attempts to estimate local abundance using a Leslie depletion model (Leslie and Davis, 1939³). No consistent depletion has been detected in these previous studies.

2.47 The Workshop noted that for local depletion to be expected, a number of assumptions had to be made. The principal assumption was that the rate of removal was substantially greater than the rate of movement. This raised questions of the rate of movement and the distances over which movements take place (see section on stock identity, structure and movements). There was also considerable uncertainty concerning the area of influence of a longline. If fish are attracted into the area of a longline, over what distances might this occur? This process has both horizontal and vertical components - the fish are likely to be dispersed both across the seabed and within the water column. The distribution of fish within the water column is unknown (see section on stock identity, structure and movements).

2.48 Despite the difficulties in interpreting the results of previous analyses, some possible further analyses may be warranted. For instance, some localities might show greater potential for local depletion than others, due to differences in local conditions. However, considerable time had already been spent on this approach with little return in terms of results on which to base management advice. It was agreed that work on other approaches should take precedence at the Workshop.

Inter- and Intra-seasonal Depletion Studies

2.49 Longer term depletion-type analyses have also been attempted by WG-FSA at previous meetings (e.g., WG-FSA-91). However, these had not revealed any consistent pattern and

³ Leslie, P.H. and D.H.S. Davis. 1939. An attempt to determine the absolute number of rats on a given area. *J. Anim. Ecol.*, 8: 94-113.

resulting abundance estimates included considerable uncertainty. The Workshop considered that this might be the result of a large number of variables influencing the catch per unit effort (CPUE) and its relationship with abundance.

2.50 Standardisation of the CPUE series was considered to be a high priority. The first step was an initial data analysis to identify the key variables for an analysis of variance. One immediate concern was the degree of overlap between periods of vessel activity to analyse seasonal and year effects. Other possible explanatory variables were fishing ground, vessel and gear type.

2.51 There were a number of possibilities for the dependent variable (CPUE). Both catch per hook and catch per hook-hour could be investigated as part of the analysis of variance.

2.52 A subgroup was assigned the task of carrying out an analysis of the CPUE data using Generalised Linear Models (GLMs). The results are discussed in section 3.

Commercial Trawl Data

2.53 *D. eleginoides* have been taken in trawl fisheries in various parts of the Convention Area, including as a by-catch in the bottom trawl fishery in Subarea 48.3 during the 1980s and early 1990s, and a directed trawl fishery in Subarea 58.5 (Kerguelen). Interactions between trawl and demersal longline fisheries targetting the same resource have been studied in other parts of the world, particularly in South Africa.

2.54 There has not been any detailed analysis of the trawl by-catch taken in the 1980s in Subarea 48.3. There has been little overlap between the trawl and longline fisheries in Subarea 48.3 due to the decline in the trawl fishery during the early 1990s. There was therefore little scope for interactions between the two fisheries.

2.55 The Workshop considered that the monitoring of abundance using these data would be difficult, but it might be possible to generate an index of recruitment. Some preliminary exploratory data analysis was required to investigate the extent of the data available and possible methods of analysis. However, it was considered that data analysis should be undertaken during the intersessional period rather than during the Workshop or WG-FSA.

Trawl Survey Data

2.56 A large number of bottom trawl surveys have been undertaken on the shelf in Subarea 48.3 during the last 20 years. These surveys were not targeted specifically at *D. eleginoides*, covering only the shallower part of their range, however, catches of young fish were occasionally taken. The subgroup considered that it might be possible to determine which age classes were fully represented in the trawl survey catches and to develop an index of potential recruitment to the size classes fished by longlines. An analysis of fish density at length was suggested as a means of investigating this. The progress of this analysis is described in section 3.

Fishing Radius of Longlines

2.57 Some work has been done by WG-FSA on the estimation of local density directly from catches on individual longlines and assumptions about the size of the area from which fish are attracted to the baits. This approach has promise in that it might provide estimates of absolute abundance. It is also needed to extrapolate from local depletion abundance estimates to the whole fishable area. The Workshop had almost no information on the process of attraction of fish to the longlines, such as the range at which baits could be detected, swimming speed of the fish and current speeds at depth. Investigations of fishing radius in other longline fisheries, undertaken by Norwegian scientists, have been reported in the literature and might provide some guidance in this area.

Age-based Methods

2.58 The use of age-based methods of assessment, such as virtual population analysis (VPA), was discussed. The main limitation at this stage is the length of the time series. This approach might prove useful in the future.

Estimates of Total Catches

2.59 Considerable evidence exists that there has been an increasing amount of catches of *D. eleginoides* by longliners in Subarea 48.3 that have not been reported to CCAMLR.

2.60 Many of the methods of estimating the abundance of *D. eleginoides* rely on estimates of total removals. The Workshop therefore agreed that every effort should be made to estimate these as accurately as possible.

2.61 Several possible methods for estimating total removals were identified and a subgroup was assigned the task of obtaining best estimates. The results are discussed in section 3.

Yield

2.62 Estimates of sustainable yields in previous CCAMLR assessments have been calculated from yield-per-recruit analyses. In this approach, the catch-biomass ratio was calculated from a yield-per-recruit analysis with an $F_{0.1}$ reference fishing mortality rate and multiplied by the estimated biomass to determine a long-term sustainable yield (WG-FSA-93). The calculations undertaken were deterministic, but account was taken of demographic uncertainty by presenting ranges of possible total allowable catches (TACs) corresponding to likely ranges of values of demographic parameters.

2.63 An alternative method for estimating precautionary yields was used for the myctophid *Electrona carlsbergi* (WG-FSA-94/21⁴) and subsequently used for *D. eleginoides* at Heard Island (WG-FSA-94). This was similar to the method originally developed for estimating precautionary TACs for krill (the krill yield model, Butterworth *et al.*, 1994⁵). A generalised version of the fish yield model was described in WG-FSA-95/41.

2.64 The generalised fish yield model in WG-FSA-95/41 takes account of both demographic uncertainty and stochastic variability by carrying out stock projections over a specified number of years into the future. This method is very similar to that currently being used for *D. eleginoides* assessments in Chile (WG-FSA-95/30 and 31).

2.65 The Workshop agreed that as a method to be used at the forthcoming meeting of WG-FSA, it preferred the stock projection approach taken in WG-FSA-95/41 over the yield-per-recruit approach.

⁴ Constable, A.J. and W.K. de la Mare. 1994. Revised estimates of yield for *Electrona carlsbergi* based on a generalised version of the CCAMLR krill yield model. Document WG-FSA-94/21. CCAMLR, Hobart, Australia.

⁵ Butterworth, D.S., G.R. Gluckman, R.B. Thomson, S. Chalis, K. Hiramatsu and D.J. Agnew. 1994. Further computations of the consequences of setting the annual krill catch limit to a fixed fraction of the estimate of krill biomass from a survey. *CCAMLR Science*, Vol. 1: 81-106.

2.66 It noted, however, that there were several matters that required further discussion and that possible amendments to the method would be required before it could be applied to the established fishery for *D. eleginoides* in Subarea 48.3. These relate to the appropriate biomass levels to be used as constraints on final spawning stock biomass, the number of years for forward projection, and the manner in which historical catches were to be taken into account in the projections.

2.67 The Workshop agreed that further discussion on these topics should be deferred to the meeting of WG-FSA. Since application of an amended stock projection method would involve changes to existing computer programs, however, it agreed that yield-per-recruit calculations should also be carried out at that meeting.

Assessment Methods Used in Comparable Fisheries

2.68 As agreed by the Scientific Committee, two experts had been invited to the Workshop. Dr Zuleta described the stock assessment carried out for the Chilean fishery for *D. eleginoides* between 47° and 57°S. Dr Japp described comparative studies of trawl and longline fisheries for hake and kingklip off South Africa.

2.69 The Chilean fishery for *D. eleginoides* has annual landings of 5 000 to 7 000 tonnes. The fishery has operated since 1991, in recent years under the limit of a TAC set annually by the Chilean government. The assessment of stock size has been based on an analysis of the catch-at-age data assuming an equilibrium age structure and constant recruitment. A yield-per-recruit model gave estimates of the various reference fishing mortality rates. Papers WG-FSA-95/30 and 31 describe the procedure used to calculate the TAC in the fishery. In 1995 the projections incorporate uncertainty both in natural mortality and recruitment. A stock projection approach was suggested for use in the future when fitting the CPUE abundance indices derived from the commercial longline fishery.

2.70 The South African trawl fishery for hake has operated for many years on two main species of *Merluccius*: *M. paradoxus* (deep-water species) and *M. capensis* (shallow-water species). Following the decline of the kingklip stock, an experimental longline fishery directing effort at hake was initiated (WG-FSA-95/20). It was pointed out that caution was needed when introducing a longline fishery on top of an already established trawl fishery. The South African experience with kingklip had shown that the different selectivity patterns of the two gear types had resulted in a recruitment problem. Longlines targetted the spawning stock and could lead to a reduction in recruitment to both the trawl and longline fisheries.

2.71 The hake-directed pilot study aimed firstly at comparing the potential yields of longline and trawl, given the selectivity patterns of the two gear types. This study showed that longlines and bottom trawls catch different sizes of fish (WG-FSA-95/20). Longlines exploit only larger hake whilst trawls catch a much broader spectrum of sizes. These differences were mainly attributed to differences in the target species, area fished and the sex of the fish caught. Seasonal patterns and vessel effects (see paragraph 3.7) were also important. Paper WG-FSA-95/22 presents yield-per-recruit results which show that higher yields could be expected from the longline fishery. The hake-directed pilot study was seen as an example of how specific data could be collected in a scientifically controlled manner. This information could then be used to determine the potential of any future longline fishery.

Possible New Assessment Methods

2.72 The Workshop discussed methodologies which could overcome some of the difficulties previously encountered in CCAMLR stock assessments for *D. eleginoides*. The various research techniques were classified into four broad categories based on their practicality and feasibility.

- (i) Possible to complete currently:
 - (a) analysis of standardised CPUE data from the fishery; and
 - (b) improved stochastic projection methods.

- (ii) Possible to complete in the near future:
 - (a) tagging at the vessel (trawl, longline or crab pot) or by hook tags for analysis of movement and migration;
 - (b) research using bottom and midwater trawling to study vertical distribution;
 - (c) comparative fishing studies (longline and trawl);
 - (d) validation of age estimates from scales/otoliths;
 - (e) analysis of previous plankton samples for eggs/larvae of *D. eleginoides*; and
 - (f) maturity ogives.

(iii) Long-term studies:

- (a) trawl or longline survey in deep water over range of species distribution;
- (b) stock identification studies using otolith chemistry, parasite or genetic studies;
and
- (c) experimental longline fishing (directed) with standard gear.

(iv) New studies:

- acoustic survey with deep-towed body;
- camera studies (flash or low-light sensitive equipment) to assess distribution and abundance;
- plankton surveys (egg production assessment methods and studies of larval distribution); and
- studies on fish foraging behaviour to improve biomass estimation from longline surveys and to study the effective fishing area of each hook.

REVIEW OF DATA AND ANALYSES

Estimation of Total catch in Subarea 48.3

3.1 The use of abundance indices in stock assessment requires that the total removals are known. The complete catch history is also required to estimate the size of the unexploited stock, which determines the scale of the fishery and the target stock size. Accurate catch information is therefore critical for both assessment and management of the fishery.

3.2 It is clear from circumstantial evidence and confidential records that the reported catches from the longline fishery in Subarea 48.3 do not represent the true level of removals:

- (i) the presence of fishing vessels in Subarea 48.3 in months outside the CCAMLR season clearly indicates fishing in excess of allowable catch levels;

- (ii) many catches of *D. eleginoides* reported from areas just outside 200-mile limits represent misreporting to avoid the constraints of national and CCAMLR catch limits; and
- (iii) fishermen have confided in scientists working in the fishery about misreported catch.

3.3 The Workshop has attempted to estimate the total removals from Subarea 48.3 and adjacent banks (Rhine and North Banks) using all available sources of data (Table 3). The procedure required the use of confidential records which are not available in an official capacity. The column labelled 'estimate of additional catch' in the table includes:

- (i) the amount of catch which cannot be accounted for in the official statistics reported from different countries. The official statistics correspond to catches within the CCAMLR season, catches taken in non-CCAMLR fishing grounds and those clearly misreported from zones which are far from Subarea 48.3, but which are not appropriate for *D. eleginoides*;
- (ii) catches where the area of capture is known but the dates do not correspond with the CCAMLR season; and
- (iii) catches estimated from sightings of fishing vessels in the area outside the fishing season. The assumption was made that these vessels catch the equivalent volume of fish per trip, as they reported during the CCAMLR season. The total catch estimated will probably be an underestimate because not all vessels may be sighted.

Table 3: Estimates of total catches *D. eleginoides* in Subarea 48.3 and adjacent Rhine and North Banks.

Split-year	CCAMLR Catch (tonnes)	Estimate of Additional Catch	Best Estimate of Real Catches ¹
1990	8156.0	345	8501.0
1991	3639.0	565	4206.0
1992	3841.6	3470	7309.6
1993	3088.5	2500	5588.5
1994	459.5	6145	6604.5
1995	3301.1 ²	2870	6171.1

¹ Include the adjacent banks

² Includes 180 tonnes taken by Bulgaria in August 1994

3.4 In conclusion, the total removals in Table 3 for each year is an approximation and likely to be slightly underestimated. However, it is apparent that over the last four years the CCAMLR reported catch is only about 40% of the total catch from Subarea 48.3 and adjacent areas.

Standardisation of Longline CPUE Data

3.5 A preliminary analysis of the CPUE data was completed to identify key variables for analysis of variance. The individual longline sets from 1992 to 1995 were edited to remove data where area was unknown and where effort was recorded as zero. However, zero catches were included in the data set. The level of overlap in fishing activity between vessels was fairly limited but sufficient to carry out the analysis.

3.6 One method of standardising catch and effort data is to use GLMs. This approach was adopted for the preliminary analysis, and four independent variables (vessel, year, month and area) were included in the model. The dependent variable of CPUE used was kilogram per hook.

3.7 The vessel effect was found to be highly significant. This variable includes all the differences between vessels, including fishing gear (longline method, baiting efficiency and hook type), experience of the skipper and nationality. Area was also found to be a significant variable in the model, but month explained very little of the deviations. Although month did not show up as a significant factor, it still may be an important determinant of catch rates in the fishery, particularly if seasonal migrations occur. The data set was dominated by hauls taken in only a few months of the year.

3.8 The standardised approach appears very promising and highlights the value of reporting by individual haul. Comparison with raw CPUE indices from each fleet and the use of alternative models would be useful as the GLM analysis can be sensitive to outliers in the data. Analysis of the CPUE data will continue during WG-FSA including use of kilogram per hook-hour as the dependent variable and the possible effect of depth on catch rates.

Selectivity of Fishing Methods

3.9 Although the size frequency of *D. eleginoides* in catches indicates major differences between longline and trawl methods, much of this difference may be attributed to the fishing

grounds and depth fished. An attempt was therefore made to compare size distribution obtained using both methods in the same area. Limited data sources were available at the Workshop, but more data are available to enable this comparison to be made in future.

3.10 Although the available data were not widespread, there appears to be major differences in the size selectivity of the fishing gear. In the Kerguelen area, the fish taken by trawl were much smaller than catches from longlines in a similar depth (300 to 600 m) and area (Figure 4). Data from the Argentinian longline and trawl fisheries operating on the Patagonian shelf showed a similar pattern, but with a greater separation between the two selectivity curves (Figure 5). The differences observed are affected by hook size and type, bait used and the size distribution of the population. However, a number of tentative conclusions could be made from this comparison. Small fish, even if present in the area, may not be taken by the lines. Therefore trawls may be more useful to map the distribution and abundance of small fish throughout the depth range.

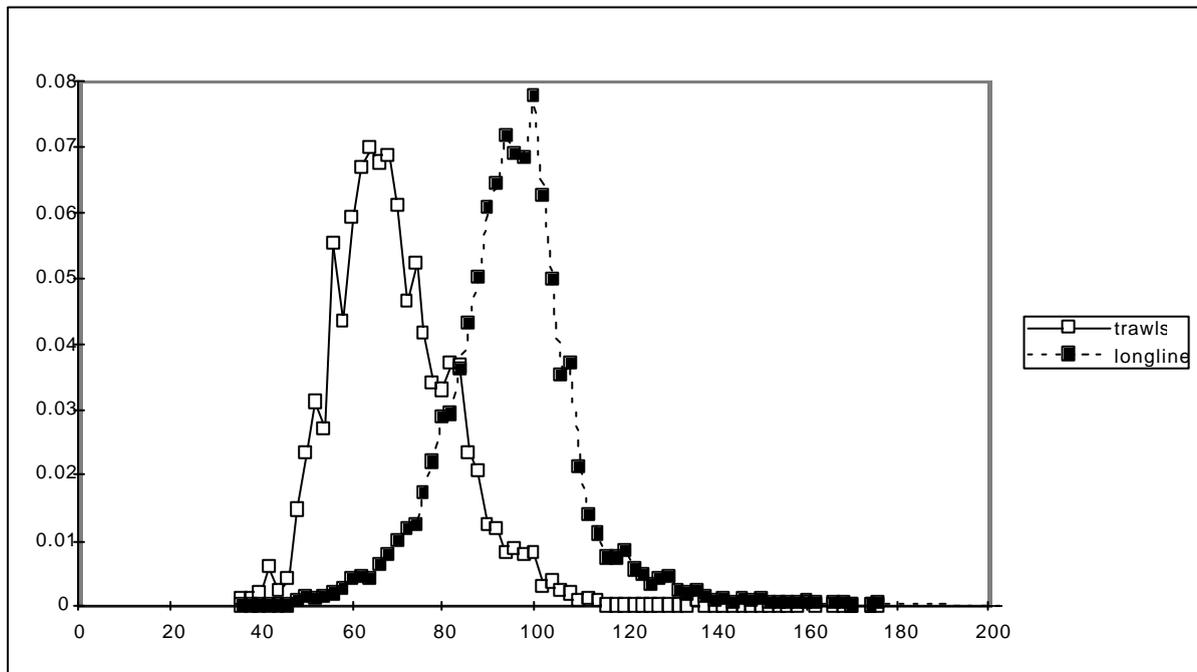


Figure 4: Length frequency distribution of *D. eleginoides* from trawl and longline catches in western Kerguelen from 1992 to 1994, from similar areas and depths (300 to 600 m).

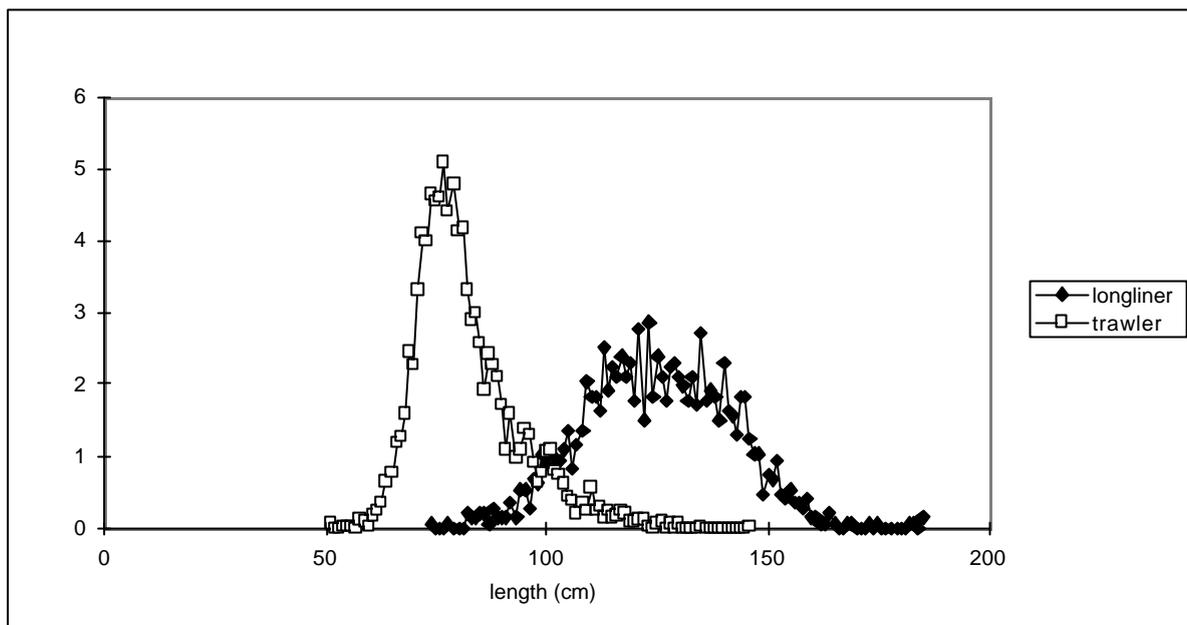


Figure 5: Comparison of Argentinian trawler and longline data from fine scale position 54°S 62°W.

Length-Density Analysis

3.11 Paper WG-FSA-95/23 listed the research surveys for which *D. eleginoides* has been recorded and data have been reported to CCAMLR. This includes 12 surveys in Subarea 48.3 over the period 1987 to 1995 and three surveys from Heard Island from 1990 to 1993. Most of these surveys have been based on a random stratified survey design, using a bottom trawl to sample at stations between 50 and 500 m deep. One survey (1987) used a pelagic net to fish close to the bottom. The surveys cover only part of the known depth distribution of *D. eleginoides*. From what is known about the size composition of the catches it appears that they sample only the younger age classes. It may be possible to use these data to develop a series of indices of the abundance of younger fish, which are considered to be well sampled by the surveys. These estimates can then be stochastically projected forwards to the adult population, using known catches.

3.12 A procedure for analysis of the trawl survey data was developed and preliminary data processing undertaken. The Workshop recommended that this data analysis should be continued by WG-FSA.

3.13 Length data from the trawl surveys will be analysed to determine year class strength. The abundance at length of fish sampled by the surveys is decomposed into separate age classes using mixtures of normal distributions. The method involves a maximum likelihood fit to the length data

from individual trawl stations (de la Mare, 1994⁶). The method is similar to the method using MIX software in MacDonald and Pitcher, 1979⁷, but overcomes errors in variance estimation of the area under the curve (year class strength).

RECOMMENDATIONS TO WG-FSA

4.1 The Workshop had four main areas of recommendations:

A. An experimental approach to assessing stock abundance must be initiated.

(i) Research programs must be developed, particularly on estimates of absolute abundance. It is clear that attempts to use relative abundance indices derived from commercial data have to date provided inconclusive results.

(ii) An experimental approach is therefore required. The Workshop considered that such an approach would include:

(a) fisheries dependent data: collection of data by observers to allow standardisation of the CPUE series to be improved, should be considered a high priority;

(b) fisheries independent data: directed research surveys are required; and

(c) experimental/directed fishing should be considered (e.g., with standardised gear).

B. Data consistency and quality from the commercial fishery must be improved.

(i) Every effort must be made to estimate total removals as accurately as possible. This could be improved by increasing confidence in the accuracy of the reported quantity and location of catches.

⁶ de la Mare, W.K. 1994. Estimating krill recruitment and its variability. *CCAMLR Science*, Vol. 1: 55-61.

⁷ MacDonald, P.D.M. and T.J. Pitcher. 1979. Age groups from size frequency data: a versatile and efficient method of analysing distribution mixtures. *J. Fish. Res. Board Can.*, 36: 987-1001.

- (ii) It was recognised that the best data acquired from the fishery so far had been that from the 1995 observer program. Nevertheless,
 - (a) improvements in completeness of both historical and future records for catch, effort, location, bait type, hook type, depth and soak time are needed;
 - (b) additional data such as environmental factors - current, wind strength, sea state, temperature at sea surface and depth should be gathered; and
 - (c) WG-FSA is urged to give consideration to the most appropriate mechanism for acquiring different types of data from both trawl and longline fisheries (e.g., through scientific observers or vessel masters). Further consideration should be given to the level of observer coverage required to achieve these results.

C. Estimates of biological and demographic parameters must be improved.

- (i) The age distribution using data from commercial and research sources should be determined. This should proceed by, in order of execution,
 - (a) developing methods in order to validate ageing from otoliths and scales; and
 - (b) an experimental approach to determine the magnitude of biases in estimated age/length keys caused by use of different hook type and sizes and different species and bait size.
- (ii) The level of mixing of *D. eleginoides* between different regions should be determined. This includes tagging experiments to determine mobility and stock identification. Other methods to investigate stock identification are genetic, parasite markers etc., but these probably should not be considered a priority.
- (iii) Further studies should be made to determine times and locations of spawning. Accurate identification of maturity stages is needed to determine maturity ogives.

D. Specific recommendations for assessments at WG-FSA-95 should be made.

- (i) The length-density analyses described in paragraphs 3.11 to 3.13 should be completed by WG-FSA during its 1995 meeting.
- (ii) WG-FSA should determine which of the estimates of von Bertalanffy growth parameters are appropriate for yield calculations in the light of size selectivity of different fishing methods.
- (iii) WG-FSA should perform stock projections and yield analysis using the information derived above.
- (iv) The CPUE standardisation described in paragraph 2.50 should be completed by WG-FSA during its 1995 meeting.

ADOPTION OF THE REPORT
AND CLOSE OF THE WORKSHOP

5.1 The report of the Workshop was adopted.

5.2 In closing the meeting the Convener thanked the rapporteurs, Secretariat and all participants for cooperating well to complete a successful workshop. In particular, he thanked Mr Japp and Dr Zuleta for providing their expert assistance to the deliberations of the Workshop.

5.3 Dr Kirkwood delivered a vote of thanks to the Convener, Dr de la Mare, for conducting a productive Workshop.

5.4 The Convener then closed the meeting.

AGENDA

Workshop on Methods for the Assessment of *Dissostichus eleginoides*
(Hobart, Australia, 5 to 9 October 1995)

1. Introduction
 - (i) Appointment of Chairman
 - (ii) Appointment of Rapporteurs
 - (iii) Adoption of Agenda
2. Review of Possible Assessment Approaches
 - (i) Previous CCAMLR Assessments
 - (ii) Assessment Methods used in Comparable Fisheries
 - (iii) Possible New Assessment Methods
3. Review of Data and Analyses
 - (i) Longline fisheries
 - (ii) Trawl fisheries
4. Application of Possible Methods to Selected Data Sets
5. Recommendations to WG-FSA
 - (i) Using Existing Types of Data
 - (ii) New or Refined Data Requirements
 - (iii) Using New Methods (directed research and/or data collected during commercial fisheries)
6. Adoption of Report
7. Close of Workshop.

LIST OF PARTICIPANTS

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(Hobart, Australia, 5 to 9 October 1995)

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STRUCTURE OF THE GENERALISED YIELD MODEL

(by Drs A. Constable and W. de la Mare)

The generalised yield model is introduced in WG-FSA-95/41 and paragraphs 3.44 to 3.47 of this report. The rationale for assessing the status of stocks using stochastic projections is discussed in SC-CAMLR-XIII, paragraphs 5.18 to 5.26. This appendix describes the manner in which projections are undertaken within the yield model and the way in which the spawning stock is monitored under specified catch regimes.

STRUCTURE OF A PROJECTION RUN

2. Figure 1 shows the basic structure of a projection run. Mean recruitment and natural mortality are determined for each run from specified functions to take account of uncertainty in the estimates of these parameters (e.g., see paragraphs 5.70 to 5.72; random normal and random uniform functions were used respectively in the *D. eleginoides* assessment).

3. The remainder of the run is made up of three parts:

I. Establishment of the Age Structure and Spawning Biomass at Time 0

4. The age structure at time 0 of the projection can be determined using two methods:

- (i) The first method (used by Butterworth et al., 1994¹) is to start with a set number of recruits (in the case of Butterworth et al., 1994, this was equal to 1.0 at age 0) and to apply the value of M for the run (modified by the age-specific mortality coefficient) to each successive age class to obtain a deterministic age structure. This population is then projected for a number of years, equivalent to at least the number of age classes in the stock, with recruitment varying from year to year within the bounds of recruitment variability specified in the recruitment function.

¹ Butterworth, D.S., G.R. Gluckman, R.B. Thomson, S. Chalis, K. Hiramatsu and D.J. Agnew. Further computations of the consequences of setting the annual krill catch limit to a fixed fraction of the estimate of krill biomass from a survey. *CCAMLR Science*, Vol. 1: 81-106.

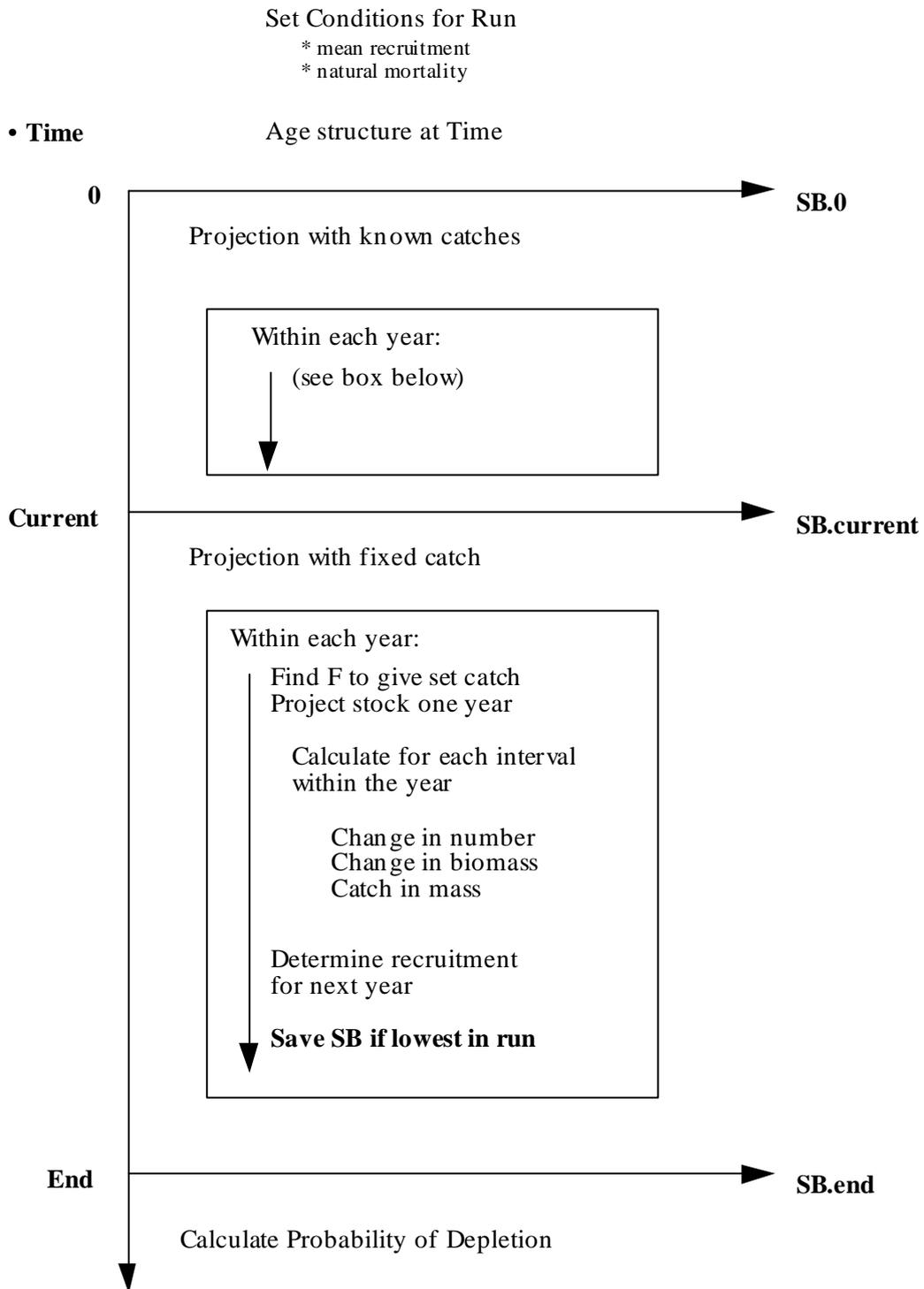


Figure 1: Flow chart of a projection run in the generalis ed yield model (GLM).

This removes the influence of the initial deterministic age structure. At time 0, the spawning biomass is determined. The stock is then ready for phases II and III of the projections (see below).

- (ii) The second method introduces recruitment variability into the formulation of the initial age structure, eliminating the need to project the stock forward one generation. In this formulation, each age class is assigned a different level of recruits at age 0 (or a specified starting age, such as 4 for *D. eleginoides*). These are drawn from the random recruitment function that incorporates recruitment variability. Each of these recruitments is then projected forward using the natural mortality function to the required age to give the number at age in the stock. A plus class can be included in this formulation.

5. After the initial age structure is set up, the spawning biomass at time 0 can be calculated using the maturity-at-age and length-at-age functions and the weight-at-age function specified in the input parameters.

6. In the case of the projections used in the assessment of *D. eleginoides*, the second option was chosen, with ages 4 to 34 years and a plus class. The initial age structures for two example projection runs are shown in Figure 2. Note that the age structure in real numbers is dependent on the random recruitments, yielding a structure that is different to a deterministic stable age distribution. The difference between the initial age structures of the two runs results from the random recruitments generated by the recruitment function, combined with the estimates of mean recruitment derived for each run.

7. If estimates of actual recruitment are used as inputs into the model, then the estimate of spawning biomass at time 0 will be an estimate of the actual spawning biomass of the stock, given the uncertainties in the input parameters and M . This differs from the model of Butterworth et al. (1994) who were seeking to find the proportion of the estimate of pre-exploitation biomass which could be exploited while satisfying the decision rules for γ_1 and γ_2 . As a consequence, their model outputs of Butterworth et al. were relative to B_0 and did not operate in the domain of actual biomasses.

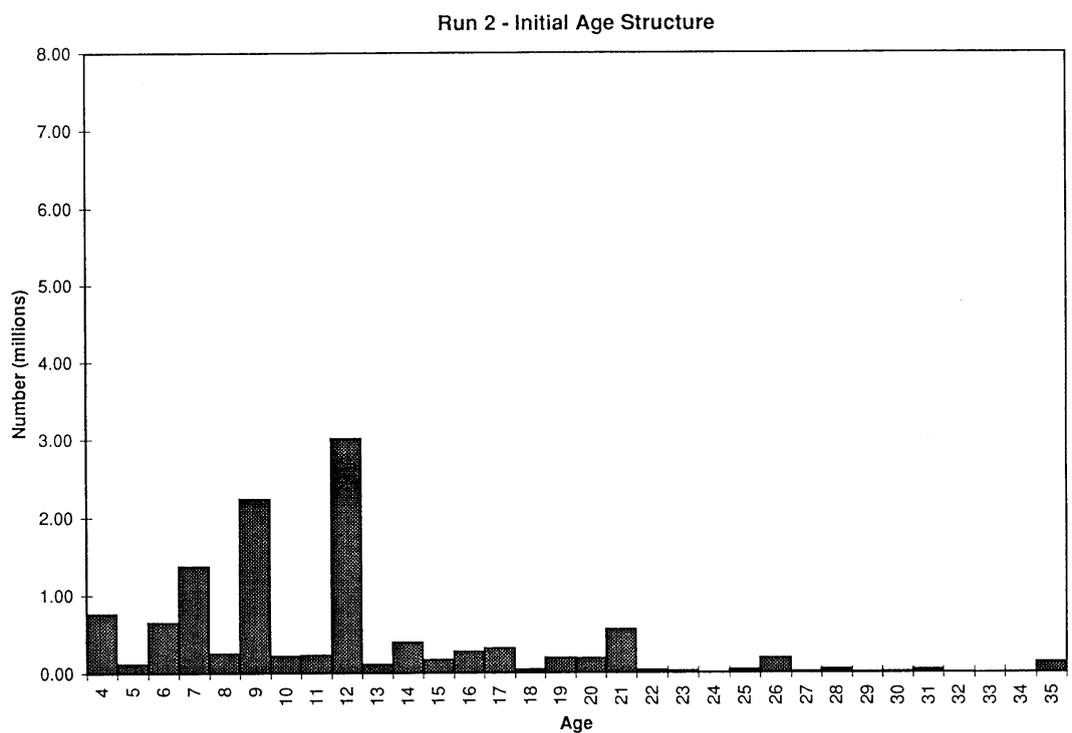
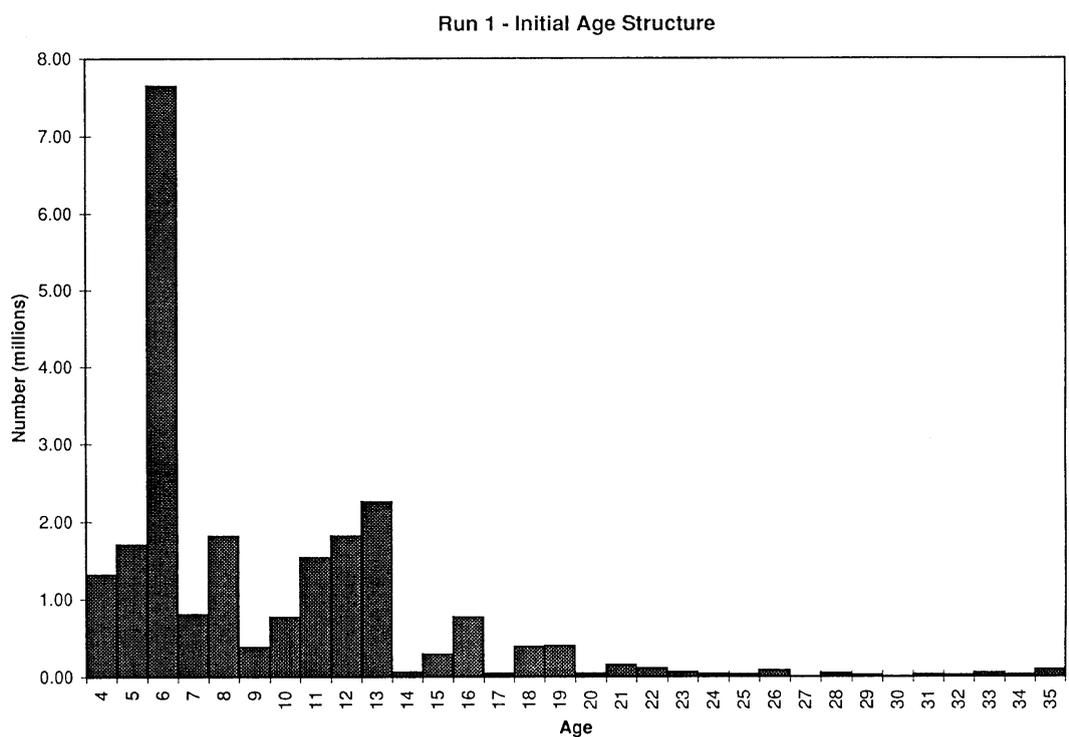


Figure 2: Initial age structure from example runs 1 and 2 in a projection for *D. eleginoides* in Subarea 48.3. The input parameters for the projection are presented in this report (paragraph 3.46). The projection included uncertain mean recruitment, interannual recruitment variability, $M = 0.16$ and a constant catch rate in the projection period with fixed catch of 5 400 tonnes. The age class 35 was a plus class established to include ages 35 to 55.

II. Projection of Stock through a Period of Known Catches

8. A projection through a period of known catches from time 0 to current (Figure 1) is then undertaken. For each year, F is calculated to yield the appropriate catch identified in the catch history. This level of fishing mortality was then used as a basis for projecting the stock forward for one year.

III. Projection of Stock for a Specified Period to Examine Performance Under a Specified Catch Regime

9. The main projection extends from the current time to the end of the projection period (Figure 1). In a single run, the model can project the stock forward under three different options: (i) a constant catch set as a proportion of an estimate of the pre-exploitation spawning stock (time 0 in the run); (ii) a constant catch specified in the input file; or (iii) a constant fishing mortality, e.g. $F_{0,1}$.

10. The first option is that used by Butterworth et al. (1994). This does not require knowledge of the number of recruits. The second option allows an examination of the performance of the stock under a constant catch scenario with real catches specified. In this case, estimates of real levels of recruitment are required. Both of these options require the determination of F for each year to yield the requisite catch before projecting the stock forward. The third option allows the performance of the stock to be examined under a set fishing mortality.

11. Figure 3 shows the trajectory of the spawning stock over the two example runs in the assessment of *D. eleginoides*, with a constant catch of 5 400 tonnes. These two runs show the influence of random recruitment on the outcomes. Fishing mortality varies each year to yield the requisite catch.

12. During the projection period, the program monitors the status of the spawning stock and, for each run, notes the minimum spawning biomass that occurred during the projection period. At the end of all runs this minimum is compared to the median spawning biomass at time 0. In the assessment of *D. eleginoides*, 1 001 runs were undertaken for each scenario. The probability of depletion under each catch scenario was determined as the proportion of runs in which the spawning stock descended below 0.2 of the median B_0 level at any time during the projection run. Run 2 in the example was one such run where the stock was depleted. In this run, fishing mortality continually increased in order to obtain the same level of catch each year. This was a result of low levels of recruitment throughout the run. In contrast, the stock in Run 1 was never considered as depleted during the projection period. Recruitment was much greater early in the projection period.

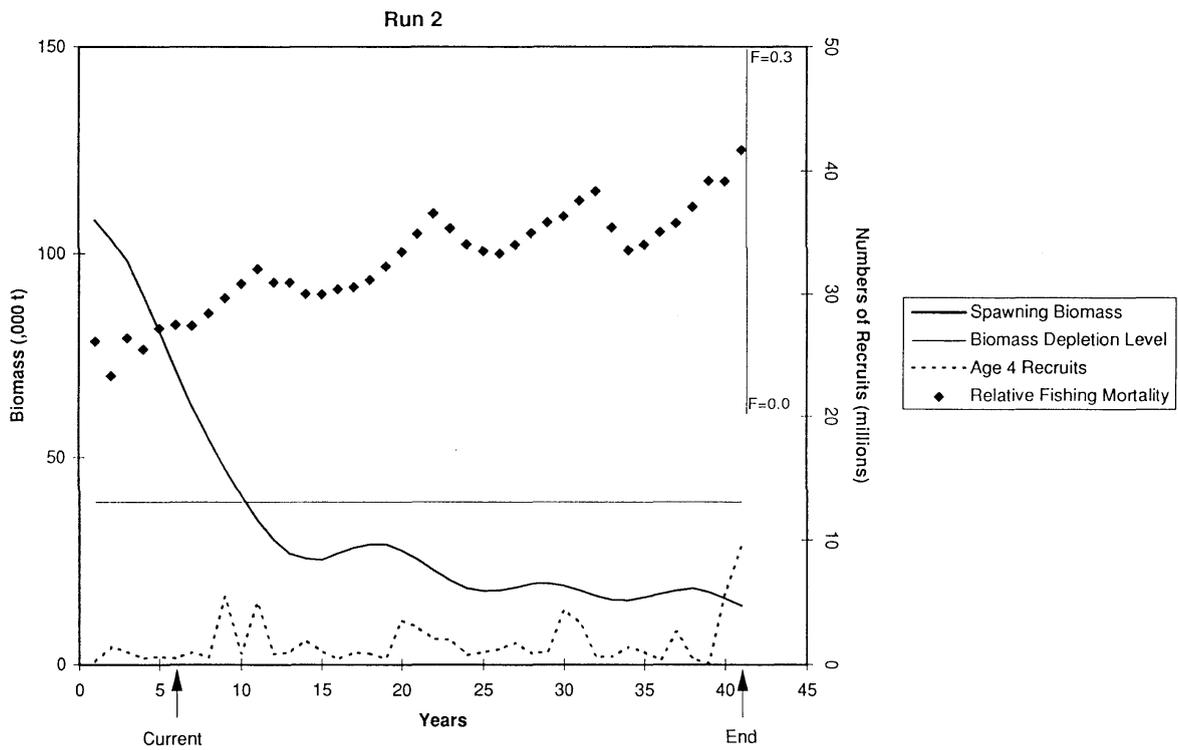
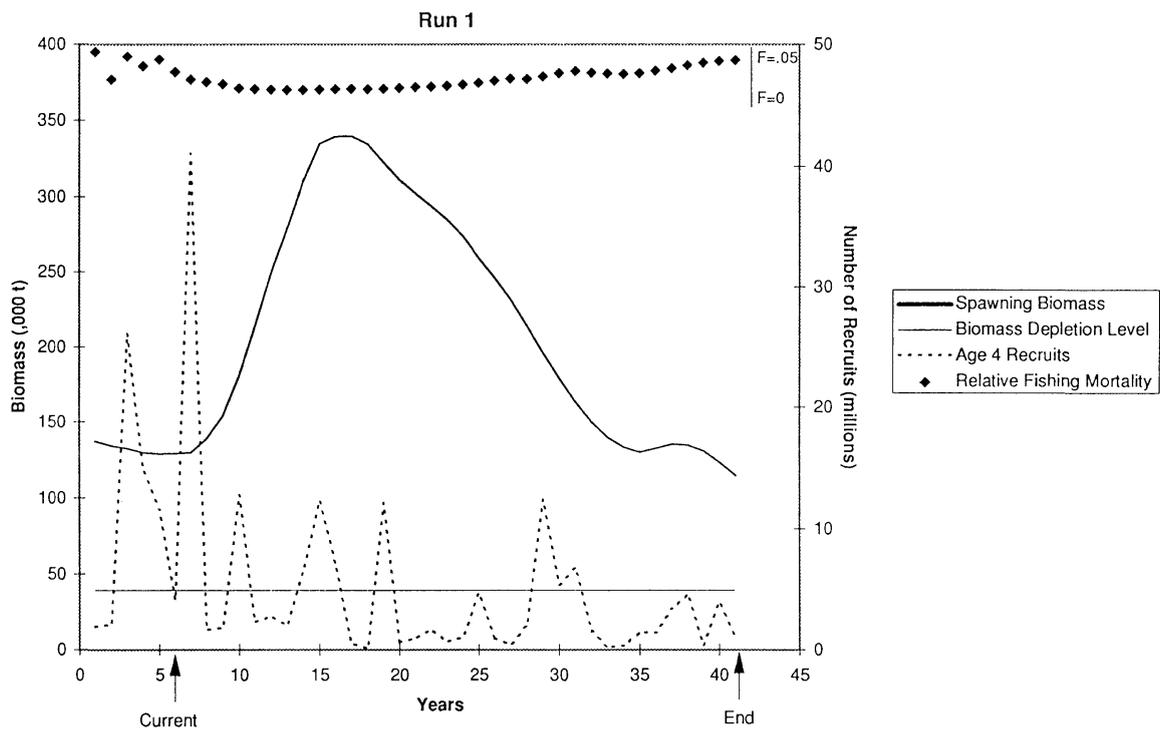


Figure 3: Spawning biomass, recruitments and levels of F in the two example projection runs from the initial age structures in Figure 2. The biomass depletion level was 0.2 of the median spawning biomass at Time 0.

PROJECTION WITHIN EACH YEAR

13. An adaptive Runge-Kutta procedure (Press et al., 1992²) is used to integrate the catches taken over one year and to project the numbers-at-age forward one year. This procedure solves the following set of differential equations which specify the growth rate of the stock and the rate of catch to be expected in each interval for each age of fish:

- (i) change in numbers-at-age in a specified time interval:

$$-(m_t \cdot M(t) + f_t \cdot F(t)) \cdot Y_0$$

where m_t = coefficient to modify natural mortality;

M = natural mortality;

f_t = coefficient to modify fishing mortality;

F = fishing mortality;

t = time increment in year; and

Y_0 = numbers-at-age at the beginning of the time interval.

- (ii) change in biomass-at-age during that time interval:

$$-(m_t \cdot M(t) + f_t \cdot F(t)) \cdot Y_0 \cdot \text{Weight}(t) + Y_0 \cdot dWt(t)$$

where $\text{Weight}(t)$ = weight of an individual at time t ; and

$dWt(t)$ = rate of change in weight of an individual at time t

- (iii) catch (in mass) of that age class in that time interval:

$$f_t \cdot F(t) \cdot Y_1$$

where f_t = coefficient to modify fishing mortality;

F = fishing mortality;

t = time increment in year; and

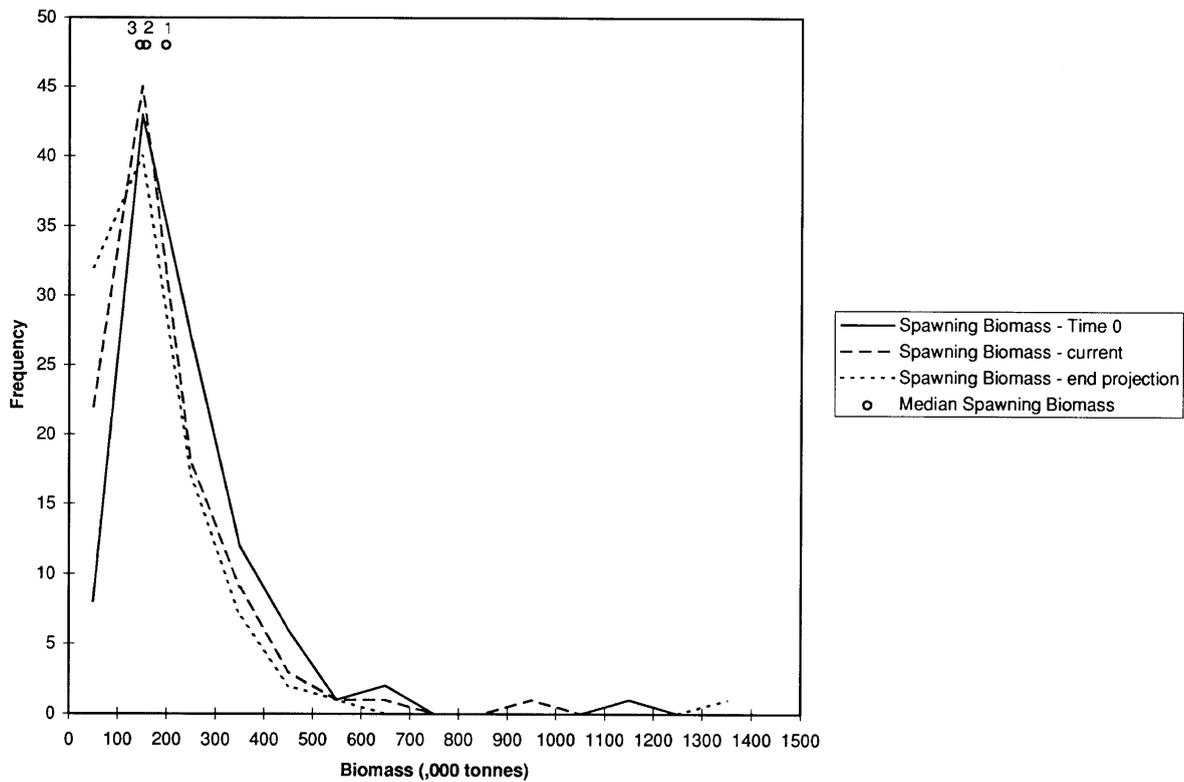
Y_1 = biomass-at-age at the beginning of the time interval.

14. Paper WG-FSA-95/41 illustrates how the coefficients f_t and m_t are derived from the biological parameters and the parameters that influence fishing mortality for fish at each age and time of the year.

² Press, W.H., B.P. Flannery, S.A. Teukolsky and W.T. Vetterling. 1992. *Numerical Recipes. The Art of Science Computing (FORTRAN Version)*. Cambridge University Press, Cambridge, UK.

MODEL OUTPUTS

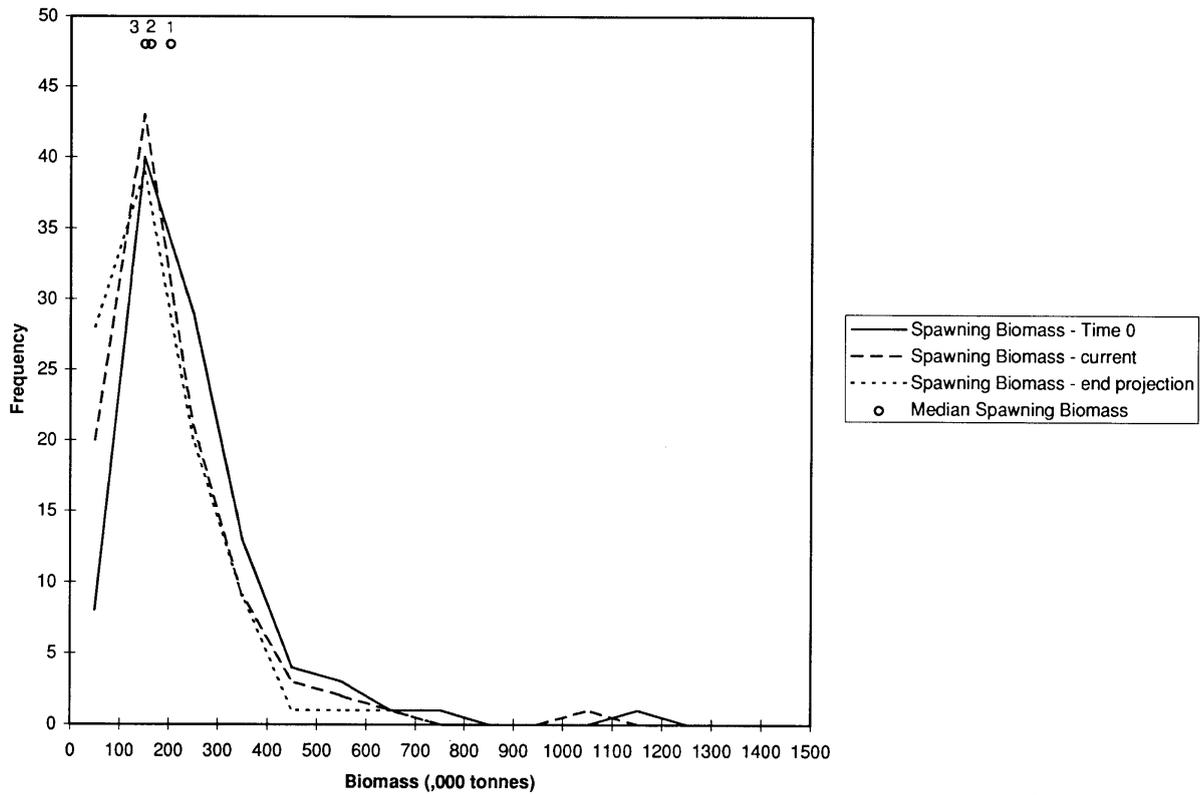
15. The outputs of the model at the end of a set of projection runs include estimates of the spawning stock at time 0, the end of the catch period (current) and the end of the projection period, as well as counts of the number of runs when the spawning stock became depleted at some time compared to the median spawning stock biomass at time 0 (i.e., depletion was $0.2 * \text{median } B_0$). These estimates take into account uncertainty in the estimates of the input parameters. The frequency distributions of the estimates of spawning biomass at the three critical times for *D. eleginoides* in the scenario of 5 400 tonnes are shown in Figure 4. The median estimates are also shown. The same results, but for the projection scenario of a constant catch during the projection period of 4 000 tonnes, are shown in Figure 5.



2

Figure 4

Figure 4: Results of the projection for a fixed catch of 5 400 tonnes. Relative frequencies of estimates of spawning biomass in 1989 (time zero), 1995 (current) and projected status after 35 years - 2030 (end projection). Median values of these distributions are shown (diamonds: 1 = B1989, 2 = B1995, 3 = B2030).



2

Figure 5: Results of the projection for a fixed catch of 4 000 tonnes. Relative frequencies of estimates of spawning biomass in 1989 (time zero), 1995 (current) and projected status after 35 years - 2030 (end projection). Median values of these distributions are shown (diamonds: 1 = B1989, 2 = B1995, 3 = B2030).

**METHODOLOGY APPLIED IN THE ANALYSIS OF *DISSOSTICHUS ELEGINOIDES*
CPUE DATA USING GENERALISED LINEAR MODELS (GLMS)**

SUBAREA 48.3 (SOUTH GEORGIA)

Following preliminary work conducted by the Workshop on Methods for the Assessment of *Dissostichus eleginoides* (WS-MAD) (Appendix E of this annex, paragraphs 3.5 to 3.8), five variables were selected as predictors for standardising the CPUE data with Generalised Linear Models (GLMs): vessel, year, month, geographic area and depth. Vessel, year, month and area were modelled as factors whereas depth was modelled as a continuous covariate.

2. Individual vessels were considered to be levels for the vessel factor. Twenty-three vessels from six different fleets (Argentina, Bulgaria, Chile, Korea, Russia and Ukraine) were included in the analysis. The area factor had five levels; east South Georgia, northwest South Georgia, south South Georgia, Shag Rocks and west of Shag Rocks. Figure 1 in the main text of this annex maps the boundaries of the area factors.

3. The predictor variables were used to model four CPUE indices; kilogram per hook, numbers per hook, kilogram per hook-hour and numbers per hook-hour.

4. The GLMs were fitted to *D. eleginoides* haul-by-haul data from Subarea 48.3 over the period 1992 to 1995. The data were screened according to the rules outlined in the following list.

For all models omit:

- (i) all records from hauls taken in unknown areas;
- (ii) all records where catch is greater than zero and effort either not reported or reported as zero;
- (iii) all records where depth at start of set was not reported; and
- (iv) single outlier where depth at start of set was reported as 6 065 m.

For models with hook-hours used as effort omit:

- (v) all records with soak-time less than or equal to zero or soak time not reported (soak time was calculated as time at start of hauling minus time at start of setting); and
- (vi) single outlier where soak time was reported as 104.5 hours.

5. Depth was taken as depth at start of setting. It was not possible to calculate a mean depth for each haul because many of the records in the haul-by-haul database do not have information on the depth at end of setting.

6. In general, the predictor effects were considered to be multiplicative, so standardised catch rates ($CPUE_{STD}$) were modelled with the following equation:

$$CPUE_{STD} = CPUE_0 \cdot vessel_i \cdot year_j \cdot month_k \cdot area_l \cdot depth_i \cdot E_i$$

Interaction terms were not included in the model.

7. $CPUE_0$ is the catch rate for a set of reference predictors (vessel = '1'; year = '1992'; month = '1' and area = 'east South Georgia'). $Vessel_i$, $year_j$, $month_k$, $area_l$ and $depth_i$ represent, respectively, the effects of vessel, year, month, area and depth. The error terms (E_n s) were distributed according to a γ distribution with variance proportional to $CPUE_{STD}$.

8. The multiplicative model was linearised with a log transformation;

$$\ln(CPUE_{STD}) = \ln(CPUE_0) + \ln(vessel_i) + \ln(year_j) + \ln(month_k) + \ln(area_l) + \ln(depth_i) + \ln(E_i)$$

9. The model was fitted using an iterative re-weighted least squares procedure (McCullagh and Nelder, 1983¹), and predictions were made from the fitted GLMs to provide standardised catch rates by vessel and year (Figures 2 and 3 in the main text of this annex).

¹ McCullagh, P. and J.A. Nelder. 1983. *Generalised Linear Models*. Chapman and Hall, London.

**DRAFT OUTLINE OF INFORMATION TO BE INCLUDED IN
SCIENTIFIC OBSERVER SUMMARIES TO CCAMLR**

Information of the type outlined below should be included in the summaries of work undertaken by scientific observers submitted to CCAMLR. Wherever possible, specific items of information should be summarised in a consolidated form (e.g., summary tables, figures) and observers are encouraged to summarise whatever information they consider pertinent. This draft outline will be kept under review and modified as necessary.

1. Introduction

A brief outline of work undertaken and reasons for scientific observer’s presence aboard vessel.

2. Scientific Observer and Vessel Details

CRUISE NUMBER: _____

SCIENTIFIC OBSERVER DETAILS:

Name: _____

Nationality: _____

Employing Organisation: _____

Dates of Observation: from _____ to _____

Location of Boarding: _____

Location of Debarkation: _____

Area, Subarea(s) Covered: _____

VESSEL DETAILS:

Name of Vessel: _____

Flag State: _____ Port of Registration: _____

Call Sign: _____

Vessel Type: _____ Fishing Gear*: _____

Size (GRT): _____ Length (LOA): _____

On-board Acoustic Equipment: _____

Position-fixing Equipment: _____

Vessel Monitoring System: _____

Processing of catch on the vessel:

Type of catch processing (e.g., frozen whole fish, gutted fish, fillets, etc.)	Conversion factor for calculation of the nominal catch, if used

* For longlines include hook type, size and number/line if possible.

3. Cruise Itinerary:

Port/Date Departure: _____

Transit Dates/Activities: _____

Fishing Dates/Activities: _____

Transit Dates/Activities: _____

Port/Date Return: _____

4. Summary of Gear/Bait/Fishing Operations

Area: _____

Coordinates: _____ S _____ W/E

Dates: _____

Average Depth: _____

Ship Days:

 In fishing area _____

 Actual fishing _____

Total number trawls/hauls/pots: _____

Longline Set:

 Cartridges _____

 1 000s hooks set _____

Bait:

 Species _____

 Estimated baiting efficiency as percentage _____

Catch (kg):

 Total _____

 Per ship day actual fishing _____

 Per 1 000 hooks set _____

Average frozen produce per ship day actual fishing (kg):

Comments: _____

5. Summary of Work Carried Out on Fish

Number of catches sampled: _____

Number of hooks set (in thousands): _____

Total number of all fish species
measured comprised:

Species	No.
_____	_____
_____	_____
_____	_____

Total number of fish
analysed by:

Species	No.
_____	_____
_____	_____
_____	_____

Analyses undertaken: Length distribution / Age / Weight / Maturity

Total fish sampled for age
determination comprised:

Species	Otoliths	No.	Scales
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Location where samples are archived: _____

Frozen fish products produced (in tonnes): _____

6. Summary of Meteorological Conditions

Days fishing lost to weather: _____

Prevailing sea conditions: Mild / Moderate / Stormy

Short description on weather and sea conditions:

7. Summary of Fishing Strategy

Brief outline of fishing strategy (including information such as 'pilot fishing trails using short longlines')

8. Summary of Biological Observations

Information to be provided in summary form (e.g., of composite length frequency), if so desired.

(Attach if necessary)

9. Summary of Work on Seabird Incidental Mortality

Proportion of haul (in terms of number of hooks) observed:

Recorded for all hauls:

Recorded for hauls no.: _____

Streamer line details recorded:

Specification (e.g., CCAMLR, other) _____

No. of streamer lines _____

Location of deployment _____

Diagram

Offal discharge:

Location _____

Timing _____

Birds killed:

Recorded for all hauls:

Recorded for hauls no.: _____

Bird samples:

Whole specimens retained

Species	No.
_____	_____
_____	_____
_____	_____

Leg and head samples retained

Species	No.
_____	_____
_____	_____
_____	_____

Where deposited _____

Contact scientist (if known) _____

Details of banded/marked birds

Species	Band No./Mark
_____	_____
_____	_____
_____	_____

Bird observations:

Densities recorded: during set

at other times

Additional observations recorded

10. Summary of Marine Mammal Observations

Description of mitigating measures: _____

Observations on marine mammals/fishery interactions:

Species involved _____

Loss of fish assessed

Loss of fishing gear recorded

Other observations of marine mammals: _____

11. Difficulties Encountered

Identify difficulties in:

- observer tasks as prescribed by the *Scientific Observers Manual*
- operational work aboard the vessel
- any other areas/activities
- reporting of data

1995 ASSESSMENT SUMMARIES

Assessment Summary: *Notothenia rossii*, Subarea 48.3

Source of Information: This report

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²
Recommended TAC	0							
Agreed TAC	300	300	0					
Landings	2	1	1	0	2	1		
Survey Biomass	1481 ^a 3915 ^b 3900 ^b	4295 ^c 10022 ^d	7309		6600			
Surveyed by	UK/POL ^a USSR ^b	UK ^c USSR ^d	UK		UK			
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 1982 to 1992

³ From VPA using (.....)

Conservation Measures in Force: 2/III, 3/IV and 85/XIII

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1995/96: Recommend continued closure.

Assessment Summary: *Champscephalus gunnari*, Subarea 48.3

Source of Information: This report

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²
Recommended TAC	12000		8400-61900	9200-15200	0			
Agreed TAC	8000	26000	0	9200				
Landings	8027	92	5	0	13	10		
Survey Biomass	72090 ^a 442168 ^b	27111 ^a 192144 ^b	43763 ^a		16088 ^{+a} 4870 ^{*a} 2012 ^{+b} 67259 ^{*b}			
Surveyed by	UK/POL ^a USSR ^b	UK ^a USSR ^b	UK ^a		UK ^a Arg ^b			
Stock Biomass ³	50	50.5						
Recruitment (age 1)	(millions)							
Mean F (.....) ¹			0					

Weights in '000 tonnes

¹ ... weighted mean over ages (...)

* Shag Rocks

² Over period 1982 to 1992

+ South Georgia

³ From VPA (2+)

Conservation Measures in Force: 19/IX and 86/XIII

Catches: Research catch only of 10 tonnes.

Data and Assessment: No new assessment was performed.

Fishing Mortality: None.

Recruitment:

State of Stock: Stock has increased since 1993/94 but the magnitude of this increase is unknown.

Forecast for 1995/96:

Assessment Summary: *Patagonotothen guntheri*, Subarea 48.3

Source of Information: This report

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²
Recommended TAC	-	20-36000	0					
Agreed TAC	12000	0	0					
Landings	145	0	0	0	0	1		
Survey Biomass		584 ^a	12764		4589			
Surveyed by		16365 ^b						
		UK ^a	UK		UK			
		USSR ^b						
Sp. Stock Biomass ³	na							
Recruitment (age 1)	na							
Mean F (3 - 5) ¹	na							

Weights in tonnes

¹ ... weighted mean over ages (...)

² Over period 1982 to 1992

³ From VPA using (.....)

Conservation Measures in Force: 76/XIII

Catches:

Data and Assessment: No new assessment was performed.

Fishing Mortality:

Recruitment:

State of Stock: Biomass estimates provided by surveys above may underestimate stock sizes because they do not sample its complete depth range.

Forecast for 1995/96: Recommend conservation measures presently in force be retained.

Assessment Summary: *Dissostichus eleginoides*, Subarea 48.3

Source of Information: This report

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²
Recommended TAC	-					-		
Agreed TAC	-	2500 ⁴	3500	3350	1300	2800		
Landings	8311	3843	3703	2990	604	6171 ⁵		
Survey Biomass	9631 ^{*a} 1693 ^{*b}	335 ^{+a} 3020 ^{+b}	19315 [*] 885 ⁺	3353 [*] 2460 ⁺		14923 ^{*a} 4831 ^{+a}	2012 ^{*b} 67259 ^{+b}	
Surveyed by	POL/UK ^a USSR ^b		UK	UK		UK ^a Arg ^b		
Stock Biomass ³	20745 - 435817			11000- 17000				
Recruitment (age...)	na							
Mean F (.....) ¹	na							

Weights in tonnes

¹ ... weighted mean over ages (...)

* Shag Rocks

² Over period 1982 to 1992

+ South Georgia

³ Estimated from cohort projections

⁴ TAC from 1 November 1990 to 2 November 1991

⁵ Estimated by WS-MAD from various sources

Conservation Measures in Force: 69/XII, 77/XIII and 81/XIII

Catches: Reported catches: 1994/95 split-year - 3 301.1 tonnes; 1994/95 season (March to May 1995) - 3 062.1 tonnes.

Data and Assessment: Total removal estimated by Working Group over the period 1990 to 1995. Standardisation of CPUE series using generalised linear model. Analysis of the effects of various harvest strategies using the generalised yield model to project over 35 years.

Fishing Mortality: Strategy of $F_{0.1}$ shown to have a high probability of failing the γ_1 decision criterion.

Recruitment: Estimated from trawl survey data over the period 1990 to 1995 using length-density analysis (de la Mare, 1994¹).

State of Stock: Current estimated median spawning stock biomass in the region of 100 000 to 200 000 tonnes according to simulations over the period of estimated total removals (1989 to 1995).

Forecast for 1995/96: Total removals of 4 000 tonnes per annum fulfill γ_1 decision criteria with current model input, including uncertainty in recruitment.

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

Assessment Summary: *Notothenia gibberifrons*, Subarea 48.3

Source of Information: This report

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²
Recommended TAC			500-1500					
Agreed TAC			0					
Landings	11	3	4	0	4	1		
Survey Biomass	17000	25000	29600		23566			
Surveyed by	UK USSR	UK USSR	UK		UK			
Sp. Stock Biomass ³	4300	6200						
Recruitment (age 2)	27000	25000						
Mean F (.....) ¹	0.014	0.0002						

Weights in tonnes

¹ Weighted mean over ages 2 to 16

² Over period 1975/76 to 1991/92

³ From VPA using survey $q = 1$ model

Conservation Measures in Force: 76/XIII and 85/XIII

Catches:

Data and Assessment:

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1995/96: Recommend directed fishery remain prohibited.

Assessment Summary: *Chaenocephalus aceratus*, Subarea 48.3

Source of Information: This report

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²
Recommended TAC	0	300	300-500					
Agreed TAC	300	300	0					
Landings	2	2	2	0	2	0	1272	1
Survey Biomass	14226 ^a 14424 ^b 17800 ^b	13474 ^c 18022 ^d	12500			9695		
Surveyed by	UK/POL ^a USSR ^b	UK ^c USSR ^d	UK		UK			
Sp. Stock Biomass ³	5098 ⁴							
Recruitment (age 2)	4047 ⁴							
Mean F (.....) ¹								

Weights in tonnes, recruits in '000s

¹ ... weighted mean over ages 3 to 11

² Over period 1982 to 1992

³ From VPA using revised VPA from WG-FSA-90/6

⁴ Predicted

Conservation Measures in Force: 76/XIII and 85/XIII

Catches:

Data and Assessment:

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1995/96: Recommend directed fishery remain prohibited.

Assessment Summary: *Pseudochaenichthys georgianus*, Subarea 48.3

Source of Information: This report

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²
Recommended TAC	0	300	300-500					
Agreed TAC	300	300	0					
Landings	1	2	2	0	1	0	1661	1
Survey Biomass	5761 ^a 12200 ^b 10500 ^b	13948 ^c 9959 ^d	13469		5707			
Surveyed by	UK/POL ^a USSR ^b	UK ^c USSR ^d	UK		UK			
Sp. Stock Biomass ³								
Recruitment (age 1)								
Mean F (.....) ¹								

Weights in tonnes, recruits in '000s

¹ ... weighted mean over ages 3 to 6

² Over period 1982 to 1992

³ From VPA described in WG-FSA-90/6

Conservation Measures in Force: 76/XIII and 85/XIII

Catches:

Data and Assessment:

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1995/96: Recommend directed fishery remain prohibited.

Assessment Summary: *Lepidonotothen squamifrons*, Subarea 48.3

Source of Information:

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²	Mean ²
Recommended TAC	0	300	300						
Agreed TAC	300	300	0						
Landings	0	0	0	0	0	0	1553	0	563
Survey Biomass	1359 ^a	1374	1232						
	534 ^b								
Surveyed by	UK/POL ^a	UK	UK						
	USSR ^b								
Sp. Stock Biomass ³									
Recruitment (age...)									
Mean F (....) ¹									

Weights in tonnes, recruits in

¹ ... weighted mean over ages (...)

² Over period 1982 to 1992

³ From VPA using (.....)

Conservation Measures in Force: 76/XIII and 85/XIII

Catches:

Data and Assessment:

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1995/96: Recommend conservation measures presently in force be retained.

Assessment Summary: *Electrona carlsbergi*, Subarea 48.3

Source of Information:

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²	Mean ²
Recommended TAC	-	-	-						
Agreed TAC	-	-	245000	200000 ⁴					
Landings	23623	78488	46960	0	0	0			
Survey Biomass									
Surveyed by									
Sp. Stock Biomass ³									
Recruitment (age...)									
Mean F (.....) ¹									

Weights in tonnes, recruits in

¹ ... weighted mean over ages (...)

² Over period 1982 to 1992

³ From VPA using (.....)

⁴ 43 000 tonnes at Shag Rocks (Conservation Measure 67/XIII)

Conservation Measures in Force: 54/XI, 84/XIII - TAC 200 000 tonnes

Catches:

Data and Assessment: No new assessment.

Fishing Mortality:

Recruitment:

State of Stock: No new estimate of biomass.

Forecast for 1995/96:

Assessment Summary: *Notothenia rossii*, Division 58.5.1

Source of Information: This report

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²	Mean ²
Recommended TAC									
Agreed TAC									
Landings	155	287	0	0	0	0			
Survey Biomass									
Surveyed by									
Sp. Stock Biomass ³									
Recruitment (age...)									
Mean F (.....) ¹									

Weights in tonnes, recruits in

¹ ... weighted mean over ages (...)

² Over period 1982 to 1992

³ From VPA using (.....)

Conservation Measures in Force: Conservation Measure 2/III and Resolution 3/IV. Limitation of trawlers allowed on fishing grounds each year. Arrêté Nos: 18, 20, 32 (for details see SC-CAMLR-VIII, Annex 6, Appendix 10, p. 290).

Catches:

Data and Assessment: No new data from 1995 season.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1995/96: No data - fishery remains closed.

Assessment Summary: *Lepidonotothen squamifrons*, Division 58.5.1

Source of Information: This report

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²	Mean ²
Recommended TAC									
Agreed TAC									
Landings	1262	98	1	0	0	0			
Survey Biomass									
Surveyed by									
Sp. Stock Biomass ³									
Recruitment (age...)									
Mean F (.....) ¹									

Weights in tonnes, recruits in

¹ ... weighted mean over ages (...)

² Over period 1982 to 1992

³ From VPA using (.....)

Conservation Measures in Force:

Catches:

Data and Assessment: No new data from the 1995 season.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1995/96: No data - fishery remains closed, although two French trawlers will be required to operate up to 10 days each surveying *L. squamifrons* fishing grounds to provide CPUE and length frequency data.

Assessment Summary: *Champscephalus gunnari*, Division 58.5.1

Source of Information: This report

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²	Mean ²
Recommended TAC									
Agreed TAC									
Landings (Kerguelen)	226	12644	44	0	12	3936	25852	0	
Landings (Combined)									
Survey Biomass									
Surveyed by									
Sp. Stock Biomass ³									
Recruitment (age...)									
Mean F (.....) ¹									

Weights in tonnes, recruits in

¹ ... weighted mean over ages (...)

² Over period 1982 to 1994

³ From VPA using (.....)

Conservation Measures in Force: None. Recommendation that the fishery be closed until at least the 1997/98 season, and any fishing in that season to be preceded by a pre-recruit biomass survey in the 1996/97 season (paragraph 5.152).

Catches: A relatively low catch on the strong cohort expected to be present in the 1994/95 season produced a decline in CPUE from 2 tonnes/hour to <0.3 tonnes/hour.

Data and Assessment: Length frequency and CPUE data from Ukraine trawl fishery.

Fishing Mortality:

Recruitment: The expected strong cohort recruited in 1994/95 was much less abundant than previous strong cohorts.

State of Stock: Estimated abundance of the expected strong adult cohort in 1994/95 was much lower than for previous strong cohorts.

Forecast for 1995/96: No strong cohort is expected to be recruited to the fishery in the 1995/96 or 1996/97 seasons.

Assessment Summary: *Dissostichus eleginoides*, Division 58.5.1

Source of Information: This report

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²	Mean ²
Recommended TAC									
Agreed TAC									
Landings	1062	1848	7492	2722	5083	5534	7492	121	
Survey Biomass									
Surveyed by									
Sp. Stock Biomass ³									
Recruitment (age...)									
Mean F (.....) ¹									

Weights in tonnes, recruits in

¹ ... weighted mean over ages (...)

² Over period 1982 to 1994

³ From VPA using (.....)

Conservation Measures in Force: None. Recommendation not to exceed 1 400 tonnes in western fishing grounds (CCAMLR-XII, paragraph 4.21).

Catches: Catches are from three areas: western slope (Ukrainian longliners), northern slope (French trawlers) and eastern slope (French trawler). Catches in the western and northern areas have been fairly steady over the last few years. The eastern area was fished for the first time in 1995.

Data and Assessment: CPUE for longline and trawl fisheries (northern area) have been \pm steady for several years. This suggests that stock size is stable and the fishery is at an appropriate level.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1995/96: Similar stock status and catches as in 1994/95.

Assessment Summary: *Champscephalus gunnari*, Division 58.5.2

Source of Information: This report

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²	Mean ²
Recommended TAC					311				
Agreed TAC					311	311			
Landings	0	0	0	0	0				
Survey Biomass		4585	3111		31701				
Surveyed by		Australia							
Sp. Stock Biomass ³									
Recruitment (age...)									
Mean F (.....) ¹									

Weights in tonnes, recruits in

¹ ... weighted mean over ages (...)

² Over period 1982 to 1992

³ From VPA using (.....)

Conservation Measures in Force: 78/XIII - TAC 311 tonnes.

Catches: None.

Data and Assessment: No new data or assessment.

Fishing Mortality: Nil.

Recruitment:

State of Stock:

Forecast for 1995/96:

Assessment Summary: *Dissostichus eleginoides*, Division 58.5.2

Source of Information: This report

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²	Mean ²
Recommended TAC					297	297			
Agreed TAC									
Landings	0	0	0	0	0	0			
Survey Biomass		17714	3179		11880				
Surveyed by		Australia							
Sp. Stock Biomass ³									
Recruitment (age...)									
Mean F (.....) ¹									

Weights in tonnes, recruits in

¹ ... weighted mean over ages (...)

² Over period 1982 to 1992

³ From VPA using (.....)

Conservation Measures in Force: 78/XIII - TAC 297 tonnes.

Catches: None.

Data and Assessment: TAC re-assessed using revised estimates of biological parameters, the generalised yield model and γ_2 calculated using 50% escapement from the fishery. TAC remains at 297 tonnes.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1995/96:

Assessment Summary: *Lepidonotothen squamifrons*, Division 58.4.4

Source of Information: This report

Year:	1990	1991	1992	1993	1994	1995	Max ²	Min ²	Mean ³
Recommended TAC (Lena Bank)									
Agreed TAC									
Landings (Ob Bank ^a)	867	?	0	0	0	0	4999	0	1151
Landings (Lena Bank ^a)	596	?	0	0	0	0	6284	0	1335
Landings (Combined ^b)	1463	575	0	0	0	0	11283	27	2487
Survey Biomass (Ob Bank)									
Survey Biomass (Lena Bank)									
Surveyed by									
Sp. Stock Biomass ⁴	na								
Recruitment (age...)	na								
Mean F (.....) ¹									

Weights in tonnes, recruits in

¹ ... weighted mean over ages (...)

² Over period 1982 to 1992

³ Assumes TAC of 267 tonnes for Ob Bank and 305 tonnes for Lena Bank was taken in 1991

⁴ From VPA using (.....)

^a From WG-FSA-92/5

^b From SC-CAMLR-IX/BG/2 Part 2 (*Statistical Bulletin*)

Conservation Measures in Force: 2/III, 4/V and 87/XIII

Catches: Nil.

Data and Assessment: No new data.

Fishing Mortality:

Recruitment:

State of Stock: Unknown.

Forecast for 1995/96:

**SCIENTIFIC COMMITTEE BUDGET FOR 1996
AND FORECAST BUDGET FOR 1997**

**SCIENTIFIC COMMITTEE BUDGET FOR 1996
AND FORECAST BUDGET FOR 1997**

1995		1996	1997
	Working Group on Fish Stock Assessment		
29 000	Meeting	33 100	34 000
8 000	<i>D. eleginoides</i> analysis workshop	0	0
35 100	Working Group on Ecosystem Monitoring and Management	41 500	43 000
0	Euphausiid Biology Symposium	0	7 000
	Ecosystem Monitoring Program		
4 000	Standard Methods Update	0	0
0	Sea-ice monitoring	0	0
0	At-sea monitoring workshop	0	8 500
0	Guide to Understanding CCAMLR's Approach to Management	1 000	10 500
	Incidental Mortality Arising from Longline Fishing		
1 000	Working Group meeting	0	0
4 000	Conservation brochure	0	0
	Travel for Scientific Committee Program		
31 200	WG-EMM meeting	38 200	39 500
0	Subgroup on Statistics	5 500	0
0	Subgroup on Monitoring Methods	4 600	5 000
4 000	Representation at ICES and CWP	0	0
3 000	International data meetings	6 000	0
2 500	APIS Program planning meeting	0	0
<u>6 000</u>	Contingency	<u>6 700</u>	<u>7 400</u>
A\$ <u>127 800</u>	Total from Commission Budget	A\$ <u>136 600</u>	A\$ <u>154 900</u>

NOTES ON THE SCIENTIFIC COMMITTEE BUDGET

WORKING GROUP MEETINGS

This item represents the costs of preparing for the meetings, support for the meetings and preparation and distribution of reports of the meetings in four languages:

- time of contract staff in correspondence, invitations, agendas and preparatory papers;
- time spent by contract staff at the meetings;
- time spent by contract staff and translators in preparing the reports of the meetings;
- postage, copying and other incidental costs relating to the above; and
- computing support for the meetings.

2. The increases in the meetings budget for both WG-FSA and WG-EMM reflect the increased length of the reports in 1995, and the anticipation that these lengths will be maintained in 1996. This, in turn, is due to the increases in work being undertaken by the Working Groups: WG-EMM is the result of amalgamation of three working groups, and WG-FSA is currently undertaking the work of two.

CONSERVATION BROCHURE ('CATCHING FISH NOT BIRDS')

3. On the advice of SCAF, costs of \$6 000 for this item in 1996 have been moved to the Commission's budget.

GUIDE TO UNDERSTANDING CCAMLR'S APPROACH

4. The Scientific Committee proposes to prepare, over the next two years, a brochure for general distribution outlining CCAMLR's approach to management of marine living resources in the Convention Area. Preliminary costs of A\$1 000 in 1996 will be followed by full production costs of A\$10 500 in 1997.

TRAVEL FOR SCIENTIFIC COMMITTEE PROGRAM

5. This item represents the costs of any Secretariat staff except the Executive Secretary travelling to workshops and working group meetings:

- airline tickets;
- excess baggage (when applicable);
- per diem expenses of staff while absent from Hobart; and
- incidental costs relating to the above (e.g., insurance).

6. The WG-EMM increase of A\$4 200 reflects the increase in travel and allowances for Bergen, Norway as opposed to Siena, Italy.

7. The Statistics and Methods Subgroup items represent the cost of transport and accommodation for Data Manager to the UK in March 1996, and for the Data Manager and one secretarial staff member to Bergen in August 1996, as well as the translation of the resulting reports.

INTERNATIONAL DATA MEETINGS

8. The amount of A\$6 000 replaces two items, of A\$4 000 and A\$3 000, for representation at ICES and/or COMNAP and SCAR/COMNAP respectively. Consolidation into a single item would enable decisions to be made during the year regarding the data/science meetings of international organisations at which representation by the Secretariat would be most beneficial.

ITEMS RECOMMENDED BY THE SCIENTIFIC COMMITTEE FOR THE COMMISSION'S BUDGET

Fast Workstation

9. The new stochastic assessment work, developed to deal with uncertainty, requires very fast computers because complex models are run many thousands of times to generate probabilities associated with various management options. The Secretariat, which is required to develop, test and run these models for both WG-EMM and WG-FSA, does not currently have such a computer. At present its fastest computer runs at about one-third the speed required and also lacks certain software required for stock assessment.

10. A fast workstation should be purchased (e.g., Digital AlphaSaver 100), A\$27 000, as well as machine-specific software including S+, MathCad 6, Fortran and C++, A\$6 000, totalling A\$33 000. This would be all capital expenditure, but the equipment will require replacement after four years.

11. A spinoff from this solution is that this fast machine may be used as a database server, considerably improving the management of the CCAMLR databases.

Observer Data Analyst

12. Scientific observer data are of very high value to the Scientific Committee and its working groups. At present the Secretariat does not employ sufficient staff to process the high volume of reports currently being received in time for observer data to be used effectively in assessments.

13. In 1996 an Observer Data Analyst should be employed to process and analyse observer data at a cost of A\$32 000. A further A\$6 000 would be required for computing and office support. A\$6 000 of this would be capital expenditure and A\$32 000 would be recurrent labour costs.

14. There would be some benefit in the Observer Data Analyst participating in the International Scheme of Observation to gain first-hand experience of observer problems, to address these and answer specific questions of the Scientific Committee. The cost of this would be A\$14 000 in non-recurrent labour costs.

Logbooks

15. Observer data are currently reported using ad hoc systems designed by each observer independently and the types of observer data collected are subject to the discretion of each observer. If observers were to use logbooks to record and report both data and other information from cruises, the Secretariat could enter observer data into databases and this would enable the Scientific Committee to analyse a consistent set of data arising from the observer program. The first logbook, for longline fisheries, should be distributed for the 1996 field season.

16. It is recommended that observer logbooks be produced at an estimated cost of A\$7 700. This will be a recurrent capital cost for at least two years until all fisheries have logbooks: 1996 - longline logbook; 1997 - krill fishery logbook; 1998 - trawl fishery logbook (possible).

World Wide Web

17. The proposal for a CCAMLR World Wide Web (www) server is set out in Secretariat paper SC-CAMLR-XIV/5. The WWW server would improve the accessibility of CCAMLR information and data, both to CCAMLR Members and to other parties.

18. For the WWW site to come on line in 1996, setup and capital costs of A\$5 500 and recurrent labour costs of A\$1 500 would be required. The total cost would be A\$7 000.

Statistical Bulletin

19. Over the last three years a considerable number of revisions have been made to historic data reported to CCAMLR. Early editions of the *Statistical Bulletin* are now, therefore, inaccurate.

20. It is recommended that a revised edition of the first volume of the *Statistical Bulletin* be produced at an estimated cost of A\$ 3 500.



Figure 1: Scientific Committee budget expressed as a percentage of the total Commission budget.