Abstract

This document presents the adopted record of the Eighth Meeting of the Scientific Committee for the Conservation of Antarctic Marine Living Resources held in Hobart, Australia, from 6 to 10 November 1989. Major topics discussed at this meeting include: krill resources, fish resources, squid resources, ecosystem monitoring and management, marine mammal and bird populations and cooperation with other organisations. Reports of meetings and intersessional activities of subsidiary bodies of the Scientific Committee, including the Workshop on the Krill CPUE Study and Working Groups on Krill, for Fish Stock Assessment and for the CCAMLR Ecosystem Monitoring Program, are appended.

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REPORT OF THE EIGHTH MEETING OF THE SCIENTIFIC COMMITTEE

OPENING OF THE MEETING

1.1* The Scientific Committee for the Conservation of Antarctic Marine Living Resources met under the Chairmanship of Dr Inigo Everson (UK) from 6 to 10 November, 1989 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, German Democratic Republic, Federal Republic of Germany, India, Japan, Republic of Korea, New Zealand, Norway, Poland, South Africa, Spain, Union of Soviet Socialist Republics, United Kingdom and United States of America.

1.3 At the invitation of the Scientific Committee, representatives from the Intergovernmental Oceanographic Commission (IOC) and the Scientific Committee on Antarctic Research (SCAR) attended the meeting as observers. Observers from the Acceding States of Italy, Peru, Sweden and Uruguay participated by invitation.

1.4 Observers were welcomed and encouraged to participate, as appropriate, in discussion of agenda items 2 through 9.

1.5 A list of participants is at Annex 1. A list of documents considered during the session is at Annex 2.

1.6 Responsibility for the preparation of the Scientific Committee's Report was assigned to the following rapporteurs: Mr D. Miller (South Africa), krill resources and squid resources; Dr J. Beddington, (UK) fish resources; Dr J. Croxall (UK), ecosystem monitoring and management; Dr J. Bengtson (USA) marine mammal and bird populations; and Mr P. Heyward (Australia) all other items.

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

ADOPTION OF THE AGENDA

1.7 The Chairman noted that as a result of discussion with the Convener of the Commission's Working Group for the Development of Approaches to Conservation of Antarctic Marine Living Resources (WG-DAC), Australia, an additional item 'Development of Approaches to Conservation of Antarctic Marine Living Resources' was proposed after the preparation and distribution of the Preliminary Agenda. Explanatory notes had been distributed to Members as required.

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

REPORT OF THE CHAIRMAN

1.9 The Chairman noted that Members had continued their work during the intersessional period with several meetings taking place. He thanked the conveners, rapporteurs, participants, host countries and the Secretariat for contributing to the success of these meetings.

1.10 A Workshop on the Krill CPUE Simulation Study (WS-KCPUE) was held at the Southwest Fisheries Centre, La Jolla, USA from 7 to 13 June 1989 (Convener Dr Beddington) and a meeting of the Working Group on Krill (WG-Krill) at the same venue from 14 to 20 June 1989 (Convener, Mr D. Miller, South Africa). The Report of the Workshop was distributed as SC-CAMLR-VIII/3. The Report of the Working Group meeting was distributed as SC-CAMLR-VIII/4 and a report on the meeting by the Convener as SC-CAMLR-VIII/5.

1.11 The Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP) met in Mar del Plata, Argentina from 23 to 30 August 1989 (Convener, Dr K. Kerry, Australia). The Report of the meeting was distributed as SC-CAMLR-VIII/6.

1.12 The Working Group on Fish Stock Assessment met in Hobart, Australia from 25 October to 2 November 1989 (Convener, Dr K.-H. Kock, FRG). The Report of the meeting was distributed as SC-CAMLR-VIII/7.

1.13 The Chairman noted that the Commission had received STATLANT reports from three Members (France, UK and USSR) on harvesting of finfish, with a total of 104 397 tonnes being caught, and reports from three Members (Japan, Republic of Korea and USSR) on harvesting of krill with 382 205 tonnes being caught. Chile and Poland subsequently reported catches of krill (5 394 tonnes and 7 871 tonnes respectively) bringing the total krill catch to 395 470 tonnes. A report from one Member (UK) had also been received on harvesting of squid, with a total of 8 tonnes being caught.

1.14 The Chairman reported on documents available for consideration by the Scientific Committee. Twelve Members' Activities Reports were submitted, nine had been received by the Secretariat by the deadline set, 11 Working Papers were submitted, nine had been received by the Secretariat by the deadline set, and 57 Background Papers were submitted, 23 had been received by the Secretariat by the deadline set.

KRILL RESOURCES

Fishery Status and Trends

2.1 The total krill catch for the 1988/89 season was some 6.7% larger than in 1987/88. At 395 470 tonnes this is the second largest annual catch for the past seven seasons (Table 2.1).

Table 2.1: National krill landings (in tonnes) since 1982/83

	Split-Year*						
Member	1983	1984	1985	1986	1987	1988	1989
Chile	3 752	1 649	2 598	3 264	4 063	5 938	5 394**
GDR	0	0	50	0	0	0	0
Japan	42 282	49 531	38 274	61 074	78 360	73 112	78 928
Republic of Korea	1 959	5 314	0	0	1 527	1 525	1 779
Poland	360	0	0	2 065	1 726	5 215	7 871**
Spain	0	0	0	0	379	0	0
USSR	180 290	74 381	150 538	379 270	290 401	284 873	301 498
Total	228 643	130 875	191 460	445 673	376 456	370 663	395 470

* 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. 1988 refers to the 1987/88 split-year).
** From catch data tabled during the meeting.

2.2 The total krill catch by statistical area and year since 1973 is illustrated in the Figure 2.1.

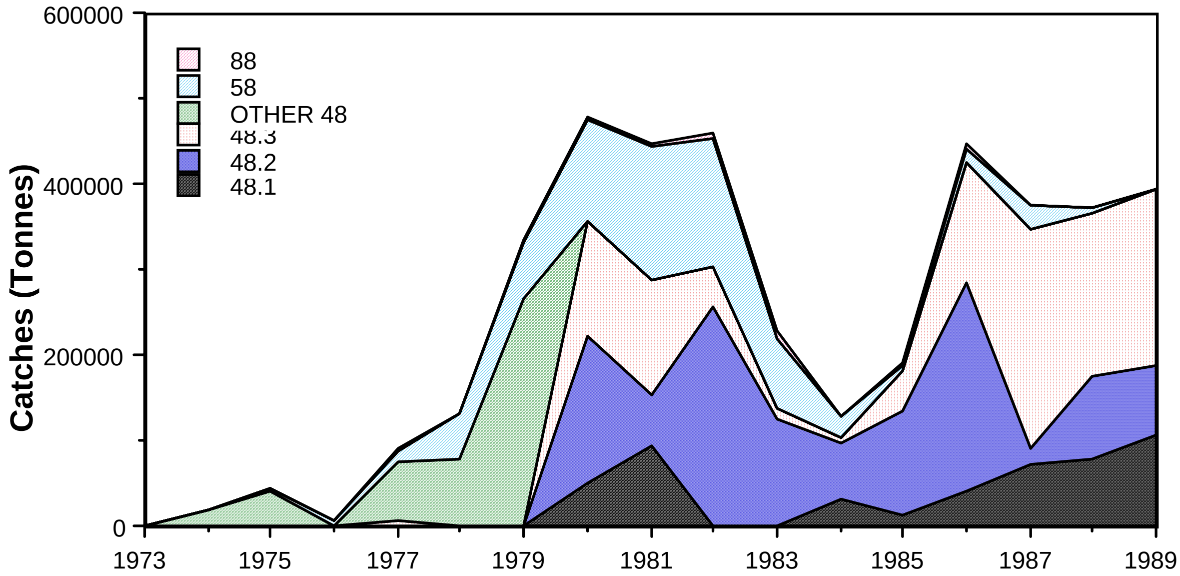

Figure 2.1: Total krill catches from 1973 to 1989. ('Other 48' refers to catches from Statistical Area 48 not allocated to Subareas 48.1, 48.2 or 48.3.)

2.3 An analysis of the 1988/89 landings by area indicated an increase in total catches from Statistical Area 48 compared with the previous year. In this regard, Soviet catches in Subareas 48.1 and 48.3 increased by approximately 20 000 and 15 000 tonnes respectively, while in Subarea 48.2 they decreased by about 13 000 tonnes (see paragraph 2.6).

2.4 In contrast to the above, there was a marked decrease of catches (from 6 490 to 217 tonnes) taken in Subarea 58.4.

2.5 With the exception of Soviet catches, which increased by some 16 600 tonnes, i.e. 6%, krill catches by most nations were similar to 1987/88 levels, although both Japanese and Polish catches increased by 5 816 tonnes, i.e. 8% and 2 656 tonnes, i.e. 50% respectively.

2.6 The total Soviet krill catch (301 498 tonnes) by area during 1988/89 was as follows:

Subarea 48.1	20 875	(0 tonnes in 1987/88)
Subarea 48.2	76 494	(89 888 tonnes in 1987/88)
Subarea 48.3	203 912	(188 391 tonnes in 1987/88)
Statistical Area 88	0	(0 tonnes in 1987/88)
Subarea 58.4	217	(6 490 tonnes in 1987/88)

2.7 Dr T. Lubimova (USSR) indicated that the increase in Soviet catches in Subarea 48.3 was as a result of the sustained presence of fishable krill concentrations in summer and autumn over the South Georgia continental slope. This was a result of the dynamics of the water circulation during the 1988/89 split-year.

2.8 Dr Lubimova indicated that for processing reasons, a priority target in krill fishing operations is krill that had not been feeding recently. Aggregations of such krill are particularly characteristic of Subarea 48.3 in the summer and autumn.

2.9 As indicated during last year's Scientific Committee meeting (SC-CAMLR-VII, paragraph 2.7), Dr Lubimova further emphasised that the continued reduction of Soviet catches in Subarea 58.4 could be attributed to unfavourable ice conditions.

2.10 In this context, Dr Y. Shimadzu (Japan) reported that the confinement of the Japanese fishery to Subareas 48.1, 48.2 and 58.4 (particularly Subarea 48.1) since 1984 was essentially the result of logistical constraints resulting from the re-direction of fishing operations from geographical areas immediately adjacent to the Convention Area.

2.11 Papers distributed at the meeting dealt with: commercial krill fishing in the Convention Area (SC-CAMLR-VIII/BG/11), the determination of krill acoustic target strength (SC-CAMLR-VIII/BG/30), the long-term distribution of krill fishing in Statistical Area 58 (SC-CAMLR-VIII/BG/21), the analysis of fine-scale data reported to the Commission (SC-CAMLR-VIII/BG/43 and 44) and Japanese krill fisheries research (SC-CAMLR-VIII/BG/28, 29, 30, 31 and 52). Dr Lubimova drew attention to various Soviet papers dealing with aspects of Soviet fishing operations and krill biology in general. Topics considered in these papers were concerned with catchability by krill trawls (SC-CAMLR-VIII/BG/9), the assessment of krill biomass in fishing grounds (SC-CAMLR-VIII/BG/4, 5, 7 and 10) and the analysis of the operating conditions of fishing vessels with respect to krill distribution, biology and behaviour (SC-CAMLR-VIII/BG/23). Various other Soviet papers dealt with the biology of krill in general (SC-CAMLR-VIII/BG/22 and 24) and population dynamics with relation to development of the fishery (SC-CAMLR-VIII/BG/21). It was agreed that detailed consideration of such papers should be referred to the next meeting of WG-Krill (see paragraph 2.29 below).

2.12 Most krill fishing nations indicated that recent trends (i.e. slight increases or decreases in catches from year to year) would continue. In this regard, Dr Shimadzu indicated that the limited market potential of krill tail meat in Japan is likely to keep Japanese krill catches at more or less current levels. Dr Lubimova reported that recent technological advances in the

Soviet Union had been made with respect to the processing of krill for human consumption and that there was some likelihood that the total krill catch from Soviet fishing would increase as operations were broadened into Statistical Areas 58 and 88 in the near future.

Report of the Workshop on the Krill CPUE Simulation Study (WS-KCPUE)

2.13 Dr J. Beddington (UK), Convener of the CPUE Simulation Study, briefly outlined the results of the Workshop on the Krill CPUE Simulation Study (Annex 4) held at the Southwest Fisheries Centre, La Jolla, USA between 7 and 13 June 1989.

2.14 The Workshop provided the opportunity for participants to work closely with the CCAMLR appointed consultants (Dr M. Mangel, University of California, Davis and Prof. D.S. Butterworth, University of Capetown) on the details of their simulations/analyses of Soviet krill survey and Japanese krill fishing operations.

2.15 Recognising limitations associated with the absence of Soviet participation in the Workshop, a substantial amount of work had been done and various conclusions reached (Annex 4, paragraphs 17 to 28). In brief, it was concluded that although the Soviet and Japanese fisheries operate in different ways, various types of catch and effort data could be utilised to obtain a Composite Index of Krill Abundance. As such, this Composite Index could be constructed from information on krill concentrations derived from USSR survey vessels and krill abundance within concentrations from Japanese fishing vessels. However, the Workshop concluded that the application of this Composite Index of Abundance is currently limited due to the small area of operation of the Japanese fishery.

2.16 The Workshop strongly emphasised that care needs to be exercised in the evaluation of the Composite Index as many of the component variables do not change in proportion to krill abundance and in addition there are considerable uncertainties with respect to how many of these variables can be best estimated. The Workshop felt, therefore, that in order to improve the applicability of the Composite Index, the collection of relevant data should, as far as possible, follow standard procedures. Furthermore, a number of suggestions were made in this regard. The Workshop agreed that certain within-krill concentration parameters (e.g. swarm size, number of swarms per unit area of concentration and inter-swarm distance) are essential for the monitoring of krill abundance and the necessary data would be best collected acoustically.

2.17 The Workshop therefore recommended the following:

(a) survey vessels operating in support of a fishing fleet should collect data in accordance with a recommended bridge log format (Annex 4, Appendix 5) and that data so obtained should be analysed to provide estimates of the size and type of krill concentrations along the lines suggested in WS-KCPUE-89/5;

(b) all catching vessels should collect haul-by-haul data in the same way as is currently done by the Japanese fishery;

(c) haul-by-haul data should be analysed to provide appropriate indices of krill abundance based on catch-per-unit searching time within krill concentrations by ten-day reporting period;

(d) the above analytical procedures should be conducted on a trial basis and reviewed after three years; and

(e) acoustic data should be used to better determine swarm size, number of swarms per unit area of concentration and inter-swarm distance within concentrations.

2.18 Dr Lubimova expressed the view that the potential utility of the Soviet research vessel data which were used to construct the model of commercial fishing operations was limited because these vessels are not operating in support of the fishery activities. In addition, a number of Soviet documents tabled at the present meeting (specifically SC-CAMLR-VIII/BG/8, 10, 21 and 23) indicated the possibility that several alternative variables could be utilised to improve current understanding and simulations of fishing operations in relation to krill abundance and distribution. Information gathered by scientists aboard Soviet fishing vessels has indicated that such information will be more objectively defined and useful than data from research vessels operating in a pre-determined way and independently of fishing vessels. Dr Lubimova also indicated that data routinely collected aboard Soviet fishing vessels were difficult to validate as it had been gathered in an unscientific manner and, as a result, its application is limited.

2.19 A further important conclusion of the Workshop was that the general properties of the Composite Index were such that small changes in krill abundance were unlikely to be detected, but any statistically significant change in the Composite Index would imply that a major change in krill abundance had occurred. Although it was possible to deduce the general properties of the Composite Index, the Workshop recognised that a detailed understanding of the quantitative behaviour of the Composite Index is required. Accordingly, the Workshop recommended that the sensitivity of the Composite Index to variation in parameter values should be further investigated. In this connection, certain delegations felt that it was rather premature to commence evaluation of the sensitivity of the Composite Index to changes in abundance in a mechanistic way and in the absence of a better understanding of certain critical biological properties of the krill population(s) being considered (e.g. seasonal emigration or immigration from or into specific geographical areas).

2.20 With respect to the views expressed in paragraphs 2.17 and 2.18 above, it was agreed that there would be considerable merit to be gained by considering the recommendations of the Workshop in combination with those from the First Meeting of the WG-Krill (see paragraphs 2.24 to 2.36 below).

2.21 The Scientific Committee thanked Dr Beddington for organising the study and for its conduct over the past few years and for convening the concluding Workshop and study as a whole.

Report of the Working Group on Krill (WG-KRILL)

2.22 The terms of reference of the WG-Krill (SC-CAMLR-VII, paragraph 2.26) and the objectives for its first meeting (SC-CAMLR-VII, paragraph 2.29) were agreed at last year's meeting of the Scientific Committee.

2.23 The Working Group met directly after (14 to 20 June 1989) the WS-KCPUE and at the same venue. The Convener, Mr D. Miller (South Africa) briefly outlined the topics addressed and conclusions resulting from the meeting (Annex 5 and SC-CAMLR-VIII/5).

2.24 In brief, the Working Group

- reviewed available data on, and techniques to determine, krill abundance and distribution;
- defined various scales of krill distribution and developed broad definitions of the types of krill concentration most frequently fished;
- acknowledged the potential utility and limitations of the Composite Index of Krill Abundance developed by the WS-KCPUE to monitor changes in krill abundance;

- reviewed available information on current and historic patterns in commercial krill catch levels as well as the distribution of fisheries activities;

- highlighted the importance of Statistical Area 48 as a whole to the krill fishery;

- made various recommendations concerning the analysis and collection of krill fisheries data, particularly length frequency distribution data from commercial catches; and

- repeatedly emphasised the importance of studying predator-krill interactions in the context of estimating the possible impact of fishing on krill-dependent predators.

2.25 The Working Group also recognised that the Krill CPUE Simulation Study had done much to focus attention on the more pertinent aspects of data necessary for monitoring effects of fishing on krill distribution and abundance. As such, the major factors introducing variance into the estimation of krill distribution and abundance were considered by the Working Group to depend on the size of the area being considered. Similarly, the applicability of available estimation techniques is also a function of the scale(s) over which the process being investigated operates.

2.26 The Scientific Committee discussed the reports of the WG-Krill and the WS-KCPUE meetings which Soviet scientists were unable to attend for reasons beyond their control. The discussions focussed on the practicality of collecting specific data and on the constraints associated with their validation and potential utility. As a general principle, it was agreed that haul-by-haul data from survey, research and commercial fishing vessels would provide information essential to improving current understanding of krill distribution/abundance in relation to krill fishing operations.

2.27 Dr Lubimova stated that there is a practical difficulty in collecting haul-by-haul data on board USSR commercial vessels which can currently be solved only when scientific observers are on board. Such scientific observers will provide reliable information in addition to simple haul-by-haul data which would be relevant to further investigations of the Working Group.

2.28 It was felt that in view of the large number of documents tabled at the present meeting, specific details of the type of analyses to be carried out on such data should be deferred to the next meeting of the Working Group. However, the Scientific Committee did agree that certain data collection and evaluation procedures could be initiated immediately and these are set out in paragraph 2.33 to 2.41.

2.29 Considerable discussion was also held on the development of an approved procedure to deal with the problem of uncertainty with respect to assessing the possible impact of fishing on both local and global krill stocks. In this connection, note was taken of one of the Working Group's recommendations that commercial catches should not greatly exceed current levels, particularly with respect to the potential impact of such catches on local predator populations within Statistical Area 48. A number of Members expressed their reservation with this recommendation as they considered the development of restrictive catch limits to be premature at this stage, especially in the absence of acceptable estimates of krill production and in the absence of necessary data concerning the functional relationships between krill and dependent predators.

2.30 The Scientific Committee, however, noted the views expressed in SC-CAMLR-VIII/BG/11 and 19 with respect to the possible extent of the impact of fishing on local krill resources and the formulation of a suitable protocol to deal with assessing such impact taking into account operational definitions of Article II of the Convention. The Scientific Committee recognised that this particular problem holds specific significance for the Commission's Working Group on the Development of Approaches to Conservation (WG-DAC) (this is discussed in general terms in paragraphs 7.6 to 7.17).

2.31 Taking into consideration Dr Lubimova's indication of possible increases in Soviet fishing activities (see paragraph 2.11 above), the Scientific Committee agreed that there was a considerable lack of relevant data concerning the functional relationships between krill abundance/distribution and dependent predators as well as more direct effects of fishing operations (e.g. the possible by-catch of already depleted fish species in krill trawls).

2.32 Dr Lubimova indicated that recent estimates of krill yield in the entire Antarctic were relatively high (ca. 50 million tonnes) (Hempel, 1988). Other Members raised considerable doubts as to the applicability of this estimate.

2.33 Given the views expressed in paragraph 2.30 and 2.31, certain Members were of the opinion that to minimise the potential for over-exploitation, consideration should be given by the Commission to the initiation of a general policy whereby precautionary Total Allowable Catches (TACs), may be set in certain restricted areas. This particular matter is discussed again in paragraph 2.48.

2.34 Finally, the Scientific Committee agreed that many of the items detailed above (paragraphs 2.22 to 2.30) and in the Working Group's Report (Annex 5) require the analysis and review of data. In view of the urgency of the Working Group's task (SC-CAMLR-VII, paragraph 2.28) as a whole, the timely submission of subsequent results will be necessary if the Working Group is to demonstrate any progress. For this reason the Scientific Committee recommended that a meeting of the WG-Krill be held during the next intersessional period.

2.35 The major objective of this meeting will be to further develop procedures to assess krill abundance and distribution in selected subareas of the Antarctic. A secondary objective would be to consider how such information could be utilised with a view to assessing the possible effects of changes in krill abundance and distribution with respect to both fishing operations and the possible impact on krill dependent predators (see also paragraphs 5.15 and 7.13 to 7.17). In order to achieve these objectives the Working Group will be required to review and consider:

(a) information on krill abundance and distribution (including available and relevant fisheries information/data);

(b) liaison with the CCAMLR Ecosystem Monitoring Program with respect to assessing any impact of changes in krill abundance and distribution on dependent and related species; and

(c) possible procedures to evaluate the impact on krill stocks and krill fisheries of current and future patterns of harvesting, including changes brought about through management action in order that the Scientific Committee may formulate appropriate scientific advice on krill to the Commission.

2.36 The Scientific Committee agreed that a meeting of the Working Group will be held in the Soviet Union at a time to be determined by the Chairman in consultation with Members.

Data Requirements

2.37 Review of the analyses of both past and currently available acoustic data should be undertaken in order to verify the definitions of concentration and aggregation types (Annex 5, Table 4) proposed by the WS-KCPUE and endorsed by the WG-Krill. Results of such analyses could be useful in the investigation of the possible underlying causes of the formation and maintenance of concentrations. As far as possible, these results should be presented at the Working Group's next meeting.

2.38 Available echo-charts should be examined to gather data on krill concentration parameters and aggregations types (i.e. swarm size, number of swarms per unit area of concentration and inter-swarm distance within-concentration). This should be undertaken as soon as possible, either on a national or cooperative basis, and submissions on how such data could be accessed and analysed should be reported to the Working Group's next meeting.

2.39 Haul-by-haul data from commercial fishery vessels should be collected. It would appear (at least for the Soviet and Polish fisheries) that the utility of these data in subsequent analyses could be most readily achieved through the placement of scientific observers aboard fisheries vessels. The development of suitable reporting formats for such data is encouraged and recommendations along these lines should be submitted to the Working Group's next meeting.

2.40 The majority of Scientific Committee Members perceived some utility in the acquisition of bridge log data from krill survey and fishing vessels. The Scientific Committee recommended that Members provide information on the type and extent of data currently being collected on fishing vessels when scientific observers are present and also on research vessels in accordance with the standard formats currently used on these vessels. This should be submitted to the next meeting of the WG-Krill along with details on extent of, and procedures followed in the annotation of echo-charts aboard both survey and fisheries vessels.

2.41 Available fine-scale catch and effort data should be further analysed in order to investigate the spatial distribution of fishing activities during ten-day periods and within each season. Similarly, the necessary analyses should be undertaken (either nationally or cooperatively) as soon as possible in order to investigate possible patterns in distribution of commercial fishing operations within a season and between years. Results of such analyses should be reported to the Scientific Committee.

2.42 The reporting of fine-scale catch data should continue for Subareas 48.1, 48.2 and 48.3. The Scientific Committee noted that there is a contradiction between paragraphs 2.19 of SC-CAMLR-VII and paragraph 59 of CCAMLR-VII in this regard. For this reason, the Scientific Committee once more recommended that fine-scale catch data should be reported from Subareas 48.1, 48.2 and 48.3. Wherever possible, fine-scale catch data from other Statistical Areas should be collected.

2.43 Studies to develop standardised sampling procedures for krill catches should be undertaken. In particular, these should take account of the number and frequency at which samples of krill length distributions in commercial catches should be collected. Due account should also be taken of developing procedures to assess within-catch variances in the sampling of length distributions as well as between-catches and vessels.

2.44 As an interim measure, length samples of at least 50 krill from one haul per day per vessel should be taken by all commercial vessels. It was agreed that, where possible, more than one sample should be taken from each haul in order to provide estimates of variance. The standard length measurement to be used should be from the front of the eye to the tip of the telson. Members are urged to report any difficulties experienced with the above sampling procedure as well as on the procedures they are currently using or intending to carry out with respect to sampling krill catch length distributions (e.g. using observers aboard single commercial vessels to record length frequencies from all catches in one area). As far as possible, Members are also urged to collect krill length frequency data from commercial and scientific catches in the same area.

Advice to the Commission

2.45 The WG-Krill should hold an intersessional meeting during 1989/90 in order to develop its tasks further and in order to sustain the momentum achieved at its first meeting.

2.46 Haul-by-haul catch and effort data including the relevant operational details should be collected and prepared pending discussion at the WG-Krill on specific analyses to be performed.

2.47 The Scientific Committee recommended that fine-scale catch data should be reported for Subareas 48.1, 48.2 and 48.3. Collection of such data in other areas where commercial fishing is undertaken, should be encouraged.

2.48 There is a substantial krill fishery in Subarea 48.3. The area is favoured by commercial operators as it contains concentrations of krill which have not been feeding. The current knowledge of the effect of krill fishing on krill predators and the impact on depleted fish stocks of by-catches, during the krill fishery, is poor.

Some Members of the Scientific Committee felt that it was now appropriate for the Commission to consider the implications of imposing a precautionary limit on the krill catch in this area.

Other Members expressed doubts about this view. Krill productivity was very important for prey-predator interactions and there were no data on this. In addition, no functional relationship between krill and its dependent predators had been established.

FISH RESOURCES

Fish Stock Assessment - Report of the Working Group

3.1 The Convener of the Working Group on Fish Stock Assessment (WG-FSA), Dr K.-H. Kock (FRG), presented a report of the meeting which had been held in Hobart at the offices of the Secretariat from 25 October to 2 November 1989.

3.2 The Report of the WG-FSA is attached at Annex 6.

3.3 In reviewing the Report, the Scientific Committee thanked the Convener and participants for all their hard work. There were a large number of background papers presented to the WG-FSA and in addition, a number of background papers presented to the Scientific Committee covered matters involved in fish stock assessment. A list of documents is given in Annex 6, Appendix 3.

3.4 The Scientific Committee endorsed the Report of the WG-FSA and in receiving the Report, used its findings as a basis for discussion of the agenda items to be covered under fish resources.

3.5 To avoid unnecessary duplication, where certain sections of the WG-FSA Report were accepted with only minor or no comment, this Report refers to the relevant paragraphs in the Working Group Report. This should be read in conjunction with this Report.

Scientific Research Exemption Provision

3.6 During the meeting of the Working Group the Secretariat had been in correspondence with the USSR**.** Three research vessels (*Slavgorod, Borispol* and *Passat 2*) had started a fishery survey in the South Georgia region (Statistical Area 48.3). It was announced during the meeting that these vessels had been withdrawn.

3.7 Dr Lubimova reported that the vessels had fished for less than one week and that catches were small and mainly of the species *Champsocephalus gunnari*. The results will be presented to CCAMLR at its next meeting.

3.8 The Scientific Committee noted the concerns of the WG-FSA, (Annex 6, paragraphs 3 and 4) and recommended that:

(a) plans for such research cruises should be circulated in advance;
(b) catches should be reported on a haul-by-haul basis to the Secretariat; and
(c) research vessel catches should be considered as part of TAC.

3.9 Dr Beddington referred to the plans presented to the WG-FSA for a further joint UK/Polish research cruise to Subarea 48.3 in January 1990. The vessel that would be used was a commercial trawler *Hillcove* as the RV *Profesor Siedlecki* was unavailable. The survey design was randomised and catches were therefore expected to be small (Annex 6, paragraph 3).

Catch and Effort Statistics

Statistical Area 48 (Atlantic Ocean Sector), (Annex 6, paragraphs 5 to 12)

3.10 The concerns of the WG-FSA about reporting catch and effort statistics from the operations of a longline fishery by the USSR for *Dissostichus eleginoides* in Subarea 48.3 were noted by the Scientific Committee.

3.11 The Secretariat at the request of the WG-FSA had prepared in SC-CAMLR-VIII/BG/54, a reporting format for presenting catch and effort statistics for longline fisheries.

3.12 The Scientific Committee <u>recommended</u> that all past and current catch and effort statistics for this fishery should be presented to CCAMLR in the format set out in this document.

3.13 Concern was expressed about the operation of this longline fishery as similar fisheries elsewhere in the world had posed conservation problems which were difficult to detect from catch and effort statistics alone. In addition, there had been significant instances of incidental mortality, particularly of albatrosses and large petrels, in other longline fisheries.

3.14 Dr Lubimova explained that the fishery operated at an average depth of 800 metres and would on occasion, go as far as 1 200 metres. The fishery targeted primarily on older age groups which appeared sporadically close to the continental slope. There was no indication of any problem of incidental mortality, but noted that SC-CAMLR-VIII/BG/54 involved a procedure for reporting any such incidents.

Statistical Area 58 (Indian Ocean Sector), (Annex 6, paragraphs 13 to 14)
Statistical Area 88 (Pacific Ocean Sector), (Annex 6, paragraph 15)

3.15 The above paragraphs were endorsed without comment.

Age Determination, (Annex 6, paragraphs 17 to 20)

3.16 Lic E. Barrera-Oro (Argentina) emphasised the importance of correct age data and noted how errors in these data would be propagated through other analyses. A workshop was considered as the best way of dealing with such problems and it was agreed that the Scientific Committee should consider holding such a workshop in two to three years time.

Other Biological Information, (Annex 6, paragraphs 21 to 27)

3.17 Some doubts were expressed by Dr Lubimova about the major difference in the length at first spawning of *C. gunnari* between South Orkney and South Georgia reported in SC-CAMLR-VIII/BG/16. These were noted, but could not be resolved.

Mesh Selection, (Annex 6, paragraphs 28 to 39)

3.18 Dr W. Slosarczyk (Poland) drew attention to some inconsistencies in different parts of the WG-FSA Report where mesh selection was discussed. The Scientific Committee noted this and endorsed the summary conclusions as follows:

Assuming that the actual size of the twine mesh in commercially used codends is on the average 10% greater than the nominal mesh (SC-CAMLR-VII/BG/11), the introduction of the following mesh sizes in the commercial fishery in Statistical Area 48 should be considered:

(a) Subarea 48.3

(i) Fishery targeted at *C. gunnari*
80 mm, to protect immature fish, or
90 mm, to protect first spawners, or
100 mm, to give an age at first capture of 4 years;

(ii) Fishery targeted at *Patagonotothen brevicauda guntheri*
50 mm, to protect immature fish;

(iii) Mixed fishery (not targeted at *C. gunnari* or *P.b. guntheri*)
120 mm extended to include *Notothenia gibberifrons*, *Chaenocephalus aceratus* and *P. georgianus* (in addition to *Notothenia rossii* and *D. eleginoides*, which have had such a mesh regulation since 1984 - Conservation Measure 2/III), to ensure better protection of immature fish;

(b) Subareas 48.1 and 48.2
110 mm, to ensure protection of first spawners of *C. gunnari* and immature *N. gibberifrons*.

In addition to the above, the provision should be included that chafers will not be used and codends will be diamond shaped mesh made of twine, no thicker than 4.5 mm.

‘Although the Working Group agreed that further work was necessary it was felt that the analyses presented were now at a stage when selection factors could be used as a guide in introducing new mesh sizes.’

3.19 Concern was expressed by Dr Lubimova that there could be substantial mortality of small fish passing through nets which could lessen the benefits to be gained from mesh regulations. Given the morphological peculiarities of the species concerned, before taking decision on new mesh size, studies should be carried out on the survival rate of fish escaped from the trawl.

3.20 Dr O. Østvedt (Norway) noted that this concern had been raised in meetings of ICES, but the decision had been that mesh regulations were still of substantial benefit and should be retained.

Assessments Prepared by Member Countries, (Annex 6, paragraphs 42 to 76)

3.21 A large number of assessments had been prepared for the WG-FSA and discussed at length by them. Given the technical nature of the work and comments, the Scientific Committee felt that it could only note and endorse these discussions.

Statistical Area 48

Subarea 48.3 (South Georgia)

Catches, (Annex 6, paragraphs 77 to 79)

3.22 Table 1, paragraph 77 of the WG-FSA Report (Annex 6) indicated catches of *Myctophidae spp.* increasing from 1 102 tonnes in 1987 to 29 673 tonnes in 1989. Concern was expressed that this was a very large increase in catch levels which had occurred without any stock assessment.

3.23 Dr Lubimova explained that this was an experimental fishery directed at a single species, *Electrona carlsbergi* which had an extended range beyond the Polar Front. Preliminary biomass estimates of the stock were high and the by-catch was limited to squid. This by-catch was at an extremely low level and only single squids were caught. Results of the analyses would be presented to CCAMLR next year.

3.24 Concern was expressed about the definition of an experimental fishery by several delegations and the view was expressed that the large increases in catch should have been preceded by some assessment that could be reviewed by the Scientific Committee.

3.25 The Scientific Committee recommended that in order to avoid confusion concerning the species involved, the Secretariat should ensure that the target species involved was identified in future reporting of catch statistics to the Commission.

Assessments of Individual Stocks

Notothenia rossii in Subarea 48.3, (Annex 6, paragraphs 80 to 84)

3.26 The Scientific Committee endorsed the WG-FSA Report and noted that there were no data presented on the size-at-age composition of the catch of this species. In view of the high degree of depletion of this species such data were essential. The Scientific Committee recommended that length compositions and age compositions from recent catches should be provided to the Working Group.

Management Advice

3.27 The Scientific Committee recommended that in view of the current low level of the stock *N. rossii*, all conservation measures should be kept in force.

Champsocephalus gunnari in Subarea 48.3 (Annex 6, paragraphs 85 to 99)

3.28 Dr Beddington pointed out that the comments on the reliability of the biomass estimates for the UK/Polish survey contained in Annex 6, Appendix 6 (paragraph 91) had been submitted by the USSR Delegation after the close of the meeting. The Scientific Committee recommended that this authorship should be reflected in a revision of paragraph 91 of Annex 6, Appendix 6.

Management Advice

3.29 There is a large difference between the assessment of the stock of *C. gunnari* as presented in two separate analyses. WG-FSA-89/27 has a high level of uncertainty as the survey estimate on which it is based could be a substantial over-estimate or under-estimate of the stock, while the WG-FSA could not agree on a way of assessing the reliability of the results presented in WG-FSA-89/22 Rev. 1.

3.30 The large differences between the two analyses for the final year pose serious problems in presenting management advice to the Commission. The TACs at different target F levels that have been derived from the two assessments are given in Table 3.1. They differ substantially.

Table 3.1: TAC levels (tonnes) for *C. gunnari*, Subarea 48.3, calculated from assessments presented in WG-FSA-89/27 and WG-FSA-89/22 Rev. 1 (M = 0.35).

	Assessment presented in WG-FSA-89/27	Assessment presented in WG-FSA-89/22 Rev. 1
$F_{0.1} = 0.313$	6 545	22 235
$F_{max} = 0.645$	11 961	40 273

3.31 In essence, if the trawl survey and the analysis based on it is correct, a TAC based on the CPUE tuned VPA will lead to a substantial depletion of the stock. If the analysis based on the CPUE tuned VPA is correct and a TAC is set on the basis of the trawl survey results, the stock will increase substantially.

3.32 A number of delegations expressed the view that given both the uncertainties and the wide differences between the estimates, any compromise position, e.g. the setting of a TAC based on the average value of the two assessments, would present problems similar to those posed in paragraph 3.31. The reason is that if the status of the stock based on the trawl survey is close to the correct one, a TAC based on an averaging of the assessments will lead to a substantial depletion of the stock. If the status of the stock based on WG-FSA-89/22 Rev. 1 is close to the correct one, the stock will increase substantially.

3.33 Dr Lubimova expressed the view that the advice given in paragraphs 3.30 and 3.31 was sufficient advice to the Commission.

Notothenia gibberifrons in Subarea 48.3,
(Annex 6, paragraphs 101 to 103)

3.34 The analysis performed in the WG-FSA had identified a strong relationship between stock and recruitment which implied that any further reduction in the stock would lead to yet lower recruitment.

3.35 Lic Barrera-Oro reiterated concern expressed in previous meetings by Argentine delegates, about the take of *N. gibberifrons* as by-catch in the directed fishery for *C. gunnari*. Even with the lowest of the TACs presented at the WG-FSA for *C. gunnari* (6 545 tonnes) the by-catch of *N. gibberifrons* will reach a level higher than the limit set by the Working Group (300 tonnes). The proportion of *N. gibberifrons* taken as by-catch in the *C. gunnari* fishery fluctuated between 4 and 10% in previous years. This view was shared by a number of other delegations.

Management Advice

3.36 The WG-FSA had reported that because of the current stock size and the evidence for a stock recruitment relationship, it is inappropriate to recommend catches at the level of $F_{0.1}$. Catches should be kept to a minimum to increase the stock size as much as possible. The Working Group recommended that there should be no directed fishery for *N. gibberifrons* and by-catch should be restricted to not more than 300 tonnes.

This <u>was endorsed</u> by the Scientific Committee with the reservation made by some delegations (see paragraph 3.33) that 300 tonnes may be too large.

Pseudochaenichthys georgianus in Subarea 48.3
Chaenocephalus aceratus in Subarea 48.3
(Annex 6, paragraphs 104 to 106 and 107 to 108 respectively)

3.37 The Scientific Committee <u>endorsed</u> the WG-FSA's review of these stocks without comment.

Management Advice

3.38 In view of the 'by-catch' problem associated with the catch of these species, its likely detrimental effects on other species with a low stock size (e.g. *N. gibberifrons*) and an apparent stock-recruitment relationship in the case of *C. aceratus*, the Scientific Committee <u>recommended</u> that no directed catches of these species be taken and by-catches be reduced to a minimum to allow the recovery of these stocks.

Notothenia squamifrons in Subarea 48.3
(Annex 6, paragraphs 110–113)

3.39 Concern was expressed that this species is relatively long lived, has a low potential yield and that no estimates of mortality or recruitment were available.

Management Advice

3.40 The WG-FSA had been unable to recommend a TAC because the status of the stock was unknown. The Scientific Committee noted this.

3.41 Some delegations expressed the view that in the absence of information on which to calculate a TAC or even estimate potential yield, two options should be presented. One option was for the Commission to recommend a cessation of any directed fishery. If this option was taken, the stock would be expected to increase. The second option was to permit a directed fishery at some level. In this situation, it would not be possible to predict the effect on the stock.

Dissostichus eleginoides in Subarea 48.3
(Annex 6, paragraphs 115 to 119)

3.42 Concern was expressed that catch levels have increased by a factor of four in the last two years and that the WG-FSA had been unable to assess the status of the stock. It was noted that the longline fishery was exploiting older age classes, and the productivity of this species is probably low, although the fecundity is high.

Management Advice

3.43 The WG-FSA had suggested a method for assessing the possible sustainable yield. Even in the absence of information on the stock size it is possible to calculate the yield for different levels of the unexploited stock size (using, for example, the Gulland formula, yield equals half the product of mortality and unexploited biomass). Natural mortality is estimated to be 0.06 (Kock, Duhamel and Hureau, 1985).

Biomass	Sustainable Yield
8 000 tonnes	240 tonnes
40 000 tonnes	1 200 tonnes

As the figure of 40 000 tonnes is some five times the stock estimate obtained by the FRG survey in 1984/85, this could be considered as a reasonable upper limit until further data become available. The Scientific Committee endorsed this as a useful basis for setting a TAC. However, the wide discrepancy between the TAC set on the basis of the survey estimate and that based on the assumption that biomass was five times the survey estimate presented in the report, was felt to be so wide as to serve only as broad guidelines for a TAC.

Patagonotothen brevicauda guntheri Subarea 48.3
(Annex 6, paragraphs 121 to 127)

3.44 The Scientific Committee endorsed the WG-FSA's analyses without comment.

Management Advice

3.45 The Scientific Committee endorsed the view of the WG-FSA that 'uncertainty in the value of natural mortality and the lack of any time series showing trends in biomass levels prevent accurate assessment of the current stock size. In the absence of reliable estimates of natural mortality to evaluate the alternative analyses and in the absence of information on current stock size, catch levels should not be based on VPA results, using $F_{0.1}$ calculations and assumptions about recruitment. The current status of this stock is unknown.'

General Management Advice

3.46 Following its review of the status of the fish stocks in Subarea 48.3, the Scientific Committee discussed the general situation. The Commission has been setting conservation measures for individual stocks over the last few years.

3.47 The view of the USSR Delegation was that this stock by stock approach was adequate to ensure conservation of the fish resources.

3.48 All other delegations present felt that an alternative option involving a closure of the fishery for a short period of at least one year, pending a new assessment, should be presented to the Commission for consideration. The status of all stocks in the area was either unknown due to the lack of data, uncertain due to wide differences in the results of different analyses or depleted and in need of protection. In the case of depleted stocks which had suffered recruitment failure, it was not clear that by-catches would be sufficiently small to ensure recovery. Accordingly, the efficiency of a stock by stock approach was currently low.

3.49 The Convener of WG-FSA was asked to draft a note outlining data and analyses and surveys which would be required to improve the knowledge of the stocks.

3.50 The benefits that might be expected from a short closure would be an increase in heavily depleted stocks and a build up of other stocks to higher levels of productivity.

Subarea 48.2 (South Orkney Islands), (Annex 6, paragraphs 128 to 135)

3.51 The Scientific Committee noted with concern that insufficient data were available for the WG-FSA to complete any assessments. Two stocks are currently exploited, *C. gunnari* and *N. gibberifrons*.

Management Advice

3.52 The management advice of the WG-FSA was that, 'due to the lack of data the Working Group was unable to recommend a TAC for either species. In case, however, the recruitment failure in *C. gunnari* is real, the stock should be protected until evidence to the contrary is available.' This was noted.

In the discussion on this advice, two views were presented. The one that in absence of assessments, some precautionary TAC should be considered. The other, that due to the sporadic nature of the occurrence of *C. gunnari* and *N. gibberifrons* in the area, no catch limit was required.

Subarea 48.1 (Antarctic Peninsula), (Annex 6, paragraphs 135 to 140)

3.53 The Scientific Committee made similar comments on the WG-FSA Report as in paragraph 3.51 for the South Orkney area.

Management Advice

3.54 Due to the lack of data the Working Group had been unable to recommend a TAC for either species. In the discussion on this advice, two views were presented. The one that in absence of assessments, some precautionary TAC should be considered. The other, that due to the sporadic nature of the occurrence of *C. gunnari* and *N. gibberifrons* in the area, no catch limit was required.

Statistical Area 58, (Annex 6, paragraphs 141 to 143)

Subarea 58.4, (Annex 6, paragraphs 144 to 146)

Division 58.4.4 (Ob and Lena Banks), (Annex 6, paragraphs 147 to 150)

3.55 The Scientific Committee endorsed the Report of the WG-FSA without comment on the above matters.

3.56 Dr Lubimova reported that attempts would be made to present historical data for the Ob and Lena Banks separately.

Subarea 58.5

Division 58.5.1 (Kerguelen Island), (Annex 6, paragraphs 151 to 180)

Champsocephalus gunnari in Division 58.5.1

3.57 The Scientific Committee noted that analysis by the WG-FSA had identified certain problems in the stratification of the joint USSR/France survey in 1988. These problems and their solutions are dealt with in paragraph 158 of the Working Group's Report.

Management Advice

3.58 The WG-FSA had reported, 'because the stock in the last decade has consisted of only one cohort every three years it should be managed with caution until further information can be collected which could determine whether high post-spawning or similar natural mortality might explain the exhaustion of the cohorts. It would be prudent to assume, on the basis of the CPUE data, that the current cohort in the fishery is of comparable strength to the preceding strong cohorts of 1979 and 1982. Thus, the biomass of the 1985 cohort during the1989 season could have been of the order of 23 to 45 thousand tonnes, and thus substantially affected by the catch of 23 thousand tonnes. A low level of fishing mortality should help to resolve the question whether high natural mortality is the cause of cohort exhaustion. If substantial survival proves possible in fish of the current age, it will have the desirable effect of increasing the number of year classes in the fishery and could lead to cohorts recruiting to the fishery more frequently than the current three year interval. Accordingly, the catch level in 1990 could be no higher than occurred on the preceding cohorts at age four, that is, in the range of 0 to 6 000 tonnes.'

The Scientific Committee noted that the final sentence was ambiguous. It was agreed that what was meant was that catches similar in size to recent catches from recent cohorts aged four, should not be exceeded in the next season.

Dissostichus eleginoides in Division 58.5.1 (Annex 6, paragraphs 160 to 166)

3.59 The Scientific Committee endorsed the WG-FSA Report without comment.

Management Advice

3.60 *D. eleginoides* is a long-lived species with probable low productivity albeit high fecundity (see paragraph 3.42). An assessment of the stock is urgently required to estimate the level of catch to stabilise the stock. Adding the cumulative catch to the survey estimate gives a rough estimate for the unexploited biomass of 38 000 tonnes. Applying the Gulland rule to this estimate gives a TAC of 1 100 tonnes.

Notothenia rossii in Division 58.5.1, (Annex 6, paragraphs 167 to 170)

3.61 The Scientific Committee endorsed the WG-FSA Report without comment.

Management Advice

3.62 Conservation Measures (no directed fishery) will be continued into the beginning of the 1990's for the adult stock. Trends in the abundance of juvenile part of the stock need to continue to be monitored. Biomass surveys will be required to establish that the stock has made a substantial recovery prior to any resumption of exploitation.

Nototthenia squamifrons in Division 58.5.1
(Annex 6, paragraphs 171 to 180)

3.63 The Scientific Committee endorsed the WG-FSA Report without comment.

Management Advice

3.64 A lack of information on recruitment patterns makes it difficult to provide objective predictions of future trends in the stock. However, given observed exploitation trends and the present status of the stock, protection of the *N. squamifrons* stock in Division 58.5.1 will be facilitated by closure of the directed fishery for this species. Similarly, recovery of this already depleted stock will be facilitated. Since only about 15% of the current total stock biomass is comprised of adults and that fishing on other species in this area will continue, the setting of acceptable by-catch levels appears necessary. As the current quota levels authorised by France in that area have not been attained, it is recommended that future by-catch levels should be substantially lower than current level.

Division 58.5.2 (Heard Island), (Annex 6, paragraphs 181 to 182)

3.65 The WG-FSA Report was endorsed subject to a note that there had been no commercial fishery at any time in this area.

General Advice to the Commission, (Annex 6, paragraphs 183 to 206)

3.66 The WG-FSA had provided answers to the Commission's questions outlined in CCAMLR-VII, paragraphs 114 to 116.

3.67 The Scientific Committee endorsed the advice given to the Commission with two exceptions:

- with reference to paragraph 193, Mr E. Balguerias (EEC) indicated that protection of *C. gunnari* at age 1 and 2 was assured using a semipelagic trawl. This was based on results of a comparison of catches made by Spanish and US/Polish surveys in 1986/87; and

- with reference to paragraph 204, Dr Lubimova pointed out that measures to minimise and assess the level of larval or young fish caught during krill fishing were in place for the last four years.

Data Requirements	Annex 6, paragraphs 207 to 212
Data Analysis	Annex 6, paragraphs 213 to 215
New Trends in Assessment Work	Annex 6, paragraphs 216 to 217
Organisation of Next Meeting	Annex 6, paragraphs 218 to 220

3.68 These matters were endorsed by the Scientific Committee without comment.

Other Business

3.69 It was agreed by the Scientific Committee that provision should be made in the budget for a visit by the Data Manager to consult with the Chairman of the Scientific Committee and the Convener of WG-FSA.

SQUID RESOURCES

Review of Activities Related to Squid Resources

4.1 Dr Beddington reported to the Scientific Committee that during February 1989, exploratory fishing was carried out by two Japanese registered commercial squid jigging vessels (with UK scientists on board). They fished within Statistical Area 48.

4.2 Catches of commercial quantities were obtained within Subarea 48.3, some 185 n miles west of Shag Rocks. A total of 8.23 tonnes of the Ommastrephid squid, *Martialia hyadesi* was caught (SC-CAMLR-VIII/BG/25). Fine-scale catch and effort data were reported to the Secretariat by the UK.

4.3 Dr Beddington also indicated that he had received information on the operation of a Taiwanese squid jigging vessel which had made catches within the Convention Area during the past year.

4.4 In discussing the above developments, the Scientific Committee agreed that there was not much likelihood that squid fishing in the Convention Area would expand in the near future. There were a number of reasons for this, but in brief, these could be mainly attributed to the limited and relatively uncompetitive market potential of *M. hyadesi*. Dr Lubimova felt that the resource was not available in sufficient quantities or with adequate predictability to be of future importance as a commercial resource. Dr Shimadzu said that it was unlikely the Japanese vessels would fish for squid in the near future.

4.5 Despite the reservations expressed in paragraph 4.4, however, the Scientific Committee was of the opinion that given the ecological importance of squid in general (particularly to certain predators found in Statistical Area 48), there would be considerable merit ensuring that fine-scale catch and effort data on future squid fishing operations (as provided by the UK) are reported to the Commission.

Advice to the Commission

4.6 The Scientific Committee drew the Commission's attention to catches of squid taken during 1988/89 in the Convention Area by a non-Member nation. It was suggested that the institution of some mechanism to obtain data of this kind from non-Member nations should be investigated.

4.7 The Scientific Committee recommended that fine-scale catch and effort data from squid fishing operations in the Convention Area should be submitted to the Commission. It was also suggested that the Secretariat should, in consultation with Members most experienced in the analysis of data and the mechanics of squid jigging operations, develop a reporting system for presenting squid jigging catch and effort statistics.

ECOSYSTEM MONITORING AND MANAGEMENT

5.1 Dr K. Kerry (Australia), Convener, presented his report (SC-CAMLR-VIII/11) and the Report of the Third Meeting of the Working Group for the CCAMLR Ecosystem Monitoring Program (CEMP), held at Mar del Plata, Argentina, 23 to 30 August 1989 (Annex 7). Tables 3, 7 and 8 in this Annex provide a detailed summary of Members' CEMP activities and related research.

5.2 The Scientific Committee noted that the Working Group had made excellent progress in responding to the extensive program of work developed at last year's meeting of the Scientific Committee (SC-CAMLR-VII, paragraphs 5.28 to 5.44). The Scientific Committee reviewed the WG-CEMP report, noting the current state of progress and the implications and requirements for future work.

Approved Predator Monitoring Parameters

Sites and Species

5.3 WG-CEMP had reviewed and revised sites and species in the light of comments from Members and specialist groups. The new list of these is at Annex 7, paragraph 7 to 19, Tables 1 and 2. Subsequently, it had been established (after actions specified in Annex 7, paragraph 16) that monitoring black-browed albatrosses at Kerguelen was inappropriate.

5.4 The Scientific Committee approved these changes and confirmed that the revised listings of species and sites are desirable and appropriate for CEMP monitoring activities in Integrated Study Regions and complementary network areas.

5.5 The Scientific Committee noted and supported the strong recommendation of the WG-CEMP (Annex 7, paragraphs 20 and 21) for registration and protection of the land-based sites at which CCAMLR's long-term predator monitoring work is being carried out (see paragraph 5.43).

Methods

5.6 The contents of the CCAMLR Booklet 'Standard Methods for Monitoring Parameters of Predator Species' were reviewed in detail (Annex 7, paragraphs 23 to 56) in the light of:

(a) Members' experiences of using them in the field; and

(b) sensitivity analyses conducted in accordance with the advice given in SC-CAMLR-VII, paragraphs 5.26 (a) and (b) and further elaborated by the Secretariat (WG-CEMP-89/13).

5.7 The Scientific Committee approved the recommendation of the WG-CEMP that investigators attempt sampling at their sites, designed to detect at least a 10% change in the measured parameter at a 90% confidence level.

5.8 WG-CEMP established a subgroup to prepare a revision of the Standard Methods booklet taking into account the information mentioned under paragraph 5.6 and other comments from Members. Additional information on sexing penguins by numerical methods was prepared by Dr D. Vergani (Argentina) and submitted for consideration at the next meeting of WG-CEMP.

Data Collection

5.9 The subgroup had completed revision of this section of all existing standard methods sheets and had developed these for the black-browed albatross as requested in Annex 7, paragraph 30. This material will now be circulated to all Commission Members and relevant SCAR specialist groups by 1 December for final comments before being adopted at the WG-CEMP's next meeting as the new standard field methods.

Data Processing and Analysis

5.10 The revision of the methods of data collection, and discussions arising from the conduct of sensitivity analyses, necessitated preparation of instructions for processing and analysing data. The Secretariat, in consultation with appropriate specialists, was asked to prepare the sections on data processing and analysis for the revised Standard Methods booklet. These methods will be circulated to all Members in preparation for discussion at the intersessional meeting of the Working Group. To facilitate these discussions it was proposed that the CCAMLR Data Manager should attend this meeting.

Data Reporting

5.11 (a) Changes to the method of data collection, processing and analysis require modifications (some quite extensive) to the existing versions of the draft data reporting forms (SC-CAMLR-VII/BG/8). The Secretariat, in consultation with the Convener of WG-CEMP, is asked to revise these as soon as possible and circulate them to all Commission Members for review and comment (Annex 7, paragraph 114), so that reporting formats (including submission of data in computer compatible media) can be discussed and revised as needed and approved at the next meeting of WG-CEMP;

(b) Procedures for checking and logical validation of data need developing and the CCAMLR Data Manager should investigate these procedures as outlined in Annex 7, paragraphs 113 and 115 and prepare a proposal for consideration at the next meeting of WG-CEMP; and

(c) As soon as the data submission and access procedures are agreed (paragraphs 13.1 and 13.7) and the reporting forms are approved, the summarised data should be submitted, annually by 30 September, by all Members who have indicated that they are monitoring approved parameters using standard methods at approved sites. Retrospective submission of data should also be requested.

Parameter Evaluation

5.12 Further work is needed to permit a critical evaluation of the limitations of presently approved parameters (Annex 7, paragraph 55). Members were urged to prepare for this before the next meeting of WG-CEMP.

Directed Research on Predators

5.13 The Scientific Committee noted the considerable amount of research:

(a) investigating additional parameters which may have potential for monitoring (Annex 7, paragraph 64 to 66, Table 7); and

(b) collecting data providing essential background information for interpreting changes in monitored predator parameters (Annex 7, paragraphs 68 and 69, Table 8).

Environmental Data for Predator Monitoring

5.14 The main environmental features that have a direct influence on predators and which need to be recorded at land-based monitoring sites were reviewed (Annex 7, paragraphs 61 and 62, Table 6). The Secretariat, in consultation with the Convener of WG-CEMP, is requested to prepare and circulate before the next meeting of WG-CEMP, draft standard instructions for recording these parameters.

5.15 Environmental features that influence predators indirectly through their effects on distribution and abundance of prey were considered in relation to the requirements of prey monitoring (see paragraph 5.20).

Prey Monitoring

5.16 In reviewing prey monitoring the WG-CEMP had in mind the comments of the Scientific Committee last year (SC-CAMLR-VII, paragraph 5.40) regarding the high priority accorded this item and had available the reports from the WG-Krill and the WS-KCPUE meetings and an analysis of the fine-scale catch data of krill (WG-CEMP-89/9).

Survey Design

5.17 WG-CEMP noted the inability of WG-Krill to start providing specifications for prey monitoring surveys as they relate to interpreting predator parameters being monitored. It remedied this by providing a detailed summary of the appropriate characteristics of predators both in general terms and for each of the Integrated Study Regions (Annex 7, paragraphs 58 to 60, Tables 4 and 5). It also noted the desirability of data on a slightly larger spatial scale and in advance of the critical time period (Annex 7, paragraph 87).

Survey Methods

5.18 WG-CEMP noted that although WG-Krill had identified acoustic and net sampling as the best methods currently available for estimating krill distribution and abundance, it had not yet been able to provide any standard method protocols.

5.19 Dr R. Holt (USA) took over as WG-CEMP coordinator of studies of net sampling efficiency and will liaise with the Convener of WG-Krill regarding studies of this topic.

Environmental Data for Prey Monitoring

5.20 WG-CEMP understood that the comprehensive list of environmental data requirements (SC-CAMLR-VI, Annex 4, Table 6) was being reviewed by WG-Krill.

General

5.21 In considering the whole topic of prey monitoring, the Scientific Committee noted that this issue was complex and felt that recent progress had been disappointing. It recommended, as a matter of high priority, that the WG-Krill, in consultation with WG-CEMP as necessary:

(a) develop appropriate designs for prey monitoring surveys for the Integrated Study Regions and their vicinities;

(b) prepare standard methods for the technical aspects of such prey surveys;

(c) review the relevant environmental data required in the context (i.e. in terms of the spatial and temporal scales involved) of CEMP's requirements for prey monitoring. The offer from the Delegation of the USA to investigate the availability of relevant satellite data and to report to the next meeting of the Scientific Committee on its relevance to CEMP and methods of accessing, processing and analysing it, was gratefully accepted; and

(d) develop operational plans for collaborative and cooperative integrated surveys, with particular emphasis on the Integrated Study Regions.

5.22 In undertaking these tasks, the Scientific Committee drew the attention of WG-Krill to the following documents made available at the present meeting: SC-CAMLR-VIII/BG/4, 5, 8, 9, 10, 28, 29, 30, 31 32 and 49.

5.23 The Scientific Committee emphasised the importance of integrating research undertaken on predators, prey and environmental features. In particular, it was recognised that cooperative research among nations linking investigations of krill, its predators and the environment would be valuable. Fostering close contact between the WG-Krill and WG-CEMP represents one of the effective means of achieving this goal.

Implications of Fine-Scale Analysis of Krill Data

5.24 WG-CEMP noted that analysis of the fine-scale data for Subareas 48.1, 48.2 and 48.3 is important in assessing the status of krill in the Integrated Study Regions and adjacent areas. This analysis has also provided the first unequivocal indication that a substantial proportion of recent krill harvesting had regularly occurred within the foraging ranges of breeding predators being monitored by CCAMLR, particularly so within the Antarctic Peninsula and South Georgia Integrated Study Regions (Annex 7, paragraphs 83, 84 and 90).

5.25 Recognising the importance to the CEMP of fine-scale krill catch data, the Scientific Committee reiterated its recommendation that the requirements for reporting fine-scale data of krill catches should be altered to include the entire Subareas 48.1, 48.2 and 48.3 (see paragraphs 2.42 and 2.47).

5.26 In preparation for the studies foreshadowed above in paragraph 5.21, WG-CEMP:

(a) recommended continued collection of data on a haul-by-haul basis; and

(b) asked Members to synthesise data on predator population size, diet and energy budgets in order to provide estimates of krill requirements of predators in Integrated Study Regions, at least during their breeding seasons (Annex 7, paragraphs 91 and 92).

5.27 The Scientific Committee endorsed these recommendations. However, it noted that estimating energy requirements (and thereby krill consumption) of predators needs careful evaluation of the appropriate parameter values to be used in many parts of the necessary models. Previous attempts to produce similar, but more general, models (e.g. for South Georgia in SC-CAMLR-VIII/BG/12 and 15) provide a useful starting point. The extensive recent data on activity-specific energy budgets (e.g. SC-CAMLR-VIII/BG/13 and 14) and foraging patterns and ranges of seals and penguins (WG-CEMP-89/22) will, however, need critical evaluation to provide for standardisation (e.g. between Integrated Study Regions and between species within regions).

5.28 The Scientific Committee requested that the Convener of WG-CEMP discuss with Members and other appropriate specialists and specialist groups how best to proceed towards this important goal. Specific proposals should be made to the next meeting of WG-CEMP.

General

Relevance of CEMP to CCAMLR Management Strategies

5.29 WG-CEMP had responded briefly to requests from:

(a) the Scientific Committee on how information from CEMP might be used in the management of fisheries in the Convention Area (SC-CAMLR-VII, paragraph 5.44); and

(b) WG-DAC via the Scientific Committee on the ability of the CEMP to detect changes in ecological relationships and to recognise the effects of simple dependencies between species, including distinguishing between natural fluctuations and those induced by fisheries (CAMLR-VII, paragraph 141).

5.30 WG-CEMP noted that:

(a) its work in defining the accuracy and precision of the predator parameter estimates provided essential first steps to answering these questions;

(b) it is actively considering various key questions about relationships between predator indices and prey abundance/availability. However, all of these, and especially the last part of the question from WG-DAC, are complex issues which require considerable further study;

(c) some Members had already produced papers addressing these strategic issues. Further discussion would take place at the next meeting of WG-CEMP; and

(d) predator indices as derived from the CEMP are not expected to provide a useful index of total prey stock abundance, but would provide a useful index of the level of prey availability to predators (Annex 7, paragraph 103).

5.31 The Scientific Committee agreed to discuss these responses under agenda item 7.

Analysis of Interdependencies between Monitoring Predators and Prey

5.32 Last year the Scientific Committee recommended that WG-CEMP investigate various aspects of this issue (SC-CAMLR-VII, paragraphs 5.22 and 5.23). Members had not responded to the request for explicit suggestions and information (SC-CAMLR-VII, paragraph 5.43). The WG-CEMP believed that this was because of difficulties in doing so until there was a clearer understanding of the type of data to be collected in monitoring operations.

5.33 The Scientific Committee endorsed the WG-CEMP request that Members should respond to the original questions so that these issues can be considered at the next meeting of WG-CEMP.

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

5.34 This Workshop is intended to permit a functional evaluation of the minke whale as a potential indicator of changes likely to result from harvesting of krill.

5.35 The Workshop was due to be held in San Diego, USA in September 1989. The Report (SC-CAMLR-VIII/8) of the CCAMLR Co-Conveners (Dr J. Bengtson, USA and Mr D. Miller, South Africa) shows that IWC asked to postpone the meeting until 1991, on advice from its Convener (Dr J. Harwood, UK), because of prior and higher-priority commitments of potential IWC Workshop contributors to the IWC Comprehensive Assessment (scheduled to be completed in 1990).

5.36 The Scientific Committee reaffirmed its commitment to this Workshop and asked the Co-Conveners to request Dr Harwood to let CCAMLR know when the analyses requested from IWC contributors are sufficiently advanced to let the Workshop be re-scheduled.

Awareness of the CEMP

5.37 WG-CEMP commended the Secretariat for producing a review of the origins, aims and development of the CEMP. It had been suggested that this might usefully be distributed outside CCAMLR to promote awareness of the CEMP in other countries (Annex 7, paragraphs 124 and 125).

5.38 The Scientific Committee agreed that the review of the CEMP (SC-CAMLR-VIII/BG/51) was useful and that the Secretariat should update it before each meeting of WG-CEMP. It was felt inappropriate to distribute to an external audience, a document primarily intended for internal use. Instead, the Secretariat was asked to prepare, for wide dissemination, a brief article on the CEMP Program and to circulate a draft of this for comments before the next meeting of WG-CEMP.

Next Meeting

5.39 WG-CEMP had emphasised the need to maintain strong links with WG-Krill, especially to ensure that the needs of the CEMP program for prey monitoring were being met.

5.40 It was noted that there were a number of substantive issues requiring discussion and action as soon as possible in order to move ahead with the work of the WG-CEMP. There was widespread approval in Scientific Committee for a meeting of WG-CEMP in 1990 and unanimous support that it should meet in conjunction with WG-Krill, ideally at the same location.

5.41 The Scientific Committee gratefully accepted the invitation extended by the Delegation of the Soviet Union to host a 1990 intersessional meeting of WG-CEMP scheduled to be held adjacent to the meeting of WG-Krill.

5.42 The Delegation of the United Kingdom felt that if a joint meeting was not possible, a separate meeting of WG-CEMP at a different time and place (which would then principally involve predator-related matters), could not be justified on the basis of the agreed priority tasks in hand (SC-CAMLR-VIII/11, paragraph 35). In these circumstances they would prefer to see the next WG-CEMP meeting postponed until 1991 (and held then in conjunction with WG-Krill). In the meantime the single really urgent matter (revision of the Standard Methods booklet), would be dealt with by correspondence in the Scientific Committee intersessional period.

Convener

5.43 Dr Kerry had informed WG-CEMP that he wished to retire as Convener. The Scientific Committee thanked him for his role in guiding CEMP through its first six years, during which great progress had been made. Dr J. Bengtson (USA) was proposed and unanimously supported as the new Convener.

Advice to the Commission

5.44 The Scientific Committee advised the Commission of the urgent need to accord some form of protection to CEMP land-based sites. It drew the Commission's attention to the reasons set out in Annex 7, paragraphs 20 and 21.

5.45 The Scientific Committee drew the attention of the Commission to the recommendation (paragraph 5.11 (a)) that, once data submission protocols are agreed, Members monitoring approved parameters of selected species at nominated sites using approved standard methods should submit these data to the Secretariat annually by 30 September. Where retrospective data, conforming to the same criteria, exist, these should also be submitted as soon as possible.

5.46 The Scientific Committee recommended that WG-CEMP should meet in 1990 in association with the meeting of WG-Krill.

MARINE MAMMAL AND BIRD POPULATIONS

6.1 At the Seventh Meeting of the Scientific Committee, a summary of information on the status and trends of marine mammal and bird populations was reviewed (SC-CAMLR-VII/9). This summary had been prepared with the assistance of the SCAR Sub-Committee on Bird Biology, the SCAR Group of Specialists on Seals, and the Scientific Committee of the International Whaling Commission.

6.2 During the intersessional period, the Executive Secretary asked the Conveners of the SCAR Group of Specialists on Seals and the SCAR Sub-Committee on Bird Biology if they would be prepared to continue to assemble and update data pertaining to the status and trends in Antarctic seal and bird populations. The Chairman of the Bird Biology Sub-Committee responded that a review of bird populations will be initiated at its next meeting (to be held in 1990), concluded at its 1992 meeting, and the results made available prior to the 1992 Meeting of the CCAMLR Scientific Committee. The Secretary of the Seals Group indicated that a review of seal populations would be undertaken on a schedule similar to the one outlined above.

6.3 Dr Kerry drew the attention of the Scientific Committee to the Report of the CCAMLR Observer to the latest meeting of the International Whaling Commission's Scientific Committee (SC-CAMLR-VIII/10). This document lists recent estimates of whale populations based on data from IDCR/IWC sightings cruises.

6.4 The Scientific Committee agreed that a comprehensive review of Antarctic seal and bird populations should be undertaken every five years, which is consistent with the timetable indicated by the SCAR groups.

6.5 It was noted that scheduling a comprehensive review of marine mammal and bird populations every five years does not preclude raising issues pertaining to the status of these populations at any time when discussion of such topics seem warranted.

6.6 E. Marschoff, noting the decline in southern elephant seal (*Mirounga leonina*) populations in some sectors of the Antarctic, suggested that the SCAR Group of Specialists on Seals and the SCAR Sub-Committee on Bird Biology should be asked to provide advice to the Scientific Committee when significant population declines are identified. The Scientific Committee agreed to seek such advice, specifically requesting guidance concerning:

(a) the likely or possible causes of particular marine mammal and bird population declines; and

(b) steps that might be taken to halt these declines.

6.7 Dr Croxall noted that new information pertaining to the declining populations of wandering albatross (*Diomedea exulans*) has recently become available (CCAMLR-VIII/BG/6). There is now considerable evidence that this population decline is due principally to incidental mortality by injury or entrapment from active gear in longline fisheries on tuna outside the Convention Area.

6.8 The Chairman had been asked by the Commission to correspond with the Conveners of the SCAR Group of Specialists on Seals and the SCAR Sub-Committee on Bird Biology concerning incidental mortality, ingestion of plastics, and entanglement in marine debris. The Sub-Committee on Bird Biology noted that the incidence of plastic ingestion by seabirds within the Convention Area is geographically widespread and includes a high proportion of species as well as a high proportion of individuals within certain populations. The Sub-Committee also made specific suggestions for appropriate research and monitoring. The reply from the Seals Group suggested standardising a sampling scheme at breeding colonies to monitor the incidence of entanglement of pinnipeds in marine debris. The Seals Group also indicated the need for CCAMLR to acquire more detailed information on seal entanglement at sea in order to assess the magnitude of this problem.

6.9 The Scientific Committee noted that although issues pertaining to the assessment and avoidance of incidental mortality are currently being addressed in the Commission, it would be desirable and appropriate for the Scientific Committee to consider these topics and provide advice to the Commission on recommended actions. The Scientific Committee agreed that in the future, it would consider these issues either as part of discussions on marine mammal and bird populations or under a separate agenda item.

DEVELOPMENT OF APPROACHES TO CONSERVATION OF ANTARTIC MARINE LIVING RESOURCES

7.1 During the last meeting of the Commission, advice was sought from the Scientific Committee (CCAMLR-VII, paragraphs 140 and141) on:

> 'operational definitions for depletion and target levels for recovery of depleted species', and
>
> 'the ability of the CCAMLR Ecosystem Monitoring Program to detect changes in ecological relationships and to recognise the effects of simple dependencies between species including distinguishing between natural fluctuations and those induced by fisheries'.

7.2 Following correspondence between the Chairman of the Scientific Committee and the Commission's Working Group for the Development of Approaches to Conservation of Antarctic Marine Living Resources (WG-DAC) during the intersessional period, these matters were referred to the specialist working groups of the Scientific Committee; the Working Group on Krill (WG-Krill), Working Group on Fish Stock Assessment (WG-FSA), Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP), and to the Workshop on the Krill CPUE Simulation Study (WS-KCPUE) for comments which might be taken into account by the Scientific Committee in providing advice to the Commission.

7.3 All working groups had considered the Commission's questions, but none had been able to devote sufficient time to consider them in depth. The responses were recorded in the groups' reports, and relevant excerpts were compiled by the Secretariat for the consideration of the Scientific Committee (SC-CAMLR/BG/56).

7.4 The Krill CPUE Simulation Study Workshop noted that the ability to detect changes in krill abundance from CPUE data is limited (see paragraphs 2.16 and 2.19). It further noted that the implications of this for a conservation strategy were a matter for the WG-Krill in the first instance.

7.5 The WG-Krill agreed that at this stage it had no contribution to make to the preparation of the advice to the Scientific Committee on the Commission's questions, but that at some stage it may be able to assist WG-CEMP in the provision of its advice on krill parameters.

7.6 In this context, the Scientific Committee also considered SC-CAMLR-VIII/BG/17. On introducing the paper, Mr Miller indicated that in his view, the approach outlined, although focussing on krill (see also paragraph 2.30), had some applicability in the broader context of development of an operational management procedure for marine living resources in the Convention Area. The approach is one already being used by other international fishery organisations (IWC, ICSEAF and ICES) and its development is based on four active principles. These are that there should be:

(a) a basis for assessment of the status of a resource in the region under consideration (an 'estimator');

(b) an algorithm for specifying appropriate levels of regulatory activities (a 'catch control law') which is a function of the assessment;

(c) a basis for assessing the performance of the management procedure (related to the two components above); and

(d) an operational definition of Article II of the Convention to provide criteria against which performance can be assessed.

The management procedure being suggested thus consists of a combination of a 'control law' and an 'estimator' ((a) and (b) above).

7.7 The overall approach espoused in the paper was not claimed to be the only one available and both the Soviet and Japanese Delegations expressed some reservations about some of the assumptions underlying its formulation with respect to the krill fishery.

7.8 Dr Shimadzu was of the opinion that an alternative or more direct approach should be given priority over the development of simulation models. Such an approach would estimate krill biomass in areas being fished, the advection of krill in and out of fishing areas, rates of exploitation of krill and the amount of krill taken by predators within fishing areas. The last point in particular would be important for the evaluation of the potential impact of krill fishing activities on local predators.

7.9 Mr Miller made the point (as is made in SC-CAMLR-VIII/BG/17) that it is inadequate to offer reservations alone. What must also be provided is alternative, and presumably better, assumptions, or indications of the extent to which the original assumptions may be in error. It is precisely such information which is relevant to testing any management procedure that may be suggested; not just the one detailed in the paper.

7.10 The Scientific Committee welcomed this initiative, and Dr Lubimova in particular emphasised the seriousness of the matters being addressed, and the need for in-depth consideration of them. The Scientific Committee therefore agreed that approaches to management of the krill fishery such as that discussed in SC-CAMLR-VIII/BG/17 should be referred to the WG-Krill for detailed consideration.

7.11 The WG-FSA noted that a useful working definition of the stock level where recruitment may be impaired would be the lowest spawning stock biomass estimated for the stock. Hence if the current spawning stock was the lowest observed, the aim of management should be to ensure that future stock levels do not drop below this level. It was noted in SC-CAMLR-VIII/BG/47 that, taking into account the average spawning stock size over a number of years, the corresponding coefficients of variation and the number of years when the spawning stock size was low, a certain level was introduced as a measure of spawning stock stability. The WG-FSA further noted that there were a number of significant uncertainties associated with the assessment of all stocks considered.

7.12 The WG-CEMP noted the progress made in the definition of the accuracy and precision of estimates of predator parameters being monitored. They were investigating the possibility of distinguishing between changes in food availability that result from commercial harvesting and changes due to natural fluctuations in the biological and physical environment. Because of the complexity of this topic and the possible need for modelling studies, they noted that advice could not be provided at present and that further work and discussion will be needed.

7.13 Dr Croxall introduced SC-CAMLR-VIII/9, which reviewed the feasibility of using indices of predator status and performance (i.e. the predator parameters being monitored by the CEMP) as part of CCAMLR fishery management strategies.

7.14 The paper suggested that it was relatively straightforward and highly desirable to devise a system for annually assessing the overall pattern of changes in indices at the levels of parameter, species, site and area. Management recommendations would arise from considering the patterns of change in predator indices in the light of available relevant biological and physical environmental data. Such recommendations would only be likely where there is evidence of significant broad-scale general effect, or of acute effects at more local levels. This would apply, however, even when there was no evidence that harvesting is, or has been, a contributing factor. The logic for this is that if predator populations may be in trouble, any level of harvesting if conducted at critical times and places may have significant adverse effects. Examples of possible management action, involving restrictions on krill catch size, timing and location were compared from the perspectives of ease of implementation, consequences for the fishery and the probability of aiding predators.

7.15 Dr Lubimova expressed reservations about paragraph 7.14 and noted that they contained a number of speculative ideas based on an approach to the problem solely from the perspective of predators. In spite of the fact that the document was distributed to the Members in all the agreed languages of the Commission, these ideas have not been discussed in any real detail at this meeting.

7.16 There was general agreement that such approaches as outlined in SC-CAMLR-VIII/9 and the comments contained in paragraph 7.15 merited further investigation and development and WG-CEMP was encouraged to discuss this whole topic at its next meeting.

7.17 From these considerations, two broad areas of the work of the Scientific Committee were identified as contributing to the development of approaches to conservation:

(a) actual work at assessment level in key areas involving coordination and integration of studies which would enable definition of appropriate management options. An example would be investigation of the krill flux in the South Shetlands/Peninsula area combined with determination of the impact of predators on stocks, leading to drawing up a budget of predator prey interactions; and

(b) the wider task of evaluating the effectiveness of approaches to management adopted by the Commission in the light of the objectives of the Convention. It was suggested that the fundamental problem is how to deal with the uncertainty of the assessments that can be made.

7.18 The Scientific Committee agreed that it was important for more time and effort to be devoted to both of these areas of work. It was therefore agreed that, in addition to the consideration of the matters referred to in paragraphs 7.14 and 7.15 above, the specialist working groups should reconsider the Commission's questions and the wider issue of development of appropriate approaches to conservation in the light of the Scientific Committee's consideration of the issue. It was recognised that there had been relevant work done by Members, particularly in the context of the Commission's WG-DAC, which would assist in this consideration.

7.19 It was recognised that the data requirements for different conservation approaches may be vastly different and the cost of pursuing inappropriate approaches could be high. It was therefore agreed that the Commission should be asked for more specific guidance on the strategic issues it would like the Scientific Committee to consider and provide advice on.

COOPERATION WITH OTHER ORGANISATIONS

8.1 The CCAMLR Scientific Committee was represented at the following meetings during the intersessional period:

77th Statutory Meeting of ICES, Dr O. Østvedt (SC-CAMLR-VIII/BG/55)

1989 Annual Meeting of the IWC Scientific Committee, Dr W de la Mare (SC-CAMLR-VIII/10)

Meeting of the BIOMASS Executive, Prof. J.-C. Hureau

EPOS-related meetings, Prof. J.-C. Hureau

8.2 The observers to ICES and IWC Scientific Committee presented their reports to the Scientific Committee. As Prof. Hureau was not present, Dr Kock reported on EPOS related meetings, and Dr Croxall reported on the meeting of the BIOMASS Executive. Dr Croxall also reported that the SCAR Workshop in Norway on 'Ecology of the Antarctic Sea Ice

Zone', which Prof. Hureau was to have attended as SC-CAMLR observer, had been postponed until 17 to 24 May 1990.

8.3 In presenting his report on the ICES meeting, Dr Østvedt noted that the Secretariat held abstracts of papers presented at the ICES meeting, and mentioned that the work of a number of ICES working groups was relevant to the work of the Scientific Committee, particularly in relation to collection of environmental monitoring data and stock assessment techniques. The work of working groups dealing with the application of hydroacoustic methods to zooplankton and mesh selectivity was also mentioned.

8.4 In presenting his report on the IWC Scientific Committee meeting, Dr de la Mare discussed the progress being made in the evaluation of assessment methodology and alternative management procedures. He also reported on the latest population estimates of the large whales of the Southern Ocean, noting that even allowing that there are high coefficients of variation for the estimates, the numbers are low, but the estimates in some cases require adjustment for incomplete survey coverage and that further revisions could be expected.

8.5 The Scientific Committee was informed that SCAR had published 'The Biology and Ecology of Antarctic Krill - A Review', (D. Miller and I. Hampton), BIOMASS Scientific Series No. 9, 1989, with financial support from CCAMLR. The Chairman noted that copies of the publication had been sent to the Secretariat.

8.6 Dr Croxall noted that the BIOMASS Executive had decided that the colloquium for final evaluation of the BIOMASS program is now to be held from 18 to 21 September 1991 back to back with the SCAR Antarctic Science Conference in Federal Republic of Germany. Before the colloquium, a suite of workshops finalising evaluation of SIBEX data will be held. Once details of these are available, they will be provided to the Secretariat. The Executive also discussed the future of the BIOMASS Data Centre. The centre will remain at the British Antarctic Survey, Cambridge until 1994. If funding for its maintenance is not available after that date, the Executive recommended that it be transferred to the CCAMLR.

8.7 Dr Kock noted that there will be a meeting in early December in Texel, Netherlands to discuss the results of the first two EPOS cruise legs, and a Workshop on fish research conducted as part of EPOS tentatively scheduled for 1990.

8.8 The Observer from SCAR (Dr Kerry) noted that SCAR XXI will be held in Sao Paulo, Brazil, from 15 to 27 July 1990, and that the Sub-Committee on Bird Biology and the Group of Specialists on Seals are both to meet then.

8.9 The Observer from IOC (Dr P. Rothlisberg) submitted a paper (SC-CAMLR-VIII/BG/57) on IOC activities in the Southern Ocean. The paper had earlier been submitted to the Fifteenth Antarctic Treaty Consultative Meeting. He also mentioned IOC activities of relevance to CCAMLR which were not detailed in the paper, including the OSLR (Ocean Science in Relation to Living Resources) Program.

8.10 The proposal from the United Nations Environment Program (UNEP) that CCAMLR sign a Memorandum of Understanding on the Global Plan of Action for Conservation, Management and Utilisation of Marine Mammals was discussed. The proposal, to be discussed in the Commission, is detailed in CCAMLR-VIII/8, and the objectives of the Global Plan are summarised in CCAMLR-VIII/BG/13.

8.11 The Scientific Committee agreed that the appropriate response to the proposal would be for the Executive Secretary to convey to UNEP that the provisions of CCAMLR, the Convention for the Conservation of Antarctic Seals (CCAS) and other elements of the Antarctic Treaty System adequately address the relevant parts of the Global Plan as it applies to the Antarctic and that CCAMLR would be happy to provide UNEP with reports of its work which might be of relevance.

8.12 After consideration of the reports of observers, it was agreed that the Scientific Committee would be represented at future meetings as indicated below:

78th Statutory Meeting of ICES, 1 to 12 October, Copenhagen, Denmark
- Dr O. Østvedt

1990 Annual Meeting of the IWC Scientific Committee, 10 to 23 June 1990, Noordwilkerhout, Netherlands
- Dr W. de la Mare

SCAR Workshop on 'Ecology of the Antarctic Sea Ice Zone', 17 to 24 May 1990, Norway
- Prof. J.-C. Hureau, or if he is unable to assume this role, Dr J. Croxall

XXIth Meeting of SCAR, Sao Paulo, Brazil
- Dr J. Croxall

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

Activities in the Intersessional Period

9.1 In previous years the Chairman of the Scientific Committee, in consultation with the Conveners of the Working Groups, had drafted plans of intersessional activities with the aim of assisting the Secretariat in organising its work. Last year it was decided that such a plan would also be of assistance to all Members in preparation for the annual meetings of the Scientific Committee and its subsidiary bodies (SC-CAMLR VII, paragraphs 8.1 and 8.2) Accordingly a schedule of activities was prepared and distributed shortly after the meeting.

9.2 The Scientific Committee agreed that the plan had been useful and the practice should be repeated.

Coordination of Field Activities for the 1989/90 and 1990/91 Field Seasons

9.3 The Scientific Committee last year requested the Secretariat to maintain, annually update and distribute a summary of national research plans (SC-CAMLR-VII, paragraph 8.8). The summary is to be used by Members and the Scientific Committee for the coordination of national research programs in support of CCAMLR. The specific aspects of coordination of field research will be handled by the Scientific Committee's specialist working groups.

9.4 Following the Scientific Committee's decision, the Secretariat requested national CCAMLR representatives for information on planned research in the 1989/90, 1990/91 and 1991/92 seasons. A summary of research plans of Members for these seasons was later compiled by the Secretariat and distributed as SC-CAMLR-VIII/BG/3.

9.5 It was emphasised that these are not statements that activities are definitely to take place, but indications of activities that it is hoped will take place, and which may present opportunities for collaboration.

9.6 It was pointed out that the request for this information was sent out shortly after that for Reports of Members' Activities and that the two involved similar, but not identical information which complicated the task of its compilation for some Members. It was also pointed out that SC-CAMLR-VIII/BG/3 had only become available very late in the meeting and still did not include information on some Members' plans, limiting its usefulness in facilitating coordination of research.

9.7 It was agreed that the Secretariat should be asked to look at the range of information requested of Members and presented to the Commission and Scientific Committee, not with a view to a change in the information required, but to review the means and timing of requests for the information, the format in which it is presented, and the time it is presented to the Scientific Committee.

9.8 Last year Dr I. Barrett (USA) informed the Scientific Committee of a special methodology used in the Southwest Fisheries Centre (La Jolla) for elaboration of a strategic framework on long-term research plans (SC-CAMLR VII, paragraph 8.11).

9.9 Dr Barrett reported to the Scientific Committee that he had submitted additional documentation on the method to the Secretariat, as he had undertaken, and had introduced it to participants in the meeting of the WG-Krill, held at the Centre during 1989. This is reported in SC-CAMLR-VIII/4, paragraphs 97 and 98. He also referred to a paper on strategic planning for the US Antarctic Marine Living Resources Program (SC-CAMLR-VIII/BG/50) which briefly describes an application of the process. Participants included some Members of the CCAMLR Scientific Committee.

BUDGET FOR 1990 AND FORECAST BUDGET FOR 1991

10.1 The Scientific Committee developed a proposal for the 1990 Budget and the Forecast Budget for 1991 in accordance with the recommendations made for activities during the forthcoming intersessional period. The proposed Budgets for 1990 and 1991 as approved by the Commission are given in Annex 8.

ELECTION OF VICE-CHAIRMEN OF THE SCIENTIFIC COMMITTEE

11.1 E. Marschoff (Argentina) nominated Dr T. Lubimova (USSR) and Dr Y. Shimadzu (Japan) nominated Dr G. Duhamel (France) as Vice-Chairmen of the Scientific Committee. In making the nominations, E. Marschoff and Dr Shimadzu referred to the considerable experience of Dr Lubimova and Dr Duhamel in Antarctic marine research, their active participation in, and valuable contributions to the work of the Scientific Committee, and their existing record of collaboration.

11.2 Dr Lubimova and Dr Duhamel were unanimously elected as Vice-Chairmen of the Scientific Committee for the period from the end of the Eighth Meeting until the end of the Scientific Committee meeting in 1991, in accordance with Rules 3 and 8 of the Rules of Procedure.

11.3 The Chairman congratulated the new Vice-Chairmen on their election. He also paid tribute to their predecessors, E. Marschoff and Dr Shimadzu, and thanked them for their continued support and valuable contributions to the work of the Scientific Committee during the past two years.

NEXT MEETING

12.1 In accordance with discussions held during the 1988 Meeting, hotel bookings have been made in Hobart for the Ninth Meeting of the Scientific Committee and Commission for the period 21 October to 2 November 1990.

12.2 It was noted that the WG-FSA meeting has been planned in association with the Ninth Meeting of the Scientific Committee, and is tentatively scheduled for the period from 9 to 18 October 1990.

12.3 The timing and venue of future meetings will be discussed by the Commission.

OTHER BUSINESS

Access to and Use of CCAMLR Data

13.1 The Scientific Committee discussed the purposes and circumstances under which data submitted to the CCAMLR Data Centre could be used. The status and appropriate use of documents tabled at meetings of the Commission, the Scientific Committee, or any of their subsidiary bodies were also discussed. In particular, the results of previous discussions within the WG-FSA (SC-CAMLR-VII, paragraph 3.3) and the WG-CEMP (SC-CAMLR-VIII/6, paragraphs 116 to 118) were considered.

13.2 The Scientific Committee stated its understanding (paragraphs 13.3 to 13.7) regarding the appropriate uses of CCAMLR data and papers. The Scientific Committee <u>recommended</u>

that the Commission should confirm whether or not the Scientific Committee's understanding is correct.

13.3 All data submitted to the CCAMLR Data Centre should be freely available to Members for analysis and preparation of papers for use within the CCAMLR Commission, Scientific Committee, and their subsidiary bodies.

13.4 The originators/owners of the data should retain control over any use of their unpublished data outside of CCAMLR.

13.5 When Members request access to data for the purpose of undertaking analyses or preparing papers to be considered by future meetings of CCAMLR bodies, the Secretariat should supply the data and inform the originators/owners of the data. When data are requested for other purposes, the Secretariat will, in response to a detailed request, supply the data only after permission has been given by the originators/owners of the data.

13.6 Data contained in papers prepared for meetings of the Commission, Scientific Committee, and their subsidiary bodies should not be cited or used in the preparation of papers to be published outside of CCAMLR without the permission of the originators/owners of the data. Furthermore, because inclusion of papers in the 'Selected Scientific Papers' series or any other of the Commission's or Scientific Committee's publications constitutes formal publication, written permission to publish papers prepared for meetings of the Commission, Scientific Committee and Working Groups should be obtained from the originators/owners of the data and authors of papers.

13.7 The following statement should be placed on the cover page of all unpublished working papers and background documents tabled:

> This paper is presented for consideration by CCAMLR and may contain unpublished data, analyses, and/or conclusions subject to change. Data contained in this paper should not be cited or used for purposes other than the work of the CCAMLR Commission, Scientific Committee, or their subsidiary bodies without the permission of the originators/owners of the data.

Environmental Data Collection

13.8 Dr Barrett noting Dr Lubimova's comments on the need for more cooperation, made a proposal to contribute to the collection of environmental data. This involved the development of a standardised grid of oceanographic stations throughout the CCAMLR Convention Statistical Areas and a suite of data collection methods which would initially be applied, as far as possible, by any vessel at a station. Dr Barrett offered to prepare a tentative station pattern and suite of methods for consideration by the Working Groups of the Scientific Committee.

13.9 The proposal received general support, although it was recognised that the establishment of such a program would be beyond the scope of existing working groups. It was also recognised that this program may overlap with some existing international programs such as the Joint Global Ocean Flux Study (JGOFS) and the International Geosphere Biosphere Program (IGBP) and others referred to in SC-CAMLR-VIII/BG/57.

13.10 It <u>was agreed</u> that the Scientific Committee would welcome an indication from Dr Barrett as to the development of the program, including the criteria for station selection, and information on the scope of other initiatives, to prevent overlap and duplication.

Scientific Committee Papers

13.11 Dr Shimadzu raised three points in relation to papers submitted to the Scientific Committee's meeting:

(a) some papers had been dealt with by working groups and need not be submitted to the Scientific Committee;

(b) some papers may not have been given the degree of consideration that might have been warranted; and

(c) many papers arrived after the deadlines for submission, precluding early distribution.

13.12 In relation to (a) it was agreed that a paper should not be re-submitted after consideration by a working group unless it had been revised in the light of that consideration, in which case this should be indicated by the author of the paper in the revised draft. It was also agreed that Members should target their papers correctly; to a working group, as a background paper to discussion or as a working paper.

13.13 As a general response to these problems, it was proposed that the Chairman review all background papers received by the deadline with a view to determining whether they were germane to the item proposed and had been correctly targeted. The results of this review, including considerations of which papers it was not appropriate to consider, should be discussed with Scientific Committee representatives at the meeting just prior to the commencement of the annual meeting. Those papers received after the deadline would not be submitted to the Scientific Committee or its Working Groups unless they were the result of requests from the Commission or Scientific Committee.

Application by ASOC for Observer Status

13.14 Late in the meeting the Chairman received a letter from Ms L. Goldsworthy (ASOC Observer to the Commission) which requested access to the Scientific Committee as an observer. It was recalled that the Commission had decided that the ASOC observer should only have access to the plenary sessions of the Commission (CCAMLR-VIII, paragraphs 153 to 156). Some Members supported ASOC's involvement in the Scientific Committee's work, but it was agreed that the decision on the issue should be made in the Commission.

Rules of Procedure

13.15 A proposal had been made for a change in Rule 8 of the Rules of Procedure to ensure that a Chairman of the Scientific Committee is not also a representative of or adviser to a Member. This paralleled a proposal made to the Commission. It was pointed out that changes to the Scientific Committee's Rules of Procedure must be endorsed by the Commission.

ADOPTION OF THE REPORT

14.1 The Report of the Eighth Meeting of the Scientific Committee was reviewed and <u>adopted</u>.

CLOSE OF THE MEETING

15.1 The Chairman thanked Members and other participants, in particular the Conveners of Working Groups and Rapporteurs, for their cooperation and support. He thanked the interpreters for their forebearance. He especially singled out the Secretariat, conveying his gratitude for their efforts in meeting the deadlines for the preparation of documents, their translation and all other aspects of support for the meeting. He commended the Executive Secretary for having drawn together such a competent and efficient team.

ANNEX 1

LIST OF MEETING PARTICIPANTS

LIST OF PARTICIPANTS

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ANNEX 2

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SC-CAMLR-VIII/3	REPORT OF THE WORKSHOP ON THE KRILL CPUE SIMULATION STUDY (Southwest Fisheries Centre, La Jolla, USA, 7-13 June 1989)
SC-CAMLR-VIII/3 Rev. 1	REPORT OF THE WORKSHOP ON THE KRILL CPUE SIMULATION STUDY (Southwest Fisheries Centre, La Jolla, USA, 7-13 June 1989)
SC-CAMLR-VIII/4	REPORT OF THE FIRST MEETING OF THE WORKING GROUP ON KRILL (Southwest Fisheries Centre, La Jolla, California, USA, 14-20 June 1989)
SC-CAMLR-VIII/4 Rev. 1	REPORT OF THE FIRST MEETING OF THE WORKING GROUP ON KRILL (Southwest Fisheries Centre, La Jolla, California, USA, 14-20 June 1989)
SC-CAMLR-VIII/5	CONVENER’S REPORT ON THE FIRST MEETING OF THE CCAMLR WORKING GROUP ON KRILL D.G.M. Miller, Convener
SC-CAMLR-VIII/6	REPORT OF THE WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM (Mar del Plata, Argentina, 23-30 August 1989)
SC-CAMLR-VIII/7	REPORT OF THE WORKING GROUP ON FISH STOCK ASSESSMENT (25 October to 2 November 1989, Hobart, Australia)
SC-CAMLR-VIII/7 ADDENDUM 1	REPORT OF THE WORKING GROUP ON FISH STOCK ASSESSMENT (25 October to 2 November 1989, Hobart, Australia)

SC-CAMLR-VIII/8	REPORT BY CCAMLR CO-CONVENERS ON THE STATUS OF CCAMLR/IWC WORKSHOP ON THE FEEDING OF SOUTHERN BALEEN WHALES D.G.M. Miller and J. Bengtson, CCAMLR Co-Conveners, Joint CCAMLR/IWC Workshop
SC-CAMLR-VIII/9	USE OF INDICES OF PREDATOR STATUS AND PERFORMANCE IN CCAMLR FISHERY MANAGEMENT STRATEGIES Delegation of United Kingdom
SC-CAMLR-VIII/10	REPORT OF THE CCAMLR OBSERVER TO THE SCIENTIFIC COMMITTEE OF THE INTERNATIONAL WHALING COMMISSION Observer (W.K. de la Mare, Australia)
SC-CAMLR-VIII/11	WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM, REPORT OF THE CONVENER Convener (K.R. Kerry)
SC-CAMLR-VIII/11 Rev. 1	WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM, REPORT OF THE CONVENER Convener (K.R. Kerry)

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SC-CAMLR-VIII/BG/1	SUMMARY OF KRILL CATCHES Secretariat
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SC-CAMLR-VIII/BG/6	PRIMARY RESULTS OF KRILL STUDIES DURING THE RESEARCH CRUISE OF RV *DMITRY MENDELEEV* (February - April 1989) USSR (Available in Russian only)
SC-CAMLR-VIII/BG/7	SUMMARISED RESULTS OF AN INTEGRATED FISHERIES SURVEY IN THE 1987/88 SEASON USSR (Available in Russian only)
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SC-CAMLR-VIII/BG/56	RESPONSES TO QUESTIONS ON THE DEVELOPMENT OF APPROACHES TO THE CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES

SC-CAMLR-VIII/BG/57	PARTICIPATION OF THE INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION IN THE STUDIES OF THE SOUTHERN OCEAN IOC Observer

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CCAMLR-VIII/9	INCIDENTAL MORTALITY OF ANTARCTIC BIRDS AND SEALS Responses from the SCAR Sub-Committee on Bird Biology and the SCAR Group of Specialists on Seals to the CCAMLR Scientific Committee
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CCAMLR-VIII/BG/19	REPORT ON ASSESSMENT AND AVOIDANCE OF INCIDENTAL MORTALITY IN THE CONVENTION AREA 1988/89 USSR
CCAMLR-VIII/BG/20	REPORT ON ASSESSMENT AND AVOIDANCE OF INCIDENTAL MORTALITY IN THE CONVENTION AREA IN 1988/89 Japan
CCAMLR-VIII/BG/21	POTENTIAL IMPACTS OF CLIMATE CHANGE ON THE SOUTHERN OCEAN ECOSYSTEM Delegation of Australia

CCAMLR-VIII/BG/22	REPORT OF THE CCAMLR OBSERVER TO THE INTERNATIONAL WHALING COMMISSION Observer, USA
CCAMLR-VIII/BG/23	REPORT ON ASSESSMENT AND AVOIDANCE OF INCIDENTAL MORTALITY IN THE CONVENTION AREA IN 1988/89 Argentina
CCAMLR-VIII/BG/24	LETTER TO THE EXECUTIVE SECRETARY FROM UK HEAD OF DELEGATION - SOUTH GEORGIA AND SOUTH SANDWICH ISLANDS: LIMITS OF TERRITORIAL SEA
CCAMLR-VIII/BG/25	LETTER TO THE EXECUTIVE SECRETARY OF CCAMLR CONCERNING THE RIGHTS OF ARGENTINA TO SOVEREIGNTY AND JURISDICTION OVER THE MALVINAS

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CCAMLR-VIII/MA/1	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 Poland
CCAMLR-VIII/MA/2	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 Federal Republic of Germany
CCAMLR-VIII/MA/3	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 France
CCAMLR-VIII/MA/4	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 Australia
CCAMLR-VIII/MA/5	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 Brazil
CCAMLR-VIII/MA/6	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 United States of America

CCAMLR-VIII/MA/7	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 South Africa
CCAMLR-VIII/MA/8	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 USSR
CCAMLR-VIII/MA/9	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 Spain
CCAMLR-VIII/MA/10	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 Japan
CCAMLR-VIII/MA/11	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 United Kingdom
CCAMLR-VIII/MA/12	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 Republic of Korea
CCAMLR-VIII/MA/13	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 Chile
CCAMLR-VIII/MA/14	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 Norway
CCAMLR-VIII/MA/15	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 Argentina
CCAMLR-VIII/MA/16	REPORT OF MEMBER'S ACTIVITIES IN THE CONVENTION AREA IN 1988/89 German Democratic Republic

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ANNEX 3

AGENDA FOR THE EIGHTH MEETING OF THE SCIENTIFIC COMMITTEE

AGENDA FOR THE EIGHTH MEETING
OF THE SCIENTIFIC COMMITTEE

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

2. Krill Resources
   (i) Fishery Status and Trends
   (ii) Report of the Workshop on the Krill CPUE Simulation Study
   (iii) Report of the Working Group on Krill
   (iv) Data Requirements
   (v) Advice to the Commission

3. Fish Resources
   (i) Fish Stock Assessment - Report of the Working Group
   (ii) Scientific Research Exemption Provision
   (iii) Data Requirements
   (iv) Advice to the Commission

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

5. Ecosystem Monitoring and Management
   (i) Report of the Working Group for CEMP
   (ii) CCAMLR/IWC Workshop on the Feeding Ecology of Southern Baleen Whales
   (iii) Data Requirements
   (iv) Advice to the Commission

6. Marine Mammal and Bird Populations

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

8. Cooperation with Other Organisations
   (i) Reports of SC-CAMLR Representatives at Meetings of Other International Organisations
   (ii) Nomination of SC-CAMLR Observers to Meetings of Other International Organisations

9. Review and Planning of the Program of Work of the Scientific Committee
   (i) Activities in the Intersessional Period
   (ii) Coordination of Field Activities for the 1989/90 and 1990/91 Field Seasons

10. Budget for 1990 and Forecast Budget for 1991

11. Election of Vice-Chairmen of the Scientific Committee

12. Next Meeting

13. Other Business

14. Adoption of the Report of the Eighth Meeting of the Scientific Committee

15. Close of the Meeting

ANNEX 4

REPORT OF THE WORKSHOP ON THE KRILL CPUE SIMULATION STUDY

(Southwest Fisheries Centre, La Jolla, California, USA 7 to 13 June 1989)

REPORT OF THE WORKSHOP ON THE KRILL CPUE SIMULATION STUDY

(Southwest Fisheries Centre, La Jolla, California, USA, 7 to 13 June 1989)

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The Workshop provided the opportunity for participants to work closely with the Consultants on the details of their simulations and analyses.

2. In the light of these discussions, certain revisions of the models used were implemented and a variety of technical problems were identified and addressed.

3. The main conclusions of the Consultants' reports which, after revision, were accepted by the Group, involve a central distinction between information on the number, type and size of concentrations of krill and the information on the abundance of krill within concentrations.

4. The Workshop developed an operational classification of concentrations into three types, those of relatively dispersed, small, discrete swarms of krill, those of large aggregations of krill swarms and those of extensive layers of krill.

5. Data routinely collected by USSR survey vessels are amenable to analyses which estimate the number and size of concentrations in identified areas of ecological interest.

6. These analyses involve a number of uncertainties which could be resolved if supplementary information on the operation of the vessels were to be collected. The Workshop made recommendations for the collection of additional data so that these uncertainties could be resolved.

7. Data routinely collected by Japanese fishing vessels are in principle amenable to analyses which use the catch-per-unit searching time to estimate changes in krill abundance within concentrations. However, there are a number of difficulties involved in these analyses.

8. The Consultants' work on the Japanese fishery focussed on a distinction between time spent solely searching for krill aggregations and time when searching occurs, but other

activities continue. Japanese fishing vessels only operate in areas of high krill abundance and in these areas it is not practical to distinguish between these two modes of search.

9. Analyses at the Workshop involved assessing the sensitivity of different indices of CPUE to different types of change in krill abundance, namely: change in density within swarms, change in the size of swarms, and change in the number of swarms-per-unit area within a concentration.

10. Where a change in density within a swarm has occurred, this can be tracked by changes in an index based on catch-per-unit fishing time.

11. Where changes in swarm size or the number of swarms within a concentration have occurred, this can be tracked by changes in indices based on catch -per-searching time.

12. When krill was concentrated in layers, the relationship between krill abundance and CPUE was weak, i.e. a large change in the krill abundance was reflected by a small change in the CPUE index. In this case a strategy recommended by the Workshop was to estimate the abundance of concentrations which consist of large layers and to estimate the size of the concentrations and their density.

13. The Workshop concluded that a Composite Index of Krill Abundance could be constructed from information on krill concentrations derived from USSR survey vessels and on krill abundance within concentrations from Japanese fishing vessels. This Index would only be meaningful for identified ecological areas of the Southern Ocean where both survey and commercial fishing data are available. The task of identifying these areas should be taken up by the Working Group on Krill.

14. The general properties of the Index were such that small changes in krill abundance were unlikely to be detected, but any statistically significant change in the Index would imply that a major change in krill abundance had occurred. This has obvious implications for the deliberations of the Commission's Working Group for the Development of Approaches to Conservation of Antarctic Marine Living Resources.

15. Although the general properties of the Index could be deduced, it was recognised by the Workshop that a detailed understanding of the quantitative behaviour of the Index was required. Accordingly, the Workshop recommended that the sensitivity of the Composite Index of Abundance to variation in parameter values should be further investigated.

16. A number of uncertainties in the behaviour of the CPUE indices could only be resolved by using information obtained from acoustic surveys of krill concentrations. The Workshop referred these problems to the Working Group on Krill.

Conclusions and Recommendations

17. The USSR and Japanese fisheries operate in different ways. The USSR fishery has survey vessels which detect fishable concentrations and call catching vessels to them, whereas the Japanese catching vessels operate more or less independently. The comments which follow relative to these two fisheries are assumed to be general, so that the fishing operations of other nations can be categorised accordingly.

18. The USSR fishery, although extensive, covers a relatively small proportion of the total area of the Southern Ocean. The fishing fleet is much smaller and covers a correspondingly smaller area. Within these limited areas of fishery operations, the Workshop demonstrated that CPUE was of some utility in providing information on krill abundance.

19. Data from survey vessels which operate in support of the USSR krill fishing fleet do provide useful information on the number and size of krill concentrations.

20. The Workshop developed an operational classification of concentrations into three types, those of relatively dispersed, small, discrete swarms of krill, those of large aggregations of krill swarms and those of extensive layers.

21. The Japanese fishery operates on the latter two types of these concentrations. Haul-by-haul data from the Japanese fishery could be used to estimate abundance within concentrations. The degree to and method by which this can be achieved depends on the type of concentration and the way in which krill abundance changes, i.e. changes in size of swarms, density within swarms or number of swarms in a concentration.

22. It is impossible to define Primary Searching Time (see paragraph 62) in the Japanese fishery adequately, and hence it is not possible to use this as an index of searching effort. However, the data that are currently collected on Japanese commercial vessels, namely the start and end times of fishing, are useful because they can be used to derive an effective search time.

23. Because krill abundance and the CPUE indices do not change proportionately, the detection of a change in an index implies that there has been a substantial change in mean abundance in the areas of interest.

24. There is considerable value in combining the results from the two approaches into a Composite Index of Abundance using the USSR data to determine the numbers and sizes of concentrations and the Japanese data to determine abundance within the concentrations. However, the application of this Composite Index of Abundance is limited due to the small area of operation of the Japanese fishery.

25. Care needs to be exercised in evaluating such a Composite Index as many of the component variables do not change in proportion to abundance and also because there are considerable uncertainties regarding how many of these variables are best estimated.

26. It is essential that, in order to improve the quality of the Composite Index, data collection should follow standard procedures.

27. Certain within-concentration parameters such as swarm size, the number of swarms-per-unit area of the concentration and interswarm distance are essential for monitoring abundance. These are best determined acoustically.

28. The Workshop therefore recommended that:

(i) Survey vessels operating in support of a fishing fleet should collect data in accordance with the bridge log format discussed in paragraph 73 and detailed in Appendix 5 of the Workshop Report. Data from these vessels should be analysed to provide estimates of the size and type of krill concentrations along the lines suggested in Appendix 5 and WS-KCPUE-89/6 Rev. 1.

(ii) All catching vessels should collect haul-by-haul data in the same way as the current Japanese fishery.

(iii) Haul-by-haul data should be analysed to provide appropriate indices of abundance based on catch-per-searching time within krill concentrations on a ten day reporting period. Such analyses could be undertaken either by CCAMLR or by the fishing nation concerned, and should be conducted annually.

(iv) The analytical procedures suggested above should be conducted on a trial basis and reviewed after three years.

(v) Acoustic data should be used to determine swarm size, the number of swarms-per-unit area of the concentration and interswarm distance within concentrations.

(vi) The detailed specification of the necessary acoustic data should be referred to the Working Group on Krill.

(vii) The following further activities be undertaken:

(a) Determination of the sensitivity of the Composite Index of Abundance to variation in parameter values. However, the utility of this is dependent on the ability of the Working Group on Krill to determine key parameter values and their distributions.

(b) The simulation model of the Japanese fishery should be changed by the Consultant so as to avoid the necessity to distinguish between Primary and Secondary Searching Time.

REPORT ON THE WORKSHOP

Introduction

29. The Workshop was held at the Southwest Fisheries Centre of the National Marine Fisheries Service in La Jolla, California, USA from 7 to 13 June 1989.

30. The Convener of the study, Dr J. Beddington (UK) chaired the meeting. A provisional agenda, distributed before the meeting, was amended to include a new item requested by the Chairman of the Commission’s Working Group for the Development of Approaches to Conservation of Antarctic Marine Living Resources. The revised agenda was then adopted (Appendix 1).

31. A list of those attending is given in Appendix 2.

32. The report was prepared by Miss M. Basson, Prof. D. Butterworth, Drs I. Everson and D. Powell.

33. Meeting documents received at the CCAMLR Secretariat were circulated to participants. Further papers were tabled at the meeting. The list of meeting documents is given in Appendix 3.

Activities Following SC-CAMLR-VII

34. Discussions following the presentation of the Consultants' reports to SC-CAMLR-VII indicated that modifications of the basic simulations were necessary, based on a more detailed understanding of the Japanese and USSR krill fisheries.

35. Dr J. Beddington (Convener) and Dr M. Mangel (Consultant) had both written to the Scientific Committee representative for the USSR for similar information, but neither had received a reply. No additional information on the USSR fishery was available to the meeting.

Computing

36. A VAX 11/780 mainframe computer was available to the meeting and the analyses undertaken were done in batch mode.

Major Tasks for the Workshop

37. The major tasks for the Workshop had been set out by the Scientific Committee (SC-CAMLR-VII, paragraph 2.41):

(i) to provide an opportunity for detailed and final discussions on the models developed by the Consultants and their implications for the potential use of CPUE to index krill abundance;

(ii) to consider refinements of the krill distribution model used in the Consultants' studies in the light of further analyses of existing krill research survey data to be tabled at the Workshop and to investigate whether such refinements altered the conclusions drawn from the existing studies;

(iii) to consider the practicality of the routine collection of various types of search time information in the light of analyses to be presented of experimental collection of such data that has already taken place on Japanese vessels and of some data from Soviet research vessels; and

(iv) to make recommendations to the Scientific Committee regarding the potential utility of CPUE to index krill biomass, the most effective and practical index or indices to be used and the consequent requirements for routine data collection in the krill fishery.

REVIEW OF CONSULTANTS' REPORTS

Japanese Fishery

38. Prof. Butterworth introduced his paper 'A Simulation Study of Krill Fishing by an Individual Japanese Trawler' (WS-KCPUE-89/4). This had been tabled at SC-CAMLR-VII. The study attempts to mimic the Japanese krill fishery during January and February, the period when peak fishing activity occurs.

39. The krill distributional model used in the study is one of 'patches within patches'. On the finest scale, krill are present in 'swarms'. Groupings of these swarms are termed 'concentrations'. Japanese data indicate that the swarms within a particular concentration tend to have the same characteristics with respect to krill size and feeding condition ('greenness').

40. The model simulates the initial searching strategy for a concentration as follows. It is assumed that a fishing vessel begins searching from a position about 100 n miles north of the ice-edge at the western end of a 600 x 600 n miles area considered, and proceeds towards the centre of the southern boundary. This initial search is in a straight line. Fishing is assumed to commence once the vessel's track-line intersects the boundary of a krill concentration. The Workshop was advised that in practice fishing vessels do move in a straight line towards the ice-edge, but whenever they encounter even slight indications of krill, they perform an intensive, localised search pattern to determine whether the detected concentration found is worth fishing. Swarms and therefore also concentrations are detected acoustically.

41. The search for concentrations on reaching the southern boundary or upon leaving the concentration most recently detected, is no longer modelled by simulating the vessel's track. Instead the random search formula is used. This has the advantage of making some allowance for the movement of concentrations with time. Field estimates of speeds of movement of krill aggregations (Kanda et al.,1982; Everson and Murphy, 1987) are not inconsistent with the value of 15 cm sec^{-1} used in the model. Japanese observations indicate that in the shelf slope region, the concentrations tend to remain in more or less the same location.

42. The random search formula used in the simulation is:

$$\text{Prob (detect concentration within time } \mathbf{t}) = 1 - \exp(wdvt) \qquad (1)$$

where **d** is the density of concentrations (number per unit area) and **v** the vessel searching speed. Because echosounder and sonar search widths are small compared to concentration sizes, **w** was taken to be the median of the simulated concentration diameters. Generating a random number from a uniform distribution on [0,1] and solving formula above for **t**, yields the time taken to find the next fishable concentration (Concentration Searching Time, CST). If either the number or the typical size of concentrations decreased, CST would tend to increase because of the resultant smaller values of **d** or **w** respectively.

43. The vessel may terminate fishing on a concentration for one of three reasons: the need to return to a cargo vessel to off-load, the intervention of bad weather, or too low a catch rate. It is assumed that bad weather always causes a vessel to lose contact with the concentration and that the vessel is moved 50 n miles in a random direction. In reality, however, the vessel can often maintain contact with a good concentration even though fishing operations have to be suspended. In the model, random fluctuations of search times can lead to exceptionally long search times between fishable swarms and thus low catch rates. Concentration biomasses are much larger than the typical catch made by a trawler over the two-week period simulated, so that the catch made has a negligible effect on the catch rate. In reality, catch rates are likely to drop as a consequence of changes in the aggregation behaviour of krill over time; this feature was not incorporated in the model because of the absence of quantitative data regarding such behaviour.

44. Searching for swarms within a concentration is also modelled as a random search process as follows:

$$\text{Prob (detect swarm within } \mathbf{t} \text{ hours}) = 1 - \exp(-\lambda t) \qquad (2)$$

where $\lambda = 4$ (hours)$^{-1}$. The formula is adjusted when the number of swarms-per-unit area of the concentration drops, so that the Primary Searching Time (PST) to find the next swarm increases. Decreases in swarm radius (r) and the density of krill within a swarm (δ) also cause an increase in PST because of a decline in the proportion of swarms considered large enough to be worth fishing (see paragraph 48 following).

45. The value of **t** in equation 2 was chosen to give an average search time (λ^{-1}) of about 15 minutes, corresponding to time budget data collected for a Japanese trawler during the 1986/87 season. Mr Ichii advised that in good concentrations, Japanese vessels took only about 5 minutes to find a swarm; the balance of the 15 minutes is used for positioning to commence the haul. The simulation study results thus reflect an overestimation of the proportion of time spent on primary search. An average search time of 5 minutes corresponds to $\lambda = 12$. This is more compatible with estimates of parameters **w, d** and **v** (see paragraph 43) for searching for swarms, which indicated that $\lambda = wdv$ would lie in the range of 14–60.

46. Equation 2 assumes that fishing is directed at discrete swarms. When fishing takes place in concentrations comprised of extensive layers, the search time is essentially zero. The Workshop noted that a considerable portion of the Japanese krill fishing effort may be directed at concentrations of this type, and that the results of the simulation study would not be appropriate to such activities.

47. Fishing does not usually commence immediately after a good swarm is found. Initially some time is required to complete processing of an appropriate proportion of the catch from the previous haul. This is because krill quality deteriorates rapidly. Consequently, the catch-per-haul is usually maintained at a level of about 10 tonnes or less so that it can be processed sufficiently quickly. This waiting time, during which some further search is carried out, is termed Secondary Searching Time (SST).

48. Krill swarm size and density distribution parameters were selected from information obtained during the FIBEX survey and data in Kalinowski and Witek (1983). Catches from unselective tows on such swarms would average 1.5 tonnes, compared to the catches of 6–8 tonnes realised in the Japanese fishery from hauls on single swarms. This is attributed in the simulation study to deliberate selection on the part of the vessel's captain, who would tow only on swarms considered to be sufficiently large or dense, i.e. fishable.

Soviet Fishery

49. Dr Mangel introduced his paper ‘Analysis and Modelling of the Soviet Southern Ocean Krill Fleet’ (WS-KCPUE-89/5), which had been tabled at SC-CAMLR-VII.

50. The operational procedure for the USSR fishing fleets is quite different to that of the Japanese vessels which operate individually. The USSR fishing fleets operate in concert with survey vessels. The survey vessels continually search for new concentrations and inform the fishing vessels when new fishable concentrations are located. The fishing vessels do not move to all the concentrations that are detected. USSR fishing fleets tend to work in groups travelling more or less from west to east. The vessels travel together, often for as much as 100 n miles before returning to cover the same area.

51. For these reasons, it was considered that search time data from USSR fishing vessels will be unlikely to provide valid estimates of changes in krill abundance because their strategy is cooperative and would not approximate random search. However, echosounder charts for such activities may provide information on swarm parameters (see paragraphs 64 and 65).

52. Dr Mangel then introduced the paper WS-KCPUE-89/6 which reported an analysis of a sample of data from survey vessels accompanying the USSR fishing fleet. This analysis indicated that such data could be used to determine the size and location of concentrations. The concentrations so indicated were similar in size and location to those reported in analyses of Japanese data. It was clear from examination of Soviet data that USSR survey vessels remained within a particular concentration for some time and occasionally returned to it following activity in an adjacent area.

53. The paper proposed that these survey vessel data could be used to provide estimates of the number ($\mathbf{N_c}$) and size of concentrations in a region. In the former respect, the formula suggested is:

$$N_c = n_c/[1\text{-exp}(wvt/A)] \qquad (3)$$

where $\mathbf{n_c}$ is the number of concentrations encountered, **w** is the detection width, **v** is the vessel’s search speed, **t** is the search time and **A** is the area of the region being searched. Estimates of $\mathbf{N_c}$ from this formula are sensitive to the values used for the parameters **w**, **t** and **A**. Considerable discussion took place as to how best to refine their estimation; the results of this discussion are reflected in paragraphs 66 to 67.

Other Analyses Tabled

54. Mr Ichii and Dr Endo (WS-KCPUE-89/7) raised three problems concerning Prof. Butterworth's simulation study (WS-KCPUE-89/4) of the Japanese krill fishery. Firstly, they reported that Japanese vessels often operated on layers rather than swarms during the peak fishing season. The sizes of these layers are much larger than the swarms detected during FIBEX surveys, whereas the simulation study had used krill distribution parameter values based on the FIBEX results. Very little searching time is spent in concentrations comprised of such layers. Accordingly, they queried whether CPUE indices based on searching time would be as useful as indicated by the simulation study. Secondly, they queried the utility of indices based on the sum of Primary and Secondary Searching Time (PST + SST), because the processing time needs reflected by SST are markedly dependent on the product being produced, and the product mix varies substantially from one season to the next. Finally, they alluded to the unrealistic behaviour of the simulation model in respect of the values used for the minimum catch rate required to remain in a concentration, and suggested that the distribution model used for the simulation did not adequately reflect the actual situation of few harvestable amongst many unharvestable krill concentrations.

55. The authors suggested that experiments to test the viability of collection of PST data needed to be carried out, together with model tests of robustness to recording errors, before considering the routine implementation of search time data collection. They further suggested that improvement of the krill distribution model used was necessary before the study could be considered to have demonstrated that the routine collection of such data was warranted.

56. In discussion, it was suggested that keeping a record in the log book of the product being produced at a particular time might help resolve the second problem detailed in paragraph 54.

57. Drs Endo and Shimadzu (WS-KCPUE-89/9) reported information on the krill aggregations fished by a Japanese trawler in January 1988 in the region north of Livingston Island (north of the Antarctic Peninsula). The trawler fished during a cooperative survey with the research vessel *Kaiyo Maru* over a four day period. The aggregations fished were layers rather than swarms, and in 88% of the hauls only a single layer was fished. The mean length towed during fishing was 3.25 km, the mean layer thickness (i.e. depth dimension) detected acoustically was 13.3 m and the mean surface density estimated from catch data was 228 g/m^2. Thus these layers were 44.5 times longer, 2.7 times thicker, but 25% less dense than typical swarms dimensions calculated from acoustic data collected during FIBEX surveys.

The largest layer reported in the paper was 18.5 km in length, and the longitudinal length of the concentration exceeded 52 km.

58. Mr Ichii and Dr Endo (WS-KCPUE-89/8) considered CPUE data together with krill size and condition information from the operations of seven trawlers in the region north of Livingston Island during January–March 1988. The nature of the aggregations fished was such that there was essentially no Primary Searching Time. Catch-per-haul data appeared to depend on the end product from the catch, not the abundance of krill and showed no variation with time. Catch-per-fishing time indices showed no significant differences with time, although different vessels showed peaks in these indices at different times. The total catch taken from the area was only about 7% of the estimated krill biomass. There were no significant differences in mean body length of krill during the season. The proportion of green krill recorded was highly variable among the trawlers; the authors doubted that the routine collection of 'greenness' data would improve abundance indices.

59. Mr Ichii and Dr Shimadzu (WS-KCPUE-89/9) reported examples of time budget data recorded by a Japanese trawler in the 1986/87 season. The average proportions of time spent on cargo transfer, net handling, fishing, confirming swarm sizes and searching for swarms were presented for various periods from November to March, and further parameters of the distributions of some of these statistics were also reported. Searching times were greater and fishing times less in November and early December, but thereafter there was little trend in any of the statistics reported over the remainder of the fishing season.

Practicality of Data Collection

60. The simulation study of the Japanese krill fishery (WS-KCPUE-89/4) indicated that CPUE indices which utilise Primary Searching Time (PST) are much more effective for detecting changes in krill abundance within concentrations than those in which Primary and Secondary Searching Time were combined (PST + SST). The latter statistic could probably be recorded routinely, since they can be obtained by subtraction of the time required for other activities such as cargo transfer, net handling and fishing which are clearly defined. However, the practicality of discriminating between PST and SST was questioned and was thoroughly discussed.

61. Mr Ichii advised that for most concentrations in which substantial fishing activity took place, processing requirements were the principal determinant of the period of time between ending one haul and starting the next. Some form of searching took place throughout this

period, but the detection of the next fishable swarm to be fished was easily and rapidly achieved. It was effectively impossible, however, to identify exactly what proportion of this period should be considered as ‘Primary Searching Time’.

62. The Workshop agreed that the collection of Primary Searching Time as used in the simulation study was impractical as no operational definition would be possible. Accordingly, any attempt to use search time data from this fishery in CPUE indices would need to utilise PST+ SST or some adaptation thereof.

63. Unfortunately, since no Soviet scientists were present at the Workshop, it was not possible to comment on the practicalities of data collection from the Soviet krill fisheries. For a similar reason, no comments could be offered on this matter for the fleets of other nations participating in the krill fishery.

MATTERS ARISING FROM DOCUMENTS DISCUSSED AND ANALYSES OF RESULTS

Concentration Types

64. Advice from Mr Ichii served to emphasise that not all concentrations of krill are fishable. The majority of concentrations, whether consisting of swarms or of layers, are too ‘poor’ to be fished. Generally, Japanese fishing vessels keep no records of any ‘poor’ concentrations encountered. Only ‘good’ concentrations are fished, and interpretation of the fishing statistics collected would depend on whether such concentrations consist of swarms or layers. Accordingly, it was considered important to provide more specific definitions of what constituted ‘poor’ or ‘good’ concentrations as perceived by the fishermen. Broad definitions of a ‘poor’ concentration (consisting either of swarms or layers), a ‘good layer’ concentration and a ‘good aggregation’ concentration were agreed and are set out in Appendix 4.

65. Because interpretation of reported fishing statistics depends on whether a good layer or a good aggregation was being fished, it becomes important to ascertain whether such a characterisation could be achieved on board a fishing vessel for routine recording purposes. The Workshop agreed that this should be possible through inspection of echocharts. The matter of developing an operational definition to characterise concentrations (which would include the provision of some typical echochart examples) was referred to the Working Group on Krill.

Estimating the Number of Concentrations ($\mathbf{N_c}$)

66. Data obtained from Japanese fishing vessels cannot be used for estimating the number of concentrations for three reasons. First, the vessels do not search randomly. Second, the vessels operate in a relatively small region. Third, the vessels operate in just a few concentrations per year (often returning to the same concentration after unloading).

67. Dr Mangel suggested a formula that could be used to provide an estimate of $\mathbf{N_c}$ from Soviet survey vessel data (equation 3). Application of this equation requires estimates for **w**, **v**, **t** and **A**. The value of the searching speed **v** is known and records could readily be kept of the search time **t** between concentrations if appropriate definitions were provided. An estimate of **A** is dependent on the perceived limits of the krill distribution, but may also be refined by reference to oceanographic features and bottom topography. There is evidence that the survey vessels tend to restrict their activities to frontal zones and topographic features. This is likely to lead to positive bias in the estimate of $\mathbf{N_c}$ because the density (number-per-unit area) of concentrations over the whole area (**A**) may not be as high as that within the concentrated fishing zone. The effective search width **w** is equivalent to the diameter of the concentrations (assuming that they are circular). The estimation of average concentration radius and a bias that arises in this process are discussed in paragraphs 68 to 72 below. Further details concerning the estimation of $\mathbf{N_c}$ in this manner are detailed in Appendix 5.

Estimating the Size of Concentrations (Effective Circular Radius $\mathbf{L_c}$)

68. The size of fishable concentrations could be determined by plotting the positions of the various hauls made in that concentration. This information could be obtained from Soviet and Japanese vessels. For example, the centroid of the haul positions could be calculated and the root-mean-square distance of the individual positions from this centroid evaluated. Mathematical analysis for various shapes could indicate an appropriate value for a constant which, when multiplying this root-mean-square distance, would provide an estimate of effective radius $\mathbf{L_c}$. This in turn, would provide the estimate required for **w** in the proceeding paragraph. Even if the resultant estimate was biased, the $\mathbf{N_c}$ value obtained could still be used to provide a relative, if not an absolute, index of krill abundance.

69. Some indication of likely concentration shapes is needed to perform the analysis suggested in the preceding paragraph. Plots of haul positions from fisheries data (such as those examined by Dr Mangel in Appendix 5) might assist in this regard. Concentrations may

be associated with hydrographic features which could give rise to particular shapes. It was suggested that a better understanding of the conditions under which concentrations occur would help determine the sorts of shapes to be expected.

70. It was pointed out that an estimate of $\mathbf{L_c}$ from observed or encountered concentrations is likely to be positively biased because larger concentrations are more likely to be detected than smaller ones. An attempt was made to quantify the magnitude of this bias for the search model used in the simulation studies. These studies assumed that concentrations are circular with radii distributed uniformly over the range (5.6, 11.3) n miles. Analytical as well as simulation results evaluated during the Workshop, showed that for the parameters used in the search model, the bias in the estimate of $\mathbf{L_c}$ is of the order of ±10%. This bias affects not only the estimate of $\mathbf{L_c}$ itself, but also the estimate of $\mathbf{N_c}$ which depends on this value (see paragraphs 53 and 67).

71. The extent of the bias discussed in the preceding paragraph is determined by the statistical distribution of concentration radii, as well as the effective detection width of the search vessel (i.e. the width over which its sonar and echosounder can locate krill). It was suggested that the characteristics of the observed concentrations be summarised in terms of a size frequency histogram to give a better estimate of this distribution. It was noted, however, that this empirical distribution would be biased towards the larger concentrations. The Workshop agreed that further mathematical analyses to assess the magnitude of the bias in $\mathbf{L_c}$ and $\mathbf{N_c}$ should wait until a more detailed picture of the size distributions of concentrations has been built up from fisheries and survey data.

72. The problem of possible double counting of concentrations in analyses of Soviet survey vessel data had been raised by Dr Mangel in WS-KCPUE-89/6. This is not a problem if search is truly random, but creates difficulties in the circumstances of directed search (i.e. deliberate attempts to relocate a concentration found at an earlier time). It was recognised that the primary objective of the operations of the Soviet survey vessels is not to obtain an unbiased estimate of $\mathbf{N_c}$. It was noted, however, that a directed search component may not matter if only a relative abundance index for a well-defined subarea is required.

73. The Workshop considered that the finest scale on which catch data are currently reported to CCAMLR (on a grid approximately 30 n miles x 30 n miles in size) was still too coarse to be adequate to estimate concentration sizes. The matter of the additional data which would need to be collected by survey vessels to allow $\mathbf{N_c}$ and $\mathbf{L_c}$ estimations as described above was discussed in detail, and suggestions for the development of a bridge log are given in Appendix 5.

ESTIMATION OF KRILL DISTRIBUTION PARAMETERS WITHIN GOOD CONCENTRATIONS FROM CPUE DATA

Good Aggregations

74. After considering a number of modifications to the Consultant's study (WS-KCPUE-89/4) as detailed in Appendix 6, the Workshop agreed that while there was still uncertainty regarding a number of the inputs to the simulation model, the results obtained indicated that CPUE indices using a modification of time between trawling called Pseudo Primary Searching Time, PPST, may be able to provide information on changes in biomass within a good-aggregation concentration. Such indices can detect changes that might not be detected by indices using only fishing time data. It was noted that national laboratories could in principle construct such an index using data for the times at which fishing begins and ends for each haul. This is already routinely recorded by some nations. Some minor additional annotations would be required in existing log books to indicate changes in the product being produced, and whether the normal activities of searching and fishing were interrupted by some other occurrence such as bad weather.

Good Layers

75. For practical purposes it was agreed that areal coverage of krill is virtually uninterrupted within concentrations comprised of good layers. Therefore, the only within-concentration distribution parameter for which an estimate is required is the krill surface density (δ). This is indexed by catch-per-fishing time, for which data are already collected routinely.

CONSTRUCTION OF A COMPOSITE ABUNDANCE INDEX

76. Results in the Tables of Appendix 6 indicate that for good aggregations even the best of the CPUE indices for which data could be collected in practice has only poor ability to detect a decrease in swarm radius (**r**). Decreases in krill surface density (δ) are well detected by indices involving fishing time. It appears that indices using Pseudo Primary Searching Time have the potential to detect decreases in the number of swarms-per-unit area within the concentration ($\mathbf{D_c}$). Generally the CPUE indices have the property that as the biomass drops, the value of the index falls by a smaller proportion (this is referred to as non-linear behaviour).

77. The error bars in the Figure in Appendix 6 give an indication of the precision with which changes of abundance could be detected by the index shown from one year to the next by a fishery similar in scale to the current Japanese fishery (approximately 10 vessels fishing for two to three months). These results suggest that the detection of statistically significant changes in CPUE indices will be difficult to achieve. Taken together with the non-linear behaviour of these CPUE indices discussed in the preceding paragraph, this means that detection of any statistically significant reduction in a CPUE index is likely to imply that a substantial reduction in krill biomass has occurred.

78. In view of the poor ability of CPUE indices to detect changes in swarm radius $\mathbf{r}$, it was considered that the Meeting of the Working Group on Krill could valuably discuss the possibilities of using acoustic data (from either or both fishing vessels and vessels conducting scientific surveys) to detect such changes.

79. The components of a Composite Index of Abundance, and the sources of data required to monitor their changes, are detailed in Appendix 7. A study of the likely precision with which such a Composite Index of Abundance could estimate krill biomass and more particularly relative changes in the krill biomass in a region, was recommended. The framework for such an exercise is also given in Appendix 7.

80. It was noted that the proposed method of assessing $\mathbf{N_c}$ would take account of the possibility of a decrease in krill biomass being associated with a contraction in the areal extent of the overall krill distribution, even though the local abundance of krill in the fishing area was little affected. However, it was also appreciated that the proposed Composite Index took no account of the amount of krill in poor concentrations; this might not vary in proportion to that in good concentrations as the overall krill abundance changed. Data from Soviet survey vessels may provide some information in this regard.

81. The Workshop noted that especially useful information to refine this approach could be obtained if data were available for an area in which Japanese trawlers, Soviet survey vessels and scientific survey vessels (performing systematic survey) operated simultaneously.

FURTHER ANALYSES REQUIRED

82. The likely variance of the Composite Index suggested in paragraph 79 should be assessed from estimates of the precision with which component parameters could be measured (see Appendix 7).

83. Refinement of existing analyses of krill distribution data from scientific surveys (such as FIBEX) was not seen as high priority at present. It was considered rather that more data from the fishery on the distributional parameters of aggregations fished (as provided, for example, by Drs Endo and Shimadzu in WS-KCPUE-89/9) should be obtained and analysed.

84. Information on temporal trends in krill distribution parameters (i.e. the rates at which good aggregations formed and dispersed) was also not seen as immediate priority. While such information is desirable to more closely model the process of Japanese trawlers deciding to leave concentrations when catch rates drop to a level considered to be too low, this is relevant only to the estimation of $\mathbf{N_c}$ and $\mathbf{L_c}$ from concentration searching time. However, this does not seem practical from the Japanese fishery data for other reasons.

85. A modification to the simulation model of the Japanese fishery was suggested which avoids the distinction between Primary and Secondary Searching Time. This could be achieved by fixing the total searching time between hauls on the basis of required processing time. The number of swarms detected in this period would be generated stochastically and the best of these swarms would be chosen for the following haul. It was recommended that this possibility be explored.

IMPLICATIONS OF RESULTS FOR A CONSERVATION STRATEGY

86. There were two broad results from the Workshop which were of relevance to this agenda item:

(a) the ability to detect decreases in krill abundance from CPUE data is relatively limited; and

(b) should a statistically significant decrease in a Composite Index of Krill Abundance be detected, this would imply that a substantial fall in krill biomass has already occurred.

The implications of these results for a conservation strategy was a matter for the attention of the Working Group on Krill in the first instance.

CLOSE OF MEETING

87. The Workshop agreed to adopt the report of its activities. The Chairman thanked the participants and the staff of the Southwest Fisheries Centre for hosting the meeting and assisting with related activities, particularly Drs R. Hewitt and R. Holt for general arrangements, Gaye Holder for typing and Susie Jacobson for assistance with the runs of the simulation model undertaken on the computer. The Workshop participants thanked the Chairman for the efficient and effective manner in which he had conducted the meeting.

APPENDIX 1

AGENDA

Workshop on the Krill CPUE Simulation Study
(Southwest Fisheries Centre, La Jolla, California, USA, 7 to 13 June 1989)

1. Opening: Convener's remarks

2. Adoption of the agenda

3. Appointment of rapporteurs

4. Review of documents and computing facilities

5. Review of Consultants' reports
   - (a) Analyses
     - (i) Japanese fishery
     - (ii) Soviet Fishery
   - (b) Recommendations
     - (i) Japanese fishery
     - (ii) Soviet fishery

6. Adjustment to Krill Distributional Model
   - (a) Likely effect on simulation results
   - (b) Spatial aspects
   - (c) Temporal aspects

7. Practicality of Data Collection
   - (a) Search time for Japanese fishery
   - (b) Soviet research vessels
   - (c) Fleets of other nations

8. Further Analyses Required
   - (a) Utilisation to provide composite abundance index
   - (b) Distributional data
   - (c) Simulation studies

9. Request by the Chairman of the Working Group for the Development of Approaches to Conservation of Antarctic Marine Living Resources

10. Recommendations
    (a) Utility of CPUE measures to provide an index of krill abundance
    (b) Data collection
    (c) Further analyses

11. Adoption of report

12. Close of meeting.

APPENDIX 2

LIST OF PARTICIPANTS

Workshop on the Krill CPUE Simulation Study
(Southwest Fisheries Centre, La Jolla, California, USA, 7 to 13 June 1989)

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APPENDIX 3

LIST OF MEETING DOCUMENTS

Workshop on the Krill CPUE Simulation Study
(Southwest Fisheries Centre, La Jolla, California, USA, 7 to 13 June 1989)

Papers received in advance of the meeting:

WS-KCPUE-89/1	Agenda for the Krill CPUE Workshop
WS-KCPUE-89/2	Annotated agenda
WS-KCPUE-89/3	Some aspects of the relation between Antarctic krill abundance and CPUE measures in the Japanese krill fishery. (Component of SC-CAMLR-VI/BG/4) (D.S. Butterworth)
WS-KCPUE-89/4	A simulation study of krill fishing by an individual Japanese trawler (SC-CAMLR-VI/BG/37) (D.S. Butterworth)
WS-KCPUE-89/5	Analysis and modelling of the Soviet Southern Ocean krill fleet (SC-CAMLR-VII/BG/12) (M. Mangel)
WS-KCPUE-89/6	Analysis and modelling of the Soviet Southern Ocean krill fleet, II: Estimating the number of concentrations and analytical justification for search data (M. Mangel)
WS-KCPUE-89/7	Brief comments on the simulation study made by Prof. Butterworth on krill fishing by an individual Japanese trawler (T. Ichii and Y. Endo)
WS-KCPUE-89/8	CPUEs, body length and greenness of Antarctic krill during 1987/88 season in the fishing ground north of Livingston Island (T. Ichii and Y. Endo)

The following papers were tabled during the meeting:

WS-KCPUE-89/9	Some examples of time budget data recorded by a Japanese trawler *Ehiko Maru* in 1986/87 season (T. Ichii and Y. Shimadzu)
WS-KCPUE-89/10	Size and density of krill layers fished by a Japanese trawler in the waters north of Livingston Island in January 1988 (Y. Endo and Y. Shimadzu)
WS-KCPUE-89/11	Krill aggregation characteristics: spatial distribution patterns from hydroacoustic observations. Polar Biology (in press) (D.G.M. Miller and I. Hampton)
WS-KCPUE-89/12	Some examples of time budget data recorded by a Japanese trawler, *Ehiko Maru* in 1986/87 season (Anon., Far Seas Fisheries Laboratory, Shimizu, Japan)

Other References:

Everson, I. and Murphy, E. 1987. Mesoscale variability in the distribution of krill *Euphausia superba*. Marine Ecology, Progress Series, 40, No. 1: 53-60.

Kalinowski, K. and Witek, Z. 1983. Elementy biologii, formy grupowego wystepowania i zasoby antarktycznego kryla *Eupahusia superba* (Dana/Crustacea). Sea Fisheries Institute, Gdynia, 207 pp.

Kanda, K., Takagi, K. and Seki, Y. (1982). Movement of larger swarms of Antarctic krill *Euphausia superba* population off Enderby Land during 1976-1977 season. J. Tokyo Univ. Fish 68: 25-42.

APPENDIX 4

DEFINITIONS OF KRILL CONCENTRATIONS

Type	Name	Qualitative Description	Inter-Aggregation Distance	Aggregation Diameter	Comment
1	Poor	Swarms widely spaced Diffuse aggregations	Several to 10’s km	Several to 10’s m	
2	Good Layer	Dense continuous layer	0	Several to 10’s km	Both horizontal and vertical separation is possible
3	Good aggregation	Close groups of dense swarms	10’s m	10 – 100’s m	

APPENDIX 5

ESTIMATING THE NUMBER OF CONCENTRATIONS IN A REGION

This appendix addresses a number of issues raised during the Workshop using data from the 1980-81 cruise of a research vessel *Mys Tihiy* as an example.

2. The 'concentration map' for this cruise, taken from Figure 5 of WS-KCPUE-89/6, is shown in Figure 1. The actual individual hauls are shown in Figure 2. In this figure, hauls are separated according to size (greater or less than 1 000 kg of krill). Figures 3 and 4 show the distribution of hauls within individual concentrations 4 and 8. From these figures, one sees that it is difficult to group hauls together to form concentrations. WS-KCPUE-89/6 used a '50 n miles' rule for defining a concentration, but this was an *ad hoc* choice based on the considerations from simulations. Alternatively, one could attempt to define concentrations in the geometrically smallest way possible (e.g. defining concentrations as ellipses rather than circles).

3. Some of the difficulties are best illustrated in Figure 4. Here the majority of hauls took place in the region around 64.5° S and 140° E, with a few hauls of 65.5° S and 138° E. Given the fishing log book data, it is difficult to determine if the gap in Figure 4 corresponds to a region that is lacking krill or to one in which krill were present, but the vessel simply did not sample those krill.

4. An area of future work should be refinement of the operational definitions of concentrations for use in statistical analysis and krill abundance estimation.

5. Given this kind of difficulty, a subgroup of the Workshop participants considered the development of bridge logs to be used by survey vessels. The following is an example of such a log:

VESSEL NAME: ______________________
DATE: ______________________

Hour	Position		Speed	Course	Concentration			Tow
	S	E			Type	Same/Different	Fishable/Otherwise	
01								
02								
...								
24								

The entries in this log are the following:

Position: Usual latitude and longitude

Speed: This entry is the average speed of the vessel during the reporting period

Course: This entry describes the course type of the vessel during the reporting period:

1 - Straight course
2 - Highly variable course
3 - Hove to (bad weather)
4 - Stationary
5 - In transit, but not recording on the echosounder

Concentration:

Type: This entry is the type of concentration as defined in Appendix 4:

0 - Not in a concentration of krill
1 - Poor concentration
2 - Good layer concentration
3 - Good aggregation concentration

Same/Different:

This entry describes whether the vessel is in the same concentration as in the previous reporting period:

1 - Same concentration
0 - Different concentration

Fishable/Otherwise:

This entry describes whether or not the survey vessel considered the concentration fishable:

1 - Fishing vessels present or contacted regarding this concentration
2 - Otherwise

This variable is important, because it provides an operational definition of fishable concentrations.

Tow: This entry describes whether towing occurred during the reporting period:

1 - Towing occurred
2 - No towing

6. It is proposed that survey vessels fill out such log sheets every day from the time that they enter the Convention Area until the time that they leave the Area. On days in which the vessel is anchored, bad weather occurs, or the vessel is not surveying for other reasons, the vessels should fill out the log sheet header, with a notation indicating why survey activity did not occur that day.

7. Even with the limited data available in the log books from the cruise of *Mys Tihiy*, it is possible to answer certain questions about estimation of the number of concentrations.

Can Concentrations be Separated According
to Poor or Good Concentrations?

8. Presumably catch per fishing time in the concentration will be used as a measure of the quality of the concentration. For the 14 concentrations surveyed by *Mys Tihiy*, the catch per fishing time (defined to be from the start to end of fishing, as denoted in the logbook) is shown below:

Concentration	Catch/Fishing Time (kg/hr)
1	41
2	1530
3	359
4	879
5	907
6	184
7	531
8	629
9	918
10	395
11	1250
12	578
13	6
14	136

9. Adopting the definition that a concentration is poor if the catch is less than about 500 kg/hr suggests that concentrations 1, 3, 6, 10, 13 and 14 (nearly half of the concentrations) are poor concentrations.

How variable are Concentration Radii?

10. Using the east-west and north-east extents given in WS-KCPUE-89/6, one can convert the effective rectangle to an equivalent radius. The results of such a computation are shown below:

Concentration	Effective Radius (n miles)
1	8.95
2	3.91
3	5.52
4	34.2
5	14.5
6	62.9
7	31.2
8	35.1
9	1.2
10	13.3
11	12.7
12	2.68
13	.85
14	24.3

11. When considering these numbers, it is important to consider the following issues:

- The '50 mile rule' is used to define the concentrations, and this will affect concentration size.

- There will be a bias for the radii of detected concentrations, because larger concentrations are more likely to be detected. Running the survey portion of the model developed in WS-KCPUE-89/5 for the Soviet survey operation showed that the mean radius of detected concentrations was about 8.9 n miles, while the mean radius of all concentrations was about 8.4 n miles; this is a relatively minor bias. For a simpler one-dimensional problem, one can show that the ratio of the expected radii of detected concentrations to expected radii of all concentrations is $\mathbf{1 + CV^2}$, where **CV** is the coefficient of variation of the distribution of concentration radii.

12. For the data shown above, the range of concentration radii is 0.85 n miles to 62.9 n miles, the mean is 17.9 n miles and the standard deviation is 17.1 n miles. This gives a coefficient of variation of 0.95. Figure 5 shows a histogram of the distribution of concentration radii.

How Does the Estimation Formula Depend Upon Parameters?

13. Based on the random search formula, the estimated number of concentrations $\mathbf{N_c}$ in a sector of size **A** is given by

$$N_c = \text{int} \left[n_c / \left(1 - \exp(-wvt/A) \right) \right] \tag{1}$$

14. In this equation, **int[Z]** denotes the largest integer smaller than z and

N_c = estimated number of concentrations in the region
n_c = number of concentrations encountered
w = detection width of concentrations
v = searching speed of the vessel
t = total search time between concentrations

Dependence Upon the Area of the Sector

15. Figure 6 shows the results of applying Eqn(1) to the data collected by *Mys Tihiy*, using **w** = twice the average concentration radius, **v** = 10 knots, and the search time reported in WS-KCPUE-89/6. As the sector area ranges from 90 000 square n miles to 45 000 square n miles, the value of $\mathbf{N_c}$ ranges from 14 to 24.

Dependence Upon **w**, **v** and **t**

16. From Eqn(1), it is clear that the value of $\mathbf{N_c}$ depends upon the product **wvt**, thus compounding changes in individual values of the parameters. The general result is that if any of **w**, **v**, or **t** increase, then the estimate of $\mathbf{N_c}$ will decrease. Similar, if **A** decreases, then the estimate of $\mathbf{N_c}$ will decrease. This can be seen from the dependence of $\mathbf{N_c}$ on the value of **wvt/A**.

17. The searching speed **v** and total search time between concentrations **t** can be estimated accurately, since they are operational parameters. The general effect of varying either **v** or **t** will be analogous to the effect of varying 1/**A**; hence Figure 6 can be interpreted as the effect of increasing **v** or **t** as **A** decreases.

18. The dependence upon **w** is more problematical, since **w** is most likely a random variable and, in addition, is not fully observed. There are two biases that will tend to increase **w** (thus decreasing the estimated number of concentrations $\mathbf{N_c}$):

- Larger concentrations are more likely to be detected than smaller concentrations, hence increasing the estimated value of **w**.

- If concentrations move and the vessel(s) follows the movement of the concentration, the net effect will be an increase in the estimated value of **w**.

19. One should thus consider the estimated number of concentrations $\mathbf{N_c}$ to be a function of **w**, so that $\mathbf{N_c} = \mathbf{N_c}(\mathbf{w})$, where **w** is a random variable. Since $\mathbf{N_c}(\mathbf{w})$ is, by Eqn(1), a nonlinear function of **w**, there will be a bias in the estimate of $\mathbf{N_c}$. This bias can be computed as follows. Consider the difference between $\mathbf{N_c}(\langle\mathbf{w}\rangle)$, the estimated value of $\mathbf{N_c}$ using the average value of **w**, and $\langle\mathbf{N_c}(\mathbf{w})\rangle$. the average value of $\mathbf{N_c}(\mathbf{w})$, where the average is taken over the (unknown) distribution of **w**. Standard methods show that

$$\langle N_c(w)\rangle = N_c(\langle w\rangle) + (1/2)N_{c,ww}(\langle w\rangle)\mathrm{Var}(w) \qquad (2)$$

where $\mathbf{N_{c,ww}}$ is the second derivative of $\mathbf{N_c}(\mathbf{w})$ with respect to **w** and **Var**(**w**) is the variance of **w.**

20. Figure 6 also shows the corrected estimated number of concentrations, using Eqn(2), as a function of assessed area of the sector. In order to apply this correction, one has to estimate the variance of the concentration radii. In the light of the results of the survey simulation which showed relatively small bias in detected radii relative to all radii, the observed value of **Var**(**w**), for the *Mys Tihiy* data, was used in constructing Figure 6. The net effect is relatively small, ranging from 0 for smaller values of **A** to 3 for the largest value of **A**.

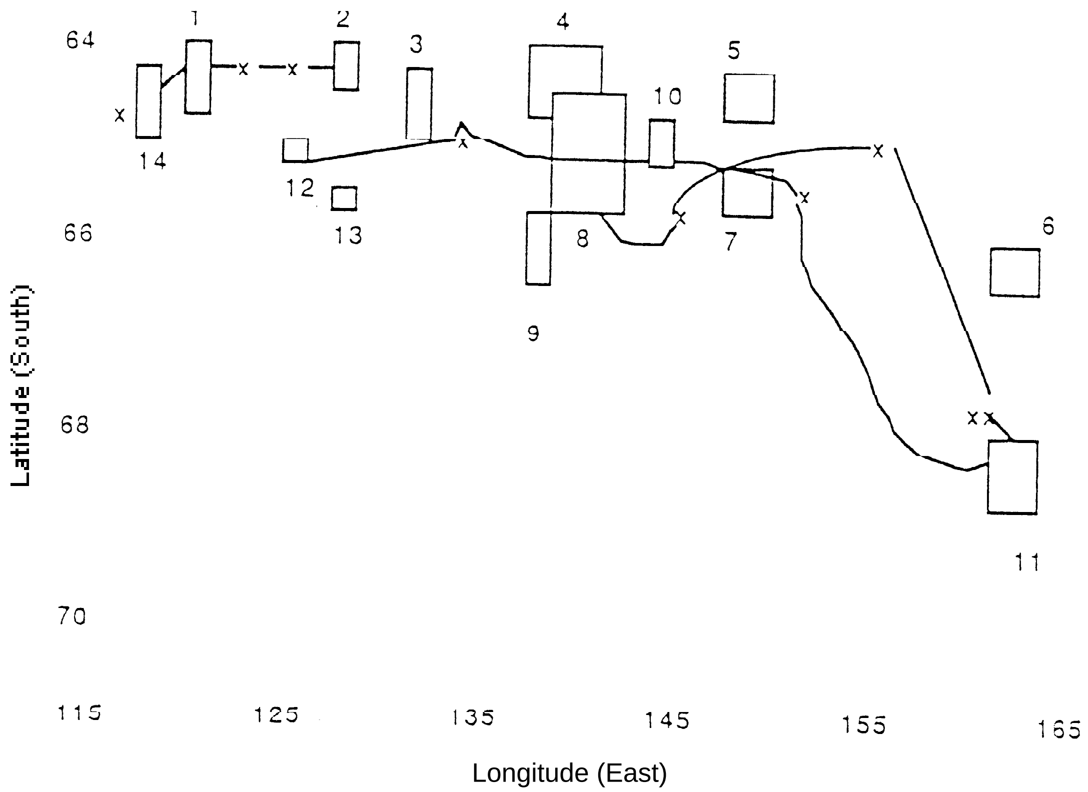

Figure 1: Concentration Map for data from research vessel *Mys Tihiy*. Concentrations are not drawn to scale. Data are taken from Mangel (WS-KCPUE-89/6).

Data from "*Mys Tihiy* 1980-81"

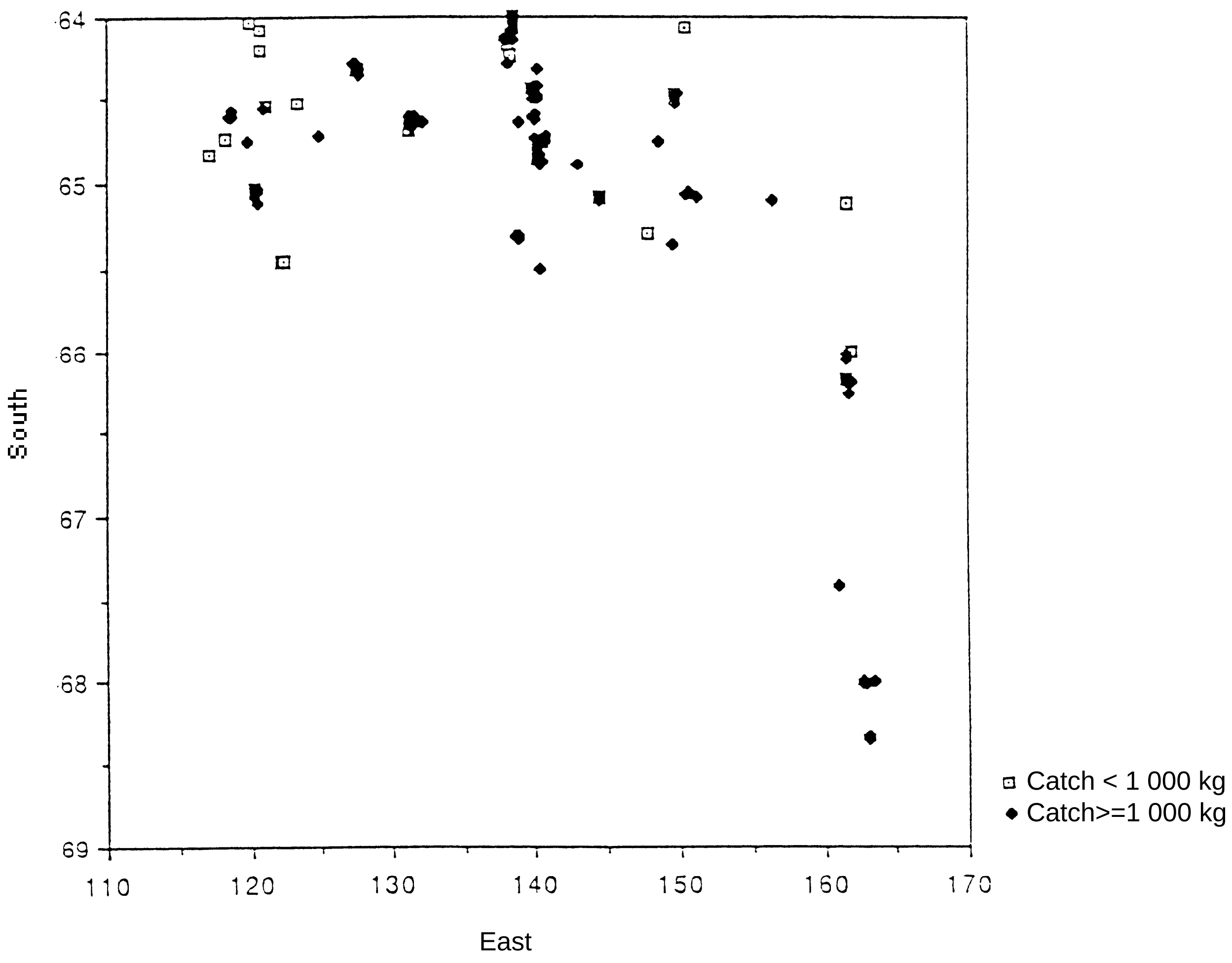

Figure 2: Haul-by-haul plot of the data used to generate the concentration map, with hauls separated by catch.

Data from “*Mys Tihiy* 1980-81”, Concentration 4

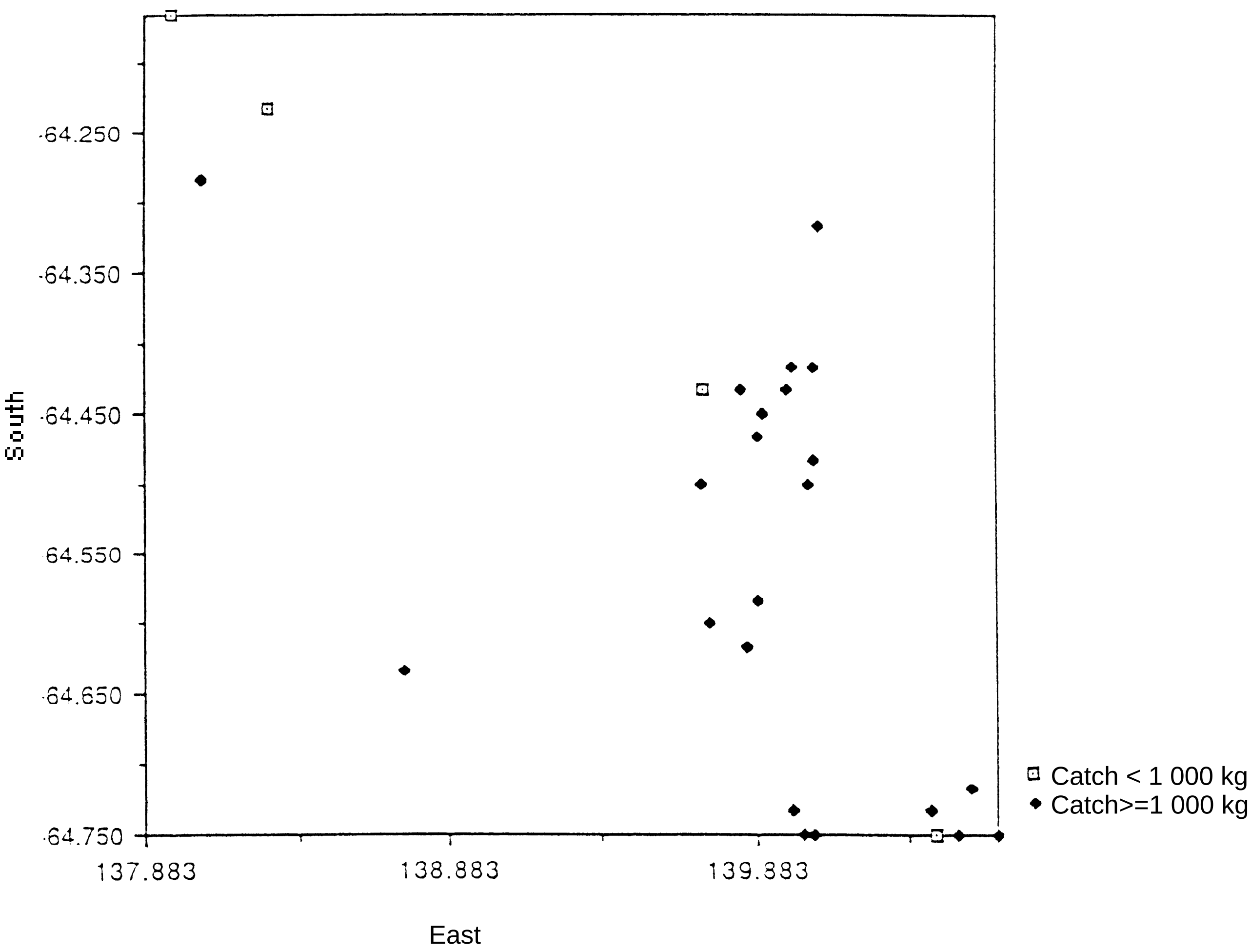

Figure 3: Haul-by-haul plot of the data from concentration 4.

Data from “*Mys Tihiy* 1980-81”, Concentration 8

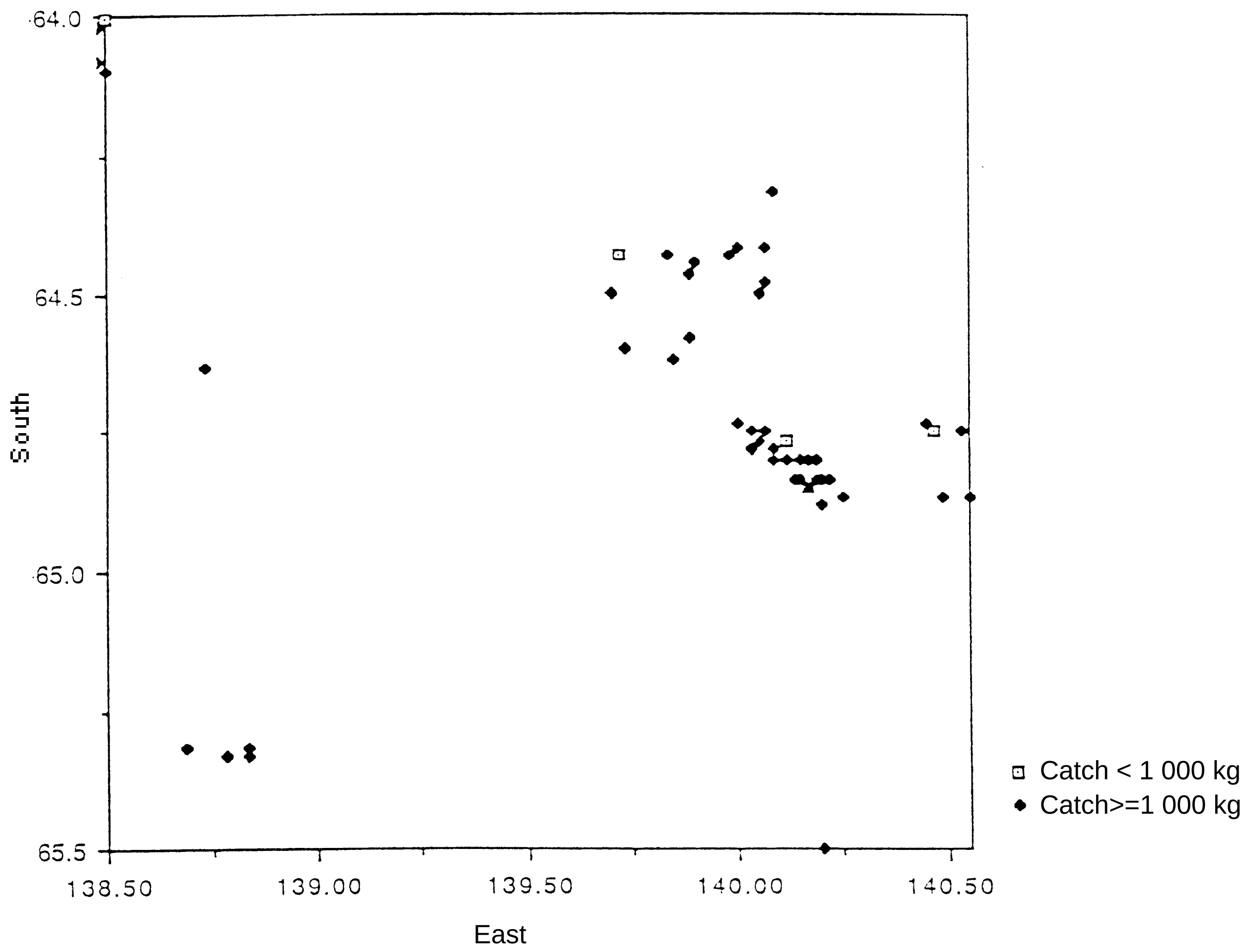

Figure 4: Haul-by-haul plot of the data from concentration 8

Data from “*Mys Tihiy* Conc Radii”

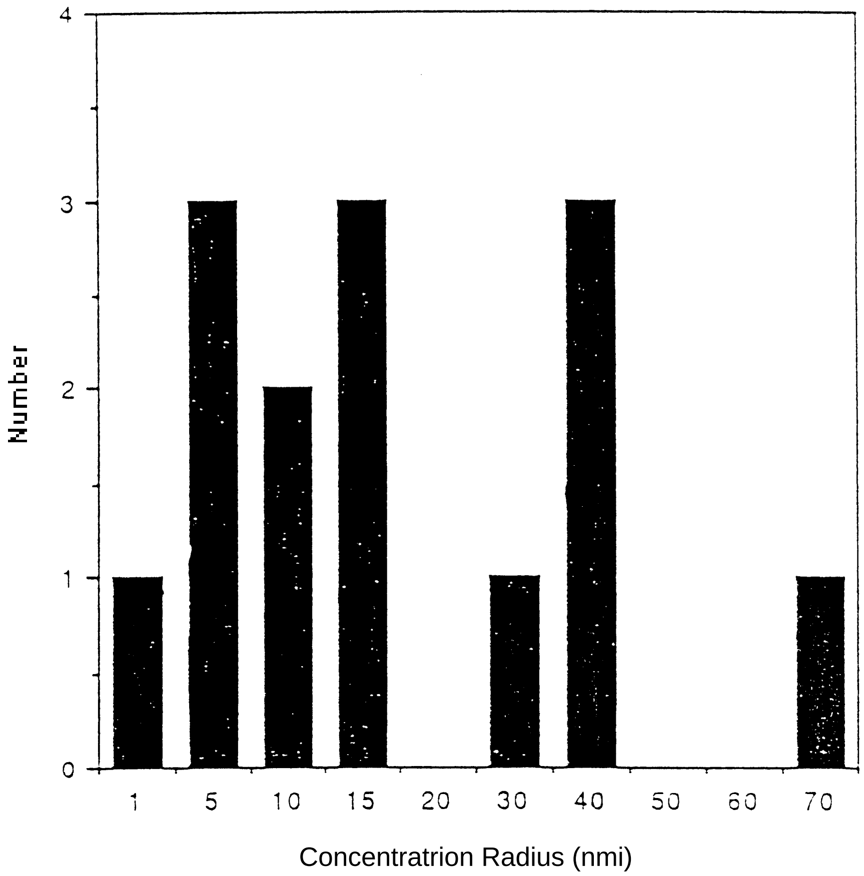

Figure 5: Histogram of concentration radii

Data from “*Mys Tihiy* Estimation”

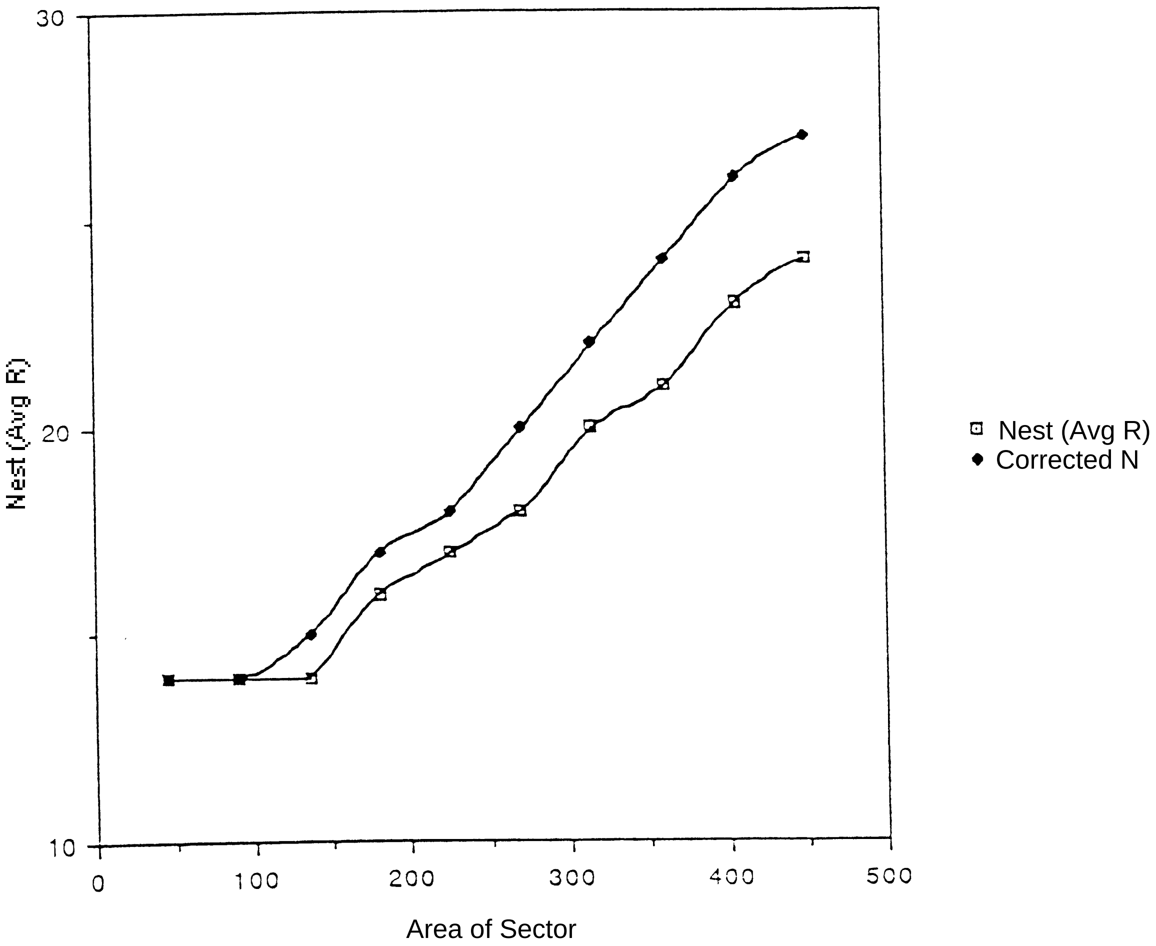

Figure 6: Estimated number of concentrations in the sector, $N_{c,est}$ (Avg R), using the average concentration radius, as a function of area of the sector. The lower curve corresponds to results from Eqn(1) and the upper curve corresponds to the results for Eqn(2), correcting the bias caused by a distribution of concentration radii.

APPENDIX 6

DETAILS OF MODIFICATIONS TO AND RESULTS FROM THE SIMULATION MODEL OF THE JAPANESE KRILL FISHERY UNDERTAKEN DURING THE WORKSHOP

INTRODUCTION

A particular problem that arose in the simulation study of the Japanese krill fishery (WS-KCPUE-89/4) was that the typical simulated fishing time required to make a catch from a single swarm was only about 15 minutes compared to the average period of one hour customarily reported for Japanese operations. Two reasons were offered during the Workshop to explain this anomaly. Firstly, the reported Japanese statistics were heavily influenced by results from fishing on good layers which require long tows, whereas fishing times on swarms in good aggregations are rather less than one hour. Secondly, swarms are not randomly distributed over these concentrations, but tend to clump together, i.e. there is positive spatial correlation of swarms in good aggregations. A group of swarms close together would be adjudged by the fishing vessel to be a single swarm with spatial dimensions much larger than those reported from scientific surveys and used in the simulation studies. The Workshop therefore addressed the questions of how this grouping effect could be taken into account by modifying the model, and whether this would change certain conclusions about the potential utility of various CPUE indices.

MODEL MODIFICATIONS

2. The major modification effected was to increase the median swarm radius (**r**) of 50 m used to describe the krill distribution in the simulation studies. Runs were carried out in turn for median **r** values of 100, 150 and 300 m. The motivation for this change was that groups of swarms seen as single units would be larger than the individual swarms, so that increasing the median **r** value in this way would be a simple (albeit approximate) way of taking this into account in the model.

3. However, increasing the median **r** value alone is inappropriate, as this soon leads to a proportional coverage of a concentration by krill swarms of more than 100% if no other distribution parameters are changed. Therefore, as median **r** was increased, the number of

swarms per unit area ($\mathbf{D_c}$) was decreased in such a way that the product $\mathbf{D_c r^2}$ remained constant. This means that the biomass of krill in the concentration and the proportion of the concentration covered by swarms remains the same as $\mathbf{r}$ is increased. This procedure was chosen because the objective of changing $\mathbf{r}$ was no more than to represent grouping of swarms within a concentration in a manner that would have the simulation model correspond to the fishermens' perception of 'swarms' within a good aggregation concentration. The values of $\mathbf{r}$ and $\mathbf{D_c}$ used in the analyses are shown in Table 1.

4. The original random search formula basis for computing primary search time (see paragraphs 44 and 45) was retained, although parameter values were adjusted as described below. The assumption of random search *per se* is questionable, because search in these concentrations may be more of the nature of directed search. However, even if search is directed, the time to travel from one group of swarms to another will increase if krill biomass drops because of a decrease in $\mathbf{D_c}$ and consequent increase in distance between groups of swarms. The random search formula gives similar results in these circumstances, so that it may be an adequate approximation for the purposes of this investigation.

5. The formula used to determine primary searching time was therefore:

Prob (detect swarm in time $\mathbf{t}$) = 1-exp(-wdvt)

where $\mathbf{v}$ = search speed (10 knots)

$\mathbf{d}$ = number of fishable swarms per unit area

$\mathbf{w}$ = $\mathbf{w_{sonar}} + 2\,\bar{\mathbf{r}}_{\mathbf{fs}}$

$\mathbf{w_{sonar}}$ = 2000 m

$\bar{\mathbf{r}}_{\mathbf{fs}}$ = mean radius of fishable swarms.

When a haul is repeated on the same swarm, a fixed 'primary searching' time of 10 minutes was used.

6. The effective search width was formulated as shown above to take account of the fact that larger swarms are more likely to be detected. As median $\mathbf{r}$ is increased, the typical size of swarms considered to be fishable would increase so that $\mathbf{w}$ would increase. The values used for $\bar{\mathbf{r}}_{\mathbf{fs}}$ were taken from the simulation model, though this parameter could be estimated from actual data if the radius of each swarm that is fished could be recorded. The parameter $\mathbf{d}$ is the product of two terms: the number of swarms per unit area ($\mathbf{D_c}$) and the proportion of these which are considered to be fishable. As median $\mathbf{r}$ is increased the first of these (S)

terms will decrease, but the second will increase. The net resultant effect is shown in Table 1 which also shows how the mean primary searching time (**wdv**)$^{-1}$ changes as median **r** is varied.

7. Only one other change to the parameters of the krill distribution model used in the Consultants studies (equation 11 of WS-KCPUE-89/4) was made. This involved the value chosen for the number of swarms per unit area ($\mathbf{D_c}$). The proportional coverage of the area of a concentration by krill swarms for the parameters used in these studies (50%) was felt to be unrealistically high. The problem was resolved by using the mean rather than the median swarm radius in calculating $\mathbf{D_c}$. For the case of a median **r** of 50 m, the mean radius is larger (90 m) because the distribution of radii is skewed. This mean value gives an estimate of approximately 10 swarms per n miles^2 when substituted in equation 10 of WS-KCPUE-89/4, compared to the 20 swarms per n miles^2 used in the calculations of WS-KCPUE-89/4. This new value for $\mathbf{D_c}$ implies a somewhat more realistic value of 25% for the proportional coverage of the concentration area by krill.

8. The particular model of the fishery for which computations were carried out during the Workshop is the 'one swarm per haul - no elongation' version described in WS-KCPUE-89/4. The fishing operation parameter values (both fixed and partially tuned) that were utilised are those of the first column of Table 2 of WS-KCPUE-89/4 with the following two exceptions. The minimum catch rate to remain in a concentration was set to a low value that would not be attained during the simulations. This was because only within-concentration statistics were of interest, so that there was no need to generate between-concentration search statistics. The repeat-haul-on-a-swarm criterion was changed from 50 tonnes/hour to 40 tonnes/hour to better reflect the reported estimate of a repeated haul attempt rate of 40% (see Table 3, WS-KCPUE-89/4) for the range of krill distribution parameters considered. Only 50 rather than 100 simulations were run for each scenario considered to save on computer time costs. This still provides adequate precision for estimates of within-concentration statistics.

RESULTS

9. The results of runs of the Japanese fishery simulation model modified as above in terms of the behaviour of CPUE indices are shown in Table 2. As the median **r** is increased from 50 m to 300 m, the average length of a swarm through which a haul is made, increases from about 0.3 n miles to 0.6 n miles and the average fishing time per haul (the time the net is at the desired depth, excluding lowering and raising times) increases from about 13 minutes to 23 minutes. Mr Ichii advised that although tows on good layers involved an average

fishing time of one hour, fishing times of about 20 minutes were typical for tows on good aggregations.

10. It seemed, therefore, that increasing the median **r** value did lead to model estimates of fishing time that were comparable to reality in good aggregation concentrations.

11. Table 2 shows that the efficiency of the CPUE indices listed to detect biomass reductions is hardly affected as the median **r** value is increased. It is clear that the performance of indices using Primary Searching Time (PST) only is much superior to those using the combination of Primary and Secondary Search Time (PST + SST). The latter have hardly any utility except a very weak ability to detect decreases in $\mathbf{D_c}$. Unfortunately (see paragraph 62 of the Workshop Report), only the latter combination could be collected routinely, as the PST component could not be distinguished in practice.

12. Thus, although indices involving fishing times could be used to monitor biomass reductions that are the result of a decrease in δ, use of indices based on total-within-concentration searching time (PST + SST) do not appear to be adequate to detect changes in **r** or $\mathbf{D_c}$.

INDICES BASED ON A MODIFICATION OF TOTAL SEARCHING TIME

13. Results given in Table 11 of WS-KCPUE-89/4 had shown that indices based on PST still performed well even if PST was estimated with considerable error, provided the estimation was unbiased.

14. This suggested that an approximate means of inferring the PST component from data on PST + SST might provide indices whose performance in detecting biomass reductions might not be substantially reduced from that of the (impractical) PST-based indices.

15. What is required is to subtract some estimate of SST from the PST + SST combination which can be measured. The SST required depends on the size of the catch from the previous haul because of processing time requirements, so that an approximate estimate of SST might be provided by some multiplier (μ) of this catch. Thus, Pseudo Primary Searching Time (PPST) was defined as the time between the end of one haul and the beginning of the next, less μ times the previous catch (**C**). The specific formula used was:

$$\text{PPST} = \max \begin{cases} \text{PST} + \text{SST} - \mu\,(\text{C} - 0.75 \times 5) \\ 3 \text{ minutes} \end{cases}$$

The reason that **C** is reduced by 3.75 tonnes is to allow for the fact that the simulation model starts the next haul (i.e. ends SST) 0.75 hours before processing of the last catch (at a rate of 5 tonnes per hour) is complete. The multiplication factor μ was chosen empirically to be 0.17 to provide good performance of the resultant CPUE indices. The minimum value of PPST for each haul of 3 minutes was introduced to avoid unrealistically small (or negative) values of PPST. It was recognized that an analysis of this sort constituted only an examination of whether such an approach might work in principle. In any practical implementation, the multiplier would need to be changed depending on the product being produced.

16. The results of the runs carried out for indices based on PPST are also shown in Table 2. Although these indices are not as effective as those using PST at detecting changes in $\mathbf{D_c}$, they perform considerably better than those which used PST + SST. Further, the efficiency of these indices improves as median **r** is increased above 50 m, which is considered to be a more realistic representation of krill distribution in a good aggregation concentration. Similar comments apply to the ability of PPST based indices to detect changes in **r**, except that the sensitivity is not as large as for $\mathbf{D_c}$.

17. The value of μ chosen for the calculations carried out was selected to attempt to achieve the best possible results in terms of sensitivity of PPST indices to biomass reductions for the particular simulation model used to represent the fishery. In reality, the parameters of this model would not be known exactly so that the value of μ used may not be optimal. Therefore, the sensitivity of the results regarding detection of changes in $\mathbf{D_c}$ was investigated for different values of μ.

18. Calculations were repeated for a number of smaller values for μ. The results of these calculations are shown in Table 3. In the simulation, the inverse of the processing rate was 0.20 hours per tonne. The value of μ is bounded above by this inverse rate, and the results show that indices involving PPST are reasonably responsive to changes in $\mathbf{D_c}$ for values of μ down to at least 0.10, which is one half of this upper bound. This wide range suggests that indices based upon PPST would retain their utility even if a value for μ which is not ideal was used.

19. Thus it seems that there is potential for search time information to be used to detect changes in $\mathbf{D_c}$ and **r.** The search time data required will involve little more data collection

than is already carried out in the Japanese fishery. These operations routinely record the time at which fishing ends for one haul and the time it begins for the next. The difference between these times is (PST + SST + the time required to raise then lower the net). These last net handling times are relatively constant from one haul to the next. Therefore PPST could be calculated simply from these data, provided information was also recorded on changes in processing rate and interruptions to the normal searching and fishing activities. Different values of μ would need to be used as the processing rate changes because a different product is being produced. Interruptions may occur, for example, because of bad weather.

LIKELY PRECISION OF CPUE INDICES INVESTIGATED

20. Figure 1 shows the relationship between the CPUE index TC/TFISHT and biomass, where the biomass changes as a result of a change in within-swarm krill areal density δ only. The non-linearity of the relationship is clear from the plot. The change in TC/TFISHT does not reflect the full extent of any biomass reduction.

21. Error bars, corresponding to 95% confidence intervals, are also shown in Figure 1. These have been derived from estimates for the standard error of the mean of the index for 50 simulation runs of the model each corresponding to a 15 day period. This is equivalent to 25 vessel-months, which is approximately the effort currently being expended by the Japanese Antarctic krill fishing fleet.

22. The specific confidence intervals illustrated in the plot correspond to the ratio of the CPUE index over two years. Thus, if δ dropped by 50% from one year to the next, these results indicate that for the level of catch taken by the Japanese fleet, the TC/TFISHT index would be 95% certain to drop by between 31% and 41%.

Table 1: Parameters used in random search formula for swarms as median **r** is increased. The search speed **v** is 10 knots throughout. The selectivity is fixed throughout, with fishable swarms being those within a biomass greater than 50 tonnes, which constitute a fraction **S** of the total number of swarms. The average Primary Searching Time for a swarm is $\bar{\mathbf{t}}$.

Median r m	$\bar{r}_{fs}$ m	$w=2000+2\bar{r}_{fs}$ m	D_c n miles^{-2}	S	$d=D_cS$ n miles^{-2}	$\bar{t}=(wdv)^{-1}$ min
50	372	2744	10	.076	0.760	5.3
100	515	3030	2.5	.183	0.458	8.0
150	628	5256	1.11	.277	0.307	11.1
300	936	3872	.278	.475	0.132	21.7

Table 2: Sensitivity **s** of various CPUE indices **I** for different biomass change scenarios. If **I(1)** is the value of the index for the base case distribution parameters, and **I(0.5)** corresponds to a biomass decrease of 50% through a change in the parameter indicated, then:

$$s = 2(1- I(0.5)/ I(1))$$

Thus **s=0** means that the index shows no change when the biomass is reduced in this manner, whereas **s=1** means that the index value falls by the same relative amount as the biomass (as would be the case for a linear CPUE-biomass relationship). The meanings of the components of the CPUE index are as follows:

TC = Total catch

TFISHT = Total fishing time

TPST = Total primary searching time*

TSST = Total secondary searching time

$\overline{PST}$ = Average primary searching time per haul

TPPST = Total pseudo primary searching time (μ = 0.17 hr/tonne)

(a) Biomass reduction through swarm radius $r \rightarrow r/\sqrt{2}$

Median r (m)	50	100	150	300
Index				
TC/TFISHT	-.19	-.30	-.27	-.26
TC/TPST*	.57	.50	.57	.45
TC/(TPST+TSST)	.05	.07	.11	.14
$TC/(TFISHT*\overline{PST})$*	.43	.29	.38	.23
$TC/(TFISHT*\overline{PST+SST})$	-.14	-.19	-.13	-.13
TC/TPPST	.20	.28	.37	.43
$TC/(TFISHT*\overline{PPST})$	.02	.03	.16	.20

* Collection not practical

(b) Biomass reduction through krill areal density as within-swarm $\delta \rightarrow \delta/2$

Median r (m)	50	100	150	300
Index				
TC/TFISHT	.61	.72	.79	.67
TC/TPST*	.77	.89	.84	.64
TC/(TPST+TSST)	-.05	-.02	.08	.16
$TC/(TFISHT * \overline{PST})$*	1.02	1.11	1.12	.90
$TC/(TFISHT * \overline{PST+SST})$	.35	.38	.53	.53
TC/TPPST	.47	.72	.78	.68
$TC/(TFISHT * \overline{PPST})$	.77	.97	1.07	.94

* Collection not practical

Table 2 continued

(c) Biomass reduction through number of swarms per unit area $D_c \rightarrow D_c/2$

Median r (m)	50	100	150	300
Index				
TC/TFISHT	.06	.07	-.20	-.10
TC/TPST*	.78	.83	.90	.87
TC/(TPST+TSST)	.10	.13	.30	.41
$TC/(TFISHT * \overline{PST})$*	.80	.83	.82	.80
$TC/(TFISHT * \overline{PST+SST})$	.13	.12	.20	.35
TC/TPPST	.40	.57	.67	.81
$TC/(TFISHT * \overline{PPST})$	.42	.56	.57	.74

* Collection not practical

Table 3: Sensitivity **s** of PPST-based CPUE indices to a reduction in $\mathbf{D_c}$ to $\mathbf{D_c/2}$ for various values of the multiplier μ of the catch subtracted from total searching time.

Index	TC/TPPST		$TC/(TFISHT * \overline{PPST})$	
μ (hr/tonne)	Median r = 50 m	Median r = 300 m	Median r = 50 m	Median r = 300 m
0.17	.40	.81	.42	.74
0.15	.29	.71	.32	.65
0.10	.18	.56	.20	.50
0.05	.13	.47	.15	.41

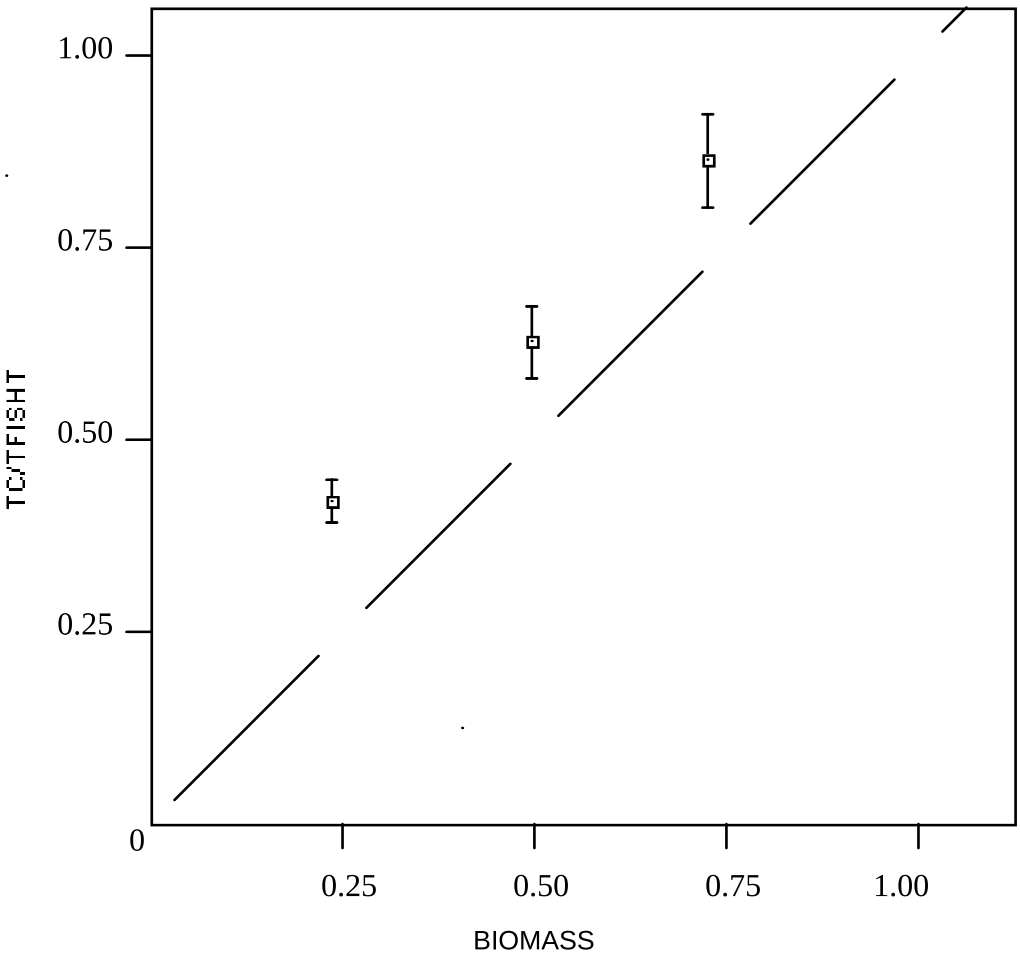

Figure 1: Plot of the TC/TFISHT index as a function of biomass when the biomass reduction is as a result of a decrease in within swarm krill areal density δ. The variables on both axes are shown as fractions of their base case levels for median **r=100 m**.

FRAMEWORK FOR A SIMULATION STUDY OF A COMPOSITE INDEX OF KRILL ABUNDANCE

The majority of discussion in this appendix concerns the Composite Index of Krill Abundance in good aggregation concentrations. An index of krill abundance in good layer concentrations is described at the end of this section.

2. A Composite Index of Krill Abundance should be constructed only on an area by area basis. The selected area should have a number of properties:

- It should be relatively homogeneous, so that one can justify ‘multiplying up’ the data collected in this area;

- Both survey and fishing vessels should operate in this area.

3. The Composite Index will be a relative measure of biomass, and hence should be constructed in ecologically sensitive areas. An example of such a region is the shelf boundary.

4. The Composite Index is given by

$$CI = N_c L_c^2 D_c r^2 \delta \tag{1}$$

In this equation, **CI** denotes the Composite Index and

N_c = number of concentrations in the area of interest
L_c = characteristic radius of concentrations
D_c = number of swarms per unit area in a concentration
r = characteristic radius of swarms in concentrations
δ = areal density of krill within swarms. (2)

5. The purpose of the simulation study of a Composite Index is to determine if such an index can monitor krill biomass effectively. It is most likely that the Composite Index will be a nonlinear function of krill biomass. The nonlinearity is likely to be such that if the index

shows a statistically significant change, then the biomass has changed by an even greater amount than the index so that krill abundance has altered markedly.

6. Since the variance of the Composite Index will depend upon the variance of the underlying variables, it is crucial to understand how these parameters both vary and can be estimated and how errors in the estimates affect the Composite Index. That is, the actual Composite Index is not given by Eqn(1), but is given by

$$CI = N_{c,est} \, L^2_{c,est} \, D_{c,est} \, r^2_{e\,st} \, \delta_{est} \tag{3}$$

where the subscript 'est' on each of the variables on the right hand side indicates that these variables are estimated.

7. The Composite Index of Krill Abundance when krill are in layers is given by

$$CI_{layer} = N_{cl} \, L^2_{c\,l} \, \delta \tag{1'}$$

where $\mathbf{N_{cl}}$ is the number of concentrations in which krill are in layers, $\mathbf{L_{cl}}$ is the characteristic length of such concentrations and δ is the density of krill in such concentrations. The general principles described below apply to krill in layers, with appropriate modification.

CURRENT KNOWLEDGE ABOUT UNDERLYING PARAMETERS, SOURCES OF UNCERTAINTY AND ESTIMATION

Number of Concentrations

8. Survey vessel data can, with appropriate mathematical analyses, be used to estimate the number of concentrations in a region. By adapting the methods described in Mangel and Beder (1985) to the situation in which depletion does not occur, one can compute the probability distribution of $\mathbf{N_{c,est}}$ as a function of the number of discoveries by the survey vessel.

9. Difficulties with the estimation of $\mathbf{N_c}$ include:

(i) double counting concentrations during the survey process;

(ii) accurate determination of vessel search speed and searching time;

(iii) accurate and confident determination of the effective detection width of concentrations; and

(iv) the non-random distribution of concentrations and associated stratification of search effort.

10. Currently, very little is known about the distribution of concentrations in ecologically sensitive areas. To improve knowledge of this variable, concentrations should be defined while at sea using the echochart, rather than *post-hoc* in a statistical analysis.

Characteristic Length of Concentrations

11. The use of a single characteristic length for concentrations presumes that either concentrations are symmetrical (e.g. circles or squares), or are not symmetrical (e.g. ellipses) but that if abundance changes then all axes of the ellipse will change in the same proportion. It is not known whether this assumption is valid and this matter deserves further attention.

12. The characteristic length of concentrations can be determined by using the detailed location data from Soviet and Japanese fishing activities. In particular, such vessels could attempt to determine:

- concentration shape; and
- concentration characteristic length.

13. At the present time, very little is known about the distribution of sizes and shapes of concentrations. In their simulation models, the Consultants assumed that diameters were uniformly distributed over the approximate range of 11 n miles to 22 n miles. Discussions at the Workshop suggest a number of modifications:

- good concentrations are at least 25 n miles in diameter;

- concentration radii have a skewed distribution, rather than a uniform distribution; and

- in a region such as the shelf edge, the relevant variable is the width of the concentration across the shelf, rather than length along the shelf.

Density of Swarms Within Concentrations

14. The density of swarms within concentrations (i.e. the number of swarms per unit area) can be estimated using Japanese logbook data or using acoustic data collected by scientific survey vessels. In poor concentrations, the distance between swarms may follow a negative exponential distribution (e.g. Miller and Hampton, 1989). In good aggregations, the negative binomial distribution, a typical aggregated distribution, might be used to model $\mathbf{D_c}$.

15. The Consultants assumed that $\mathbf{D_c=20exp(X_{.1})}$ swarms/ n miles^2, where $\mathbf{X_\sigma}$ is a normally distributed random variable with mean 0 and variance σ^2. The general feeling at the Workshop was that:

- The distribution of densities of swarms within concentrations should be relatively easily determined from echocharts.

16. In addition, there should be only modest variation in density of swarms within concentrations. If krill are indeed in swarms (versus layers), then the density cannot be too low, since in that case the krill would not be in a 'good' (i.e. fishable) concentration. Similarly, if the value of density is very high, then the krill are not in swarms, but are essentially in layers. These effects will constrain the variance.

Characteristic Radius of Swarms within Concentrations

17. This variable would be most effectively determined using acoustic information collected by survey vessels, although data collected by fishing vessels could be used as well. Full discussion of the distributional properties of **r** was referred to the Working Group on Krill. However, the following points emerge.

18. The Consultants assumed that $\mathbf{r= 50\ exp(X_{1.1})\ m}$, which leads to considerable skewness in the value of **r**. Six examples of towed swarm size distributions are given by Ichii (1987). In a region that was approximately 60 n miles in north-south extent and 60 n miles in east-west extent, Ichii's data (Figure 1) suggest four instances of swarm radii following an apparently negative exponential distribution, one instance of swarm radii following an approximately uniform distribution and one instance of swarm radii following a highly skewed distribution with minimum size 3 000 m. These kinds of results suggest that swarm radii may vary considerably over relatively small geographic areas and that the accurate determination of this variability is important.

Krill Density Within Swarms

19. The areal density of krill within swarms (i.e. g/m^2) can be determined from both Soviet and Japanese fishing vessels, using catch per fishing time as an index. Acoustic data could also be used, but **only if mean volume backscattering strength is reported**. This is required, even for a relative abundance index, in order to calibrate data from one vessel to the next.

20. The Consultants assumed that $\boldsymbol{\delta = 150 \exp(X_{1.4})}$ **g/m²**, which leads to considerable skewness in the distribution of densities. In concentrations that are fished, however, the density may be less variable, since the fishermen select concentrations on the basis of achieving a satisfactorily high catch rate. This same operational behaviour will reduce the ability of a Composite Index to detect changes in abundance.

GENERAL CONSIDERATIONS REGARDING THE COMPOSITE INDEX

21. Since $\mathbf{L_c}$ and **r** are squared in the Composite Index, uncertainties in either of these values will have proportionately greater effects than uncertainties in $\mathbf{N_c}$, $\mathbf{D_c}$ or δ.

22. At the current time, there is little known about the correlation between parameters. For example, it might be that krill biology forces the product $\mathbf{D_c}\ \mathbf{r^2}$ to be approximately constant.

23. There is also little current knowledge about the way that abundance changes may be manifest. That is, each of the five underlying variables may change independently, or there may be considerable covariation between them.

24. Since the Composite Index will most likely be a nonlinear function of abundance, the variance properties of the index become extremely important if it is to be used for monitoring abundance.

A PROTOCOL FOR A SIMULATION STUDY OF THE COMPOSITE INDEX

25. A possible protocol for a simulation study of the Composite Index involves the following steps:

(a) Choose fundamental values for the underlying distribution parameters. These can be viewed, for example, as the means or medians of these parameters;

(b) For each iteration of the simulation, use the distributional properties just described to determine particular values for each of the underlying parameters in that iteration. The biomass index **BI** for this particular run of the simulation will then be given by Eqn(1). Note that **BI** is the 'true' abundance index, as distinct from **CI** which is an estimate of this index;

(c) For each iteration of the simulation, use the distributional properties of the estimated variables and models developed by the Consultants to determine estimated values of the underlying variables, given the true values of the underlying variables. Once these estimated variables are constructed, the 'observed' Composite Index is given by Eqn(3); and

(d) Study the properties of **CI/BI** as a function of **BI** and as the underlying parameters are varied. In this way, one can consider both the nonlinearity and the variance of the Composite Index.

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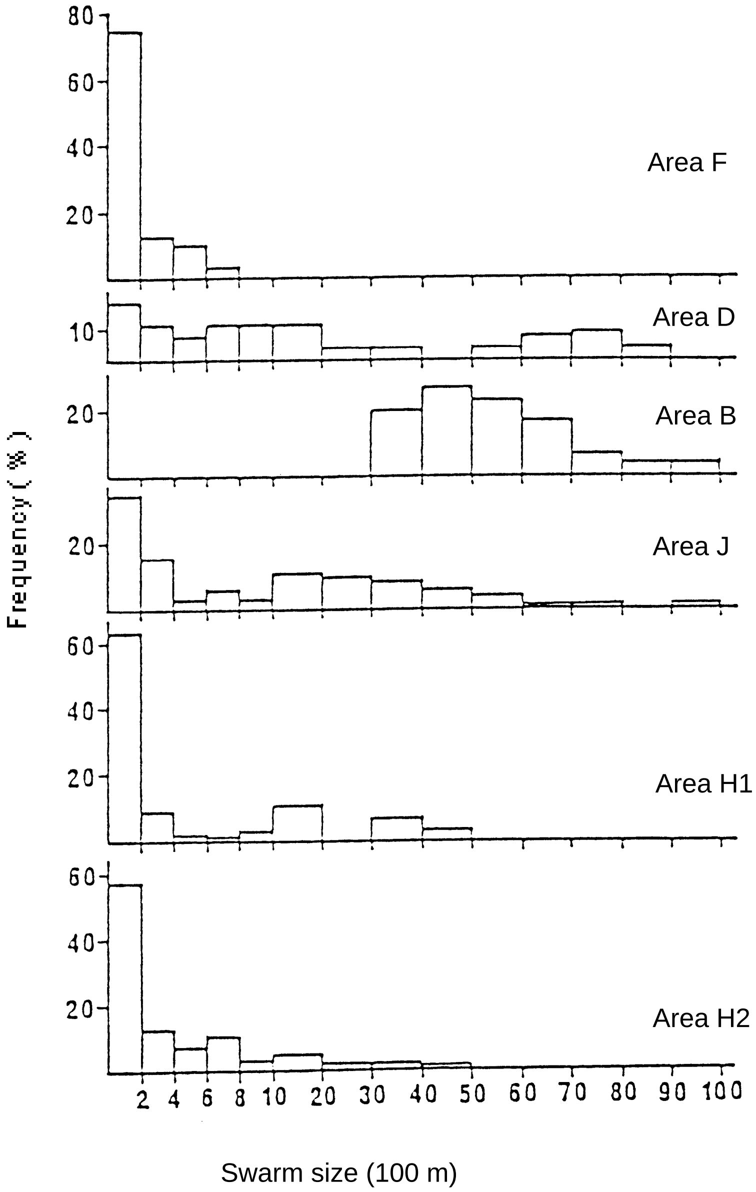

Figure 1: Frequency distributions of swarm sizes towed in each fishing area (Ichii, 1987)

ANNEX 5

REPORT OF THE FIRST MEETING OF THE WORKING GROUP ON KRILL

(Southwest Fisheries Centre, La Jolla, California, USA, 14 to 20 June 1989)

REPORT OF THE FIRST MEETING OF THE WORKING GROUP ON KRILL
(Southwest Fisheries Centre, La Jolla, California, USA, 14 to 20 June 1989)

INTRODUCTION

The meeting of the Working Group was held at the Southwest Fisheries Centre of the National Marine Fisheries Service, La Jolla, California, USA, from 14 to 20 June 1989. The Convener, (Mr D.G.M. Miller), chaired the meeting.

2. A provisional agenda, distributed before the meeting was amended to include two new subitems under 'Other Business'. One to consider a request from the Convener of the Commission's Working Group for the Development of Approaches to Conservation of Antarctic Marine Living Resources (WG-DAC), and another to include an item suggested by the US Delegation at SC-CAMLR-VII on strategic planning in the context of the Working Group's terms of reference. The subitem of the provisional agenda, 'Evaluation of impact of fishing on krill stocks', was included in item 4 under a new title 'Krill fisheries and the impact of fishing'.

3. The amended agenda was adopted (Appendix 1). A list of participants (Appendix 2) and a list of meeting documents and references (Appendix 3) are attached.

4. Responsibility for the preparation of the Working Group's report was assigned to the following rapporteurs: Drs I. Everson, E.J. Murphy, D.L. Powell and J.L. Watkins.

5. The Convener outlined the broad objectives (WG-KRILL-89/3) for the Working Group's First Meeting based on its terms of reference (SC-CAMLR-VII, paragraph 2.26). The Working Group agreed that at this, the first meeting, it was important to take full account of Article II in developing approaches and procedures for management and conservation of krill. It was acknowledged that there was a risk of giving too much attention to the assessment of fishing on the krill stocks and not enough to the impact on dependent and related species.

6. It was agreed that because of the complexity of the task and the current state of knowledge, it would be necessary to break the task into tractable parts, while remaining conscious of the total problem. That is to say, focusing on a single species (i.e. krill) initially with a view to extending the task to include dependent and related species as information

becomes available. It was agreed that when tendering advice which was based on a single species approach, it should be clearly stated that interactions with dependent and related species had not been taken into account.

7. The Working Group agreed that the terms of reference were clear in requiring advice leading to decisions on the management of the krill fishery. There was some discussion on the need for a management ‘strategy’ or ‘procedure’ for krill. The Working Group concluded that at the present stage in its work it was premature to develop a formal management procedure for krill. The recommendations of this meeting taken together therefore constitute a structured approach to the management task. The process will be refined as the Working Group’s work progresses.

METHODS FOR ESTIMATING KRILL DISTRIBUTION AND ABUNDANCE

8. The Working Group recognised that considerable data on krill abundance and distribution have been collected to date, both through national and international programs. In addition, the commercial krill fishery provides data on krill abundance and distribution.

9. Dr John Beddington, Convener of the Workshop on the Krill CPUE Simulation Study (WS-KCPUE), summarised the proceedings of the Workshop. The Working Group agreed that a number of questions arising from the Workshop were pertinent to the terms of reference of the Working Group on Krill.

10. In particular, the Working Group noted that the combination of data from the Japanese and Soviet fishery provides information that allows the calculation of a Composite Index of Krill Abundance. This index is based on measuring certain parameters of swarms and concentrations (Appendix 4). The Working Group decided to focus its discussion on the Composite Index of abundance as a way of addressing the problems associated with krill abundance estimation.

Acoustics

11. Acoustic techniques can be used to provide information on all the parameters of the Composite Index. The information obtainable with different types of acoustic equipment is summarised in Table 1. The Working Group emphasised that collection of additional

information on krill aggregations was essential. In this respect, it was agreed that information on the depth of swarms from the surface, the vertical thickness of swarms and the interswarm distances were important.

12. The Working Group attached considerable importance to the estimation of krill abundance and spatial patterns by acoustic techniques. The practical and operational considerations associated with acoustic estimation of krill consequently are reported in detail.

13. Acoustic data can be used to estimate both the relative and absolute density of krill. Reasonable estimates of relative density are directly derivable from echo-integrator outputs. Absolute density estimates can also be derived through echo-integration, but a representative mean backscattering cross section ($\bar{\sigma}$) or scaling factor must be used to convert relative estimates to absolute estimates of number density (number-per-unit volume or number-per-unit area) or biomass density (mass-per-unit volume or mass-per-unit area), respectively. The mean backscattering cross section and scaling factor may each vary with the size, distribution, behaviour (e.g. orientation) and physiological condition (e.g. nutritional, reproductive state) of krill detected and insonified. These quantities will also generally vary with the frequency of sound. Controlled measurements on *Euphausia superba* need to be conducted to ensure accurate absolute density estimates.

14. Absolute estimates of number density require knowledge of the mean backscattering cross section (see Appendix 5 for definition of $\bar{\sigma}$). As stated above, backscattering cross section is likely to be a function of krill size, behaviour and physiological condition. Previous studies with zooplankton suggest that size is the most important of these factors (i.e. explains the greatest proportion of the variance associated with acoustic detection of krill abundance). Hence, the Working Group recognised the need for controlled measurements to develop a functional relationship between the mean backscattering cross section and krill size.

15. With this relationship, net catch data on the distribution of krill sizes can be converted to a representative distribution of backscattering cross sections. From this distribution, the mean backscattering cross section can be derived and an absolute estimate of krill number density computed. Furthermore, this absolute number density estimate can be apportioned to different size classes, thus providing estimates of the absolute number density for each size class of krill.

16. In addition to the above procedure for estimating absolute number density by size class, an entirely acoustically based method of determination may also be feasible. In this case, rather than relying on net catch data, the mean and distribution of the backscattering cross sections are derived by *in situ* target strength (TS) estimation techniques (see Appendix 5 for definition of **TS**). These techniques include both 'dual-beam' and 'split-beam' methods. The key to using either of these techniques in studies of krill is to deploy the acoustic transducers sufficiently close to the animals to resolve individual scatterers. Surface deployment on ship's hulls or towed bodies are inadequate and other methods of deployment should be explored (on nets, deep-towed bodies or remotely operated vehicles). Information on the use of acoustic instrumentation on fisheries trawls, published within ICES was noted (Council Meeting Reports and Journal du Conseil).

17. Absolute estimates of biomass density require accurate estimation of a scaling factor to relate volume backscattering strength to biomass. As with backscattering cross section, this scaling factor is generally a function of krill size, behaviour and physiological condition. There is some evidence from other acoustic studies on crustacean zooplankton that treating this factor as a constant may be a reasonable first approximation. Controlled measurements, combined with sensitivity analyses, are necessary to justify this approximation. If the errors introduced by this approximation are negligible (i.e. small relative to other errors), then estimates of absolute biomass density could be made in the field using only acoustic methods. Information on the size distribution and absolute number density would require the additional procedures described in paragraphs 15 and 16.

18. The Working Group recognised a number of potential problems in the acoustic measurement of krill density. These include non-detection of animals below the acoustic threshold, the occurrence of animals out of range of the sounder either near the sea surface or under ice, inadequate determination of target strength, inadequate calibration of acoustic instrumentation and limited identification of acoustic targets.

19. Problems associated with the determination of krill target strength were addressed in a presentation by Dr K.G. Foote. The results of recent experiments conducted in austral summer 1987/88 with I. Everson, J.L. Watkins and D.G. Bone, to determine the target strength of Antarctic krill were presented (see also WG-KRILL-89/4). Caged aggregations of krill were insonified over periods ranging from 15 to 65 hours. The values of the target strength obtained at 120 kHz were at least 10 db lower than those previously reported and used for the analysis of krill acoustic data. Values measured at 38 kHz were approximately 20 db lower than those previously reported and used at 50 kHz. Independent measurements of sound velocity and density were also used to calculate the target strength based on a

scattering model (Greenlaw, 1979). Results obtained from this approach were consistent with those from the experiments on caged aggregations and this work is being published.

20. The Working Group noted that a 10 db reduction in individual target strength at 120 kHz would involve a tenfold increase in estimated biomass. The 20 db at 38 kHz would result in a hundredfold increase.

21. The Working Group recognised that as a result of this most recent work, the target strength of krill has been much more rigorously defined, although work to define the dependence of target strength on length, orientation and animal condition is still necessary. It was also emphasised that with the technology currently available for work in the Southern Ocean, the estimation of number density still requires net samples in order to determine the size distribution of animals in the population being studied.

22. Developments in echo-sounders were discussed. The next generation of echo-sounders and integrators being developed in Norway was described by Dr Foote. Several other members of the Working Group provided information on equipment being used or developed elsewhere. Details are provided in Appendix 6.

23. While a new generation of echo-sounders and integrators will significantly increase the acoustic capabilities of research vessels, the Working Group recognised that for the foreseeable future a large number of vessels will continue to utilise the present generation of equipment.

24. A simple outline of procedures which could be adopted by research and survey vessels to collect and process acoustic data was drawn up (see paragraph 79 and Appendix 7). This would provide potentially useful information for the Working Group. The approach outlined is based on that used by Dr M. Macaulay (WG-KRILL-89/10).

25. The Working Group also recognised the need to archive the original records of raw data on as fine a scale as possible and in such a way that they cannot be changed. It would also be advantageous to standardise units, formats and media on which data are stored in order to facilitate the exchange of data and analysis software between researchers involved in acoustic surveys on krill.

26. In conclusion the Working Group emphasised the potential of acoustics to provide crucial information:

(a) in areas where there is no krill fishery; and
(b) for the Composite Index in fishery areas (Appendix 4).

Nets

27. The Working Group recognised that net hauls are essential for the verification of acoustic data on krill (i.e. for target identification and to obtain representative length frequency distributions) and that catch data can also provide essential information for independent estimates of abundance.

28. When using nets for acoustic target verification, the Working Group emphasised that it is important to establish the underlying size selectivity characteristics of the equipment being used. Discussion highlighted the need for considerable additional work to be done on size selectivity factors for various nets currently being used. For instance, a comparison of a Japanese commercial fish trawl (560 m^2) with a (KYMT) research trawl (9 m^2) showed no detectable difference in mean body length of krill in catches taken with either. In contrast, a comparison of a German pelagic trawl with RMT8 catches indicated that for krill larger than 45 mm the trawl collected more krill than the RMT while the opposite occurred for krill smaller than 45 mm in length.

29. It is therefore unlikely that a single net will sample all size classes of krill representatively and it would be premature to recommend a single net for such studies. A summary of the known characteristics and problems associated with the nets most commonly used in the Antarctic is given in Table 2.

30. There is little information on inter-net comparisons for Antarctic krill and such studies would be valuable. In addition the design of new nets to overcome or reduce the problems associated with net selectivity should be encouraged.

31. The Working Group also recognised that when using nets to estimate abundance, net avoidance and integration of areas containing no krill as well as catch selectivity effects, are all potential sources of errors.

32. The Working Group recognised that even large nets may be subject to avoidance problems and the unqualified use of nets for krill abundance estimates is not encouraged for the reasons set out in paragraph 31.

Other Direct Methods

33. Methods using cameras or remotely operated vehicles to directly observe krill were discussed. It was felt that at present although such techniques may be useful for calibration of other methods (e.g. catch data from nets), they generally operate over too restricted a spatial scale to be of widespread use.

Indirect Methods

34. The Working Group agreed that the Krill CPUE Simulation Study (WS-KCPUE-89) has demonstrated that commercial catch and effort data may have some utility in relative abundance estimates.

35. Other indirect methods such as surveys of egg numbers, larvae or cast exoskeletons (exuviae) were discussed. The Working Group highlighted a number of potential problems with these techniques. These include the large vertical distribution of eggs, the effect of variation in fecundity and the number of spawning episodes in any one season, and the infrequency of catches containing exuviae. However, the Working Group concluded that such indirect methods could be potentially valuable and may provide a relatively untapped source of information on krill. Their continued development was encouraged.

36. Attempting to estimate total krill abundance indirectly based on multiplying estimated predators consumption by a calculated production/biomass ratio assumes knowledge of the age structure of the krill population. Recent research has indicated that krill live longer than previously thought and this in turn would decrease the production/biomass ratio thereby increasing the estimate of abundance.

SPATIAL AND TEMPORAL PATTERNS IN KRILL DISTRIBUTION AND ABUNDANCE

37. Over the past decade various attempts have been made to classify krill abundance and distribution in terms of fundamental characteristics and scales of occurrence. These classifications have been of major importance in refining our knowledge of krill biology and were fundamental in the development of the Krill CPUE Simulation Study.

38. Depending on the spatial and temporal scales being considered, the estimation of abundance and distribution must take account of a number of different factors. To a great extent the important factors introducing variance into the estimation of abundance depend on the scale of operation. It is possible to consider the techniques available in terms of their applicability to investigating processes operating over different scales.

39. Taking account of the various techniques discussed in the previous section (paragraphs 8 to 36), the Working Group discussed the various methods of monitoring krill abundance and distribution over different spatial scales identified at the second meeting of the Working Group for CCAMLR Ecosystem Monitoring Program (WG-CEMP) (Table 3). This discussion highlighted how various techniques may be used to monitor prey abundance and distribution over different spatial scales.

40. Using the definitions of spatial scale in Table 3, the Working Group considered krill distribution and abundance over each scale. On the global scale (> 1 000 km), it was recognised that ideally distribution and abundance should be ascertained and that this would be useful in gaining an understanding of krill population dynamics. The Working Group felt that it was impractical to attempt to estimate total krill abundance directly. The same problems generally apply to the macro scale (100–1 000 km).

41. It was agreed that the meso (1–100 km) and micro (0.01–1 km) scales are the scales most readily investigated with current methods. The Working Group also agreed that the processes operating on these scales form the basis for the Krill CPUE Simulation Study. Furthermore, all the scales from the micro to macro, are important in terms of key predator-krill interactions.

42. The Working Group was also of the opinion that available information on large scale (i.e. global-macro) krill distribution is currently limited (paragraph 40).

43. The Working Group agreed that results from the WS-KCPUE (see paragraph 2 and Figure 1, Appendix 5 of WS-KCPUE-89) indicate that concentrations of krill are consistently targetted by the commercial fishery. There is some congruence of such regions within and between seasons. The Working Group noted that at this scale prevailing hydrography and bathymetry would be important in the formation and maintenance of such concentrations.

44. In discussion of the distributions of krill concentrations the Working Group acknowledged that research vessel surveys are not able to provide a sufficiently broad areal coverage. The Working Group felt that, to determine the underlying mechanisms associated with the formation and maintenance of observed patterns in krill distribution, analysis of data from the fishery currently offers the most promise.

45. The Working Group noted that areas other than those in which the fishery operates, may be of crucial ecological importance. Furthermore, some major fishing areas are also known to be important to krill predator populations. The Working Group agreed that such areas probably cannot be considered as containing discrete populations, but they have been identified as being potentially useful for management purposes.

46. In this context, recent attempts to delineate separate stocks of krill (e.g. through genetically based analysis as in WG-KRILL-89/9) were noted and the need to develop knowledge of the spatial and temporal scales of crucial ecological processes to allow a more constructive approach to the development of management strategies was acknowledged by the Working Group.

47. Therefore, the Working Group emphasised that areas identified as being important in terms of krill's broader scale distribution, should be further investigated using other data sources than those forthcoming from the fishery. Information from as many sources as possible (including historical data such as found in the *Discovery*, BIOMASS and national data sets) should be drawn together and analysed for this purpose.

48. Taking account of the above and the fact that the WS-KCPUE had provided an operational definition of three types of krill concentrations (Table 4), the Working Group considered the proposed definitions to be workable and sensible.

49. It was acknowledged that more general definitions of krill aggregation are of greater utility than the rigid categorisation of aggregation types.

50. Similarly, the Working Group agreed that it would be useful to carry out analyses of both past and present acoustic data (e.g. echo-charts from fisheries survey vessels) to verify the defined concentration/aggregation types and to investigate the underlying ecological processes involved in their formation and maintenance.

51. It was recommended that such analyses should be undertaken as soon as possible and the results presented to the Working Group's next meeting. The Working Group also agreed that there would be considerable merit in ensuring that the echo-charts of both fisheries survey and research vessels are suitably annotated in order to provide information on krill aggregation types and their distribution.

52. An outline for the minimum level of echo-chart annotation was produced (Appendix 8), but the Working Group stressed that the effectiveness of such annotation should be considered further at the Working Group's next meeting.

53. Echo-charts should be examined in order to collect data on concentration parameters (WS-KCPUE-89) and aggregation types. The Working Group recommended that such examinations should be undertaken as soon as possible (either nationally or cooperatively) and that submissions on how these data should be accessed and analysed are to be reported to the next meeting.

54. The Working Group also considered that investigations of possible within- and between-season patterns in the distribution of fishing activity from historical data will be a valuable exercise and will facilitate identification of the requirements for possible future data collection and analyses. The Working Group also recommended that the necessary analyses should be carried out (either nationally or cooperatively) as soon as possible.

55. STATLANT and fine-scale data (1° longitude x 0.5° latitude x 10 day periods over the last three years) from the fishery are currently available within the CCAMLR database. Fine-scale data are from Subarea 48.2 and the Integrated Study Regions identified by the CCAMLR Ecosystem Monitoring Program. The Working Group concluded that available data should be analysed to investigate the spatial distribution of fishing activity during 10 day periods within each season. The Working Group recommended that the above analyses be carried out by the Secretariat as soon as possible. The available fine-scale data are still relatively coarse, the Commission has requested that haul-by-haul data be collected (CCAMLR-VII, paragraph 59) but they are not yet required for submission to CCAMLR.

56. It was agreed that given the structure of concentrations, analyses of haul-by-haul data are required for at least some of the regions in which the fishery operates (see paragraphs 28(iii) and (iv) of WS-KCPUE-89). Such analyses have potential utility in clarifying within-season variation in the location of fishing operations alluded to above.

57. The Working Group recognised that finer scale analyses of areas of krill concentration should be carried out using methods independent of the commercial fishery. These should include directed surveys using acoustics and nets as well as indirect methods such as predator based studies (various methods for studying different aspects of krill distribution and abundance have been outlined).

58. Such surveys and studies should be carried out in areas where commercial fishing occurs as well as in areas remote from the fishing operations. Results of finer scale analyses could also provide information relevant to the Krill CPUE Simulation Study.

59. The methods considered most useful for investigating particular temporal and spatial scales and their relevance to estimating the parameters required for the CPUE Composite Index (Appendix 4) have been given in Table 1.

60. The Working Group again emphasised that every effort should be made to relate fisheries to research data directly. It was noted that such a cooperative survey has already been carried out by Japanese scientists (WS-KCPUE-89/7 and WS-KCPUE-89/8) and the Working Group agreed that such information would be extremely useful.

61. The Working Group concluded that the understanding of large scale krill distribution may be enhanced from satellite imagery of sea surface temperature. This would allow the sea surface hydrodynamics to be related to the position of fishable krill concentrations. Although there are known problems in the available satellite data (e.g. excessive cloud cover) the Working Group <u>recommended</u> that currently available information should be accessed and analysed.

KRILL FISHERIES AND THE IMPACT OF FISHING

Commercial Fishing Activities

62. The current status of the krill fishery had been discussed during SC-CAMLR-VII (paragraphs 2.1 to 2.7) and it was noted that the total catch during the past three seasons

(1986–1988) had been 445 673, 376 456 and 370 663 tonnes respectively. The greatest proportion of these catches came from the Atlantic Sector in each season. The Working Group noted that at this level the Antarctic krill fishery is probably the largest single species crustacean fishery in the world.

63. Dr Endo reported that the preliminary figure for the Japanese krill catch for 1988/89 to be around 79 000 tonnes. The precise figure is not currently available as the STATLANT forms are not due to be submitted until 30 September. Dr Endo indicated that the level of the Japanese krill fishery was likely to be similar to that in the past two or three years.

64. The Working Group noted that krill catches had remained at more or less the same level over the past few years and that advice from fishing countries (SC-CAMLR-VII, paragraph 2.9) indicated that this level would continue or be increased only slightly in the foreseeable future.

65. The Working Group acknowledged that assessment of the abundance and distribution of krill in the whole of the Convention Area was extremely difficult. Historically, however, as about 90% of the catch has been taken from particular locations in Statistical Area 48, the task can be brought down to manageable proportions by focusing, at least initially, on the areas fished.

66. It was agreed that the current total catch was unlikely to be having much impact on the circumpolar krill population. However, the Working Group was unable to say whether or not the present level of krill catch was having an adverse impact on local predators. The Working Group recommended that the fishery should not greatly exceed the current level until assessment methods are developed further and until more is known about predator requirements and local krill availability. The development of suitable assessment methods is important and is encouraged.

Data Analyses

67. The Convener reported on analyses of STATLANT catch and effort data for the period 1973–1988 that he had prepared for the CCAMLR/IWC Workshop on the Feeding Ecology of Southern Baleen Whales (WG-KRILL-89/5). The results confirmed that the Atlantic Sector (i.e. Statistical Area 48) was the main area fished and has provided the bulk of the accumulated krill catch over the past fifteen years.

68. Examination of the monthly catches for Subarea 48.3 over several years indicate that the bulk of the fishing effort there took place during the months April–August (winter). In other Subareas (particularly 48.1 and 48.2) the greatest catches were taken during January–April (summer).

69. The greatest fishing effort (hours fished) by the USSR fleet was confined to winter in Subarea 48.3 and summer in Subarea 48.2. This suggests that the fleet moves northwards as ice encroaches into Subarea 48.2 during winter.

70. These results indicate that USSR krill fishery can take place year round and that the notion of a krill fishing 'season' may be misleading. The Working Group suggested that this should be borne in mind in making management decisions about the krill fishery.

71. It was agreed that the STATLANT data provide a good general picture of the fishery but they are not sufficiently detailed to determine the status of, or patterns in, the fishery with adequate precision.

72. As previously discussed, the WS-KCPUE had made use of haul-by-haul data from the Japanese krill fishery and had demonstrated that such data could be used to provide indices of abundance within krill concentrations.

73. The Krill CPUE Simulation Study had also shown that data from the USSR survey vessels can be used to estimate the numbers of concentrations in an area.

74. In terms of improving understanding of krill fishing operations, the Working Group welcomed this development and having endorsed the recommendations of the Workshop on the Krill CPUE Simulation Study (WS-KCPUE-89), noted that additional analyses of data from the fishery should be considered.

75. Dr Endo and Mr Ichii (WS-KCPUE-89/8) reported a survey of krill in an area north of Livingston Island (Subarea 48.1) in 1987/88 undertaken at the same time that the area was being intensively fished. Catches from both commercial and research vessels were sampled for length frequency distribution. Using an acoustic estimate of abundance for the surveyed area the authors estimated the impact of fishing on the krill stock in the area.

Planned Future Analyses

76. Fine-scale catch and effort data have been submitted to the CCAMLR Secretariat for Subarea 48.2 and the Integrated Study Regions identified by CEMP. These data are grouped by geographical areas of 0.5° latitude x 1° longitude and summed over 10 day periods. (Also see discussion in paragraph 87.)

77. It was agreed that fine-scale data might provide some information on the location of krill concentrations, particularly as defined by the Krill CPUE Simulation Study (see paragraphs 43 to 56 and Table 4). Furthermore, given a sufficient series of data it might also be possible to determine to what extent such concentrations appear in successive years. It was agreed that the Secretariat should provide plots of these data for examination at the next meeting of the Working Group (see paragraph 55).

78. It was also agreed that analyses of haul-by-haul data and searching vessel data, as outlined in the Report of the Workshop on the Krill CPUE Simulation Study (WS-KCPUE-89) should commence as soon as possible.

79. The collection of acoustic data, by both survey vessels accompanying the fishing fleet and by independent research/resupply vessels to define more clearly the extent and location of concentrations, is important. A data collection procedure was agreed and a data collection format is shown in Appendix 7. These data will provide information on size of concentrations, distance between concentrations and the number of swarms within a concentration. It was agreed that collection and analyses of such data should be undertaken.

80. Despite the problems associated with net selectivity already discussed (paragraphs 30 and 31), analyses of size frequency distributions from scientific net hauls had provided further information on krill growth rates. It was emphasised that in such analyses of length frequency data for assessment purposes, seasonal effects are important and should be taken into account. It was noted that analyses of length frequency distributions from commercial catches in conjunction with those from research net-based population estimates could provide valuable information on population dynamics.

81. It was stressed that such an approach requires fishery independent survey information on krill abundance in addition to length frequency data from both the fishery and the overall natural population. It was also noted that, for completeness, such analyses should consider data from predators.

82. The Working Group stressed that although all fishing fleets appear to be using the same type of nets it does not necessarily follow that these have the same selection factors. Therefore, to be effective an approach based on commercial catch information requires length frequency distribution data from all fishing fleets.

83. Some concern was expressed that, due to the small area of operation of the fleets relative to the total Southern Ocean, such analyses might not be sufficiently sensitive to detect important changes in krill demography. It was, however, noted that the analyses envisaged were only part of a broad suite of studies that might focus on abundance estimation from fishery data, water circulation patterns, identification of stocks and local predator dependence on krill. Together such studies could be used to develop advice for management. A possible schema is shown in Appendix 9.

84. The Working Group considered further possible approaches to estimating the local impact of fishing on krill stocks. It was suggested that an attempt be made to extend the analyses reported by Dr Endo and Mr Ichii (see paragraph 75) to the whole of Statistical Area 48 using the length frequency distributions from the scientific sampling and the commercial catches together with the fine-scale catch data available in the CCAMLR database. The Working Group noted, however, potential problems associated with seasonal effects in size frequency data (see paragraph 80). Nevertheless, it was agreed that such an analysis would provide a useful preliminary estimate of the potential impact of the fishery on available krill in Statistical Area 48. This would also help in identifying important deficiencies in data and methods.

85. The Working Group encouraged Members to develop methods of analysing catch length frequency distributions to infer the local impact of fishing on krill stocks.

Data Requirements

86. In order to undertake the analyses identified by the WS-KCPUE, the Working Group recommended that the following data be collected (see paragraphs 28(i), (iii) and (v) of WS-KCPUE-89):

(a) bridge log data;

(b) haul-by-haul data from commercial fishing vessels; and

(c) acoustic data for determination of concentration characteristics (paragraph 77 above).

87. To provide a longer time base with which to examine trends in fishing activity within and between seasons the Working Group recommended that fine-scale catch data should continue to be reported for Subarea 48.2 and the three CEMP Integrated Study Regions (paragraph 59, CCAMLR-VII).

88. There was considerable discussion on the type and quantity of length frequency data to be collected by the fishery. Recent evidence indicates that there are significant differences in size distribution and sex ratio of even closely adjacent swarms (Watkins et al., 1986). Similar evidence has also been obtained from layers of a size similar to those fished by commercial operations (WG-KRILL-89/6). The Working Group recommended the development of sampling procedures which take account of how many samples and how frequently samples of krill length distributions in commercial catches should be taken.

89. It is current practice in the Japanese fishery for each fishing vessel to measure a sample of 50 krill from one haul per day spent fishing. The Working Group recommended that as an interim measure sampling of at least that level be undertaken by all other commercial fleets.

90. The Japanese data are based on the krill length measurement from tip of rostrum to tip of telson measured to the nearest millimetre below. This standard is, in practice, virtually identical to the other widely used standard: front of eye to tip of telson. It was recommended that the latter standard be adopted (see Appendix 10).

OTHER BUSINESS

Liaison with CCAMLR Ecosystem Monitoring Program (CEMP)

91. At its last meeting the Scientific Committee decided that (SC-CAMLR-VII, paragraph 5.40):

(a) The WG-CEMP should identify the characteristics of predators that need to be taken into account in prey survey design;

(b) Simulation studies are likely to be particularly useful in generating advice on survey design, frequency and distribution. Work including modelling krill distribution and behaviour is being undertaken within the Krill CPUE Simulation Study. The WG-CEMP should consult with the Working Group on Krill to develop this, and other relevant studies, to provide appropriate advice; and

(c) The WG-Krill should arrange the production of standard method sheets for the technical aspects of prey surveys.

92. As a result of this decision the Convener of the WG-CEMP wrote to the Convener of the WG-Krill pointing out that as the WG-CEMP was not scheduled to meet until August 1989, there had been no opportunity since the last meeting of the Scientific Committee for the WG-CEMP to specify the characteristics of predators necessary for the design of prey surveys referred to in SC-CAMLR-VII, (paragraph 5.40 (i)). In this situation he thought it would be useful for the Working Group on Krill to consider:

(a) the nature of the CEMP and the reasons for requiring prey surveys and the development of standard methods;

(b) the requirement for prey monitoring as set out in the table taken from a CEMP Report (Table 5, Annex 4, SC-CAMLR-VI);

(c) information and advice that may help the WG-CEMP to formulate specific requests to the WG-Krill for specific methods and survey design.

93. The Working Group agreed that little progress could be made on the specification of surveys for monitoring prey until the ‘important characteristics of predators’ were specified by WG-CEMP. The Working Group also agreed that the most important characteristics (for each of the krill predator species identified by CEMP) are the foraging range, foraging frequency, the time of day that foraging is undertaken and the normal depth range over which feeding takes place (SC-CAMLR-VII/5 and SC-CAMLR-VII/BG/8).

94. With respect to point 92(a) above, the attention of WG-CEMP was drawn to several references in this report to the importance of studying predator/krill interactions in the context of estimating changes in krill abundance and distribution. Although the Working Group was not able at this stage to draw up a manual of standard methods for surveys of krill as such, most of the recommendations of the Working Group are directly relevant to the

conduct of such surveys. In particular the CEMP Integrated Study Regions were selected for the application of CPUE to estimate changes in krill abundance and the tables in the relevant sections of this report provide guidance on the implementation of acoustic surveys, of fishery independent net surveys and for sampling catches from commercial vessels in those areas.

95. The table referred to in 92(b) was modified (Table 3) and is referred to WG-CEMP for consideration.

96. It was suggested that the simulation models used in the Krill CPUE Simulation Study might be adapted for use in identifying important parameters to study predator/krill interactions in the context of CEMP.

STRATEGIC PLANNING

97. At the last meeting of the Scientific Committee, the US Delegation reported on a procedure in use at the Southwest Fisheries Centre for the planning of research programs which also takes account of various management objectives. It was suggested that the method be evaluated for possible application by the various CCAMLR working groups. A paper describing the procedure and a detailed report on the application of the method were distributed to members of the Working Group before the meeting. In addition, an outline of the process was given by the US participants. Some participants of the Working Group had taken part in the application of the method in the planning of the US Antarctic Marine Living Resources (AMLR) Program.

98. The Working Group agreed that the process is most applicable to situations for which the future direction is rather unclear, the choice of several options is possible or widely divergent views are held by potentially opposing factions. At present, none of these situations can be considered to apply to matters being addressed by the WG-Krill. It was, nevertheless, suggested that the procedure may have some application in the work of the WG-DAC.

CONSIDERATION OF A REQUEST FROM THE CONVENER OF THE WORKING GROUP FOR THE DEVELOPMENT OF APPROACHES TO CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES

99. The Convener of the WG-DAC had drawn attention to two matters on which the Commission had sought the advice of the Scientific Committee. These are:

(a) the development of operational definitions for depletion and for target levels of recovery of depleted populations; and

(b) the ability of the CCAMLR Ecosystem Monitoring Program to detect changes in ecological relationships and to recognise the effects of simple dependencies between species, including distinguishing between natural fluctuations and those induced by fisheries.

100. The Working Group agreed that at this stage it had no contribution to make to the preparation of the advice of the Scientific Committee on these issues. It was acknowledged, however, that at some stage it may be able to assist the WG-CEMP in the provision of its advice on krill predators.

CLOSE OF THE MEETING

101. Before the close of the meeting, the Convener drew attention to the ongoing responsibilities of the Working Group set down in the terms of reference (SC-CAMLR-VII, paragraph 2.26). At this meeting, the Working Group had prepared advice to the Scientific Committee concerning the current level of fishing, identified data requirements and described analyses to be undertaken. These analyses are aimed at determining the value of further data collection necessary for the management of the krill fishery. It was <u>recommended</u> that in order to maintain the momentum begun at this meeting, the Working Group should meet again in 1990. The Convener, in consultation with the Secretariat, will prepare and distribute a list of topics to form the basis of the agenda of the Working Group's next meeting before the 1989 meeting of the Scientific Committee.

102. The Convener thanked the Working Group participants, particularly the rapporteurs, for their cooperation and support. He also thanked Drs R. Holt and R. Hewitt and Mrs G. Horner for their assistance in the organisation and conduct of the meeting. Finally, he thanked the Director of the Southwest Fisheries Centre, Dr I. Barrett for hosting the meeting.

APPENDIX 1

AGENDA FOR THE FIRST MEETING

Working Group on Krill
(Southwest Fisheries Centre, La Jolla, California, USA, 14 to 20 June 1989)

1. Opening of the meeting
   (i) Review Working Group’s terms of reference
   (ii) Review objectives of meeting
   (iii) Adoption of agenda

2. Methods for estimating krill distribution and abundance
   (i) Review available information
   (ii) Evaluate available information with respect to:
      (a) Methods of determination, and
      (b) Relative value of various methods, their applicability, accuracy and precision
   (iii) Recommendations

3. Spatial and temporal patterns in krill distribution and abundance
   (i) Review available information
   (ii) Evaluate available information with respect to:
      (a) Scale of variability
      (b) Value of information at different scales, and
      (c) Potential relevance of information to CCAMLR
   (iii) Recommendations

4. Krill fisheries
   (i) Review available information
   (ii) Evaluate available information with respect to:
      (a) Detail information available
      (b) Trends in the fishery, and
      (c) Potential relevance of information to CCAMLR
   (iii) Krill fisheries and impact of fishing
   (iv) Recommendations

5. Other Business
   (i) Liaison with CCAMLR Ecosystem Monitoring Program
   (ii) Consideration of a request from the Convener of the Working Group for the Development of Approaches to Conservation of Antarctic Marine Living Resources
   (iii) Strategic Planning

6. Adoption of report

7. Close of the meeting.

APPENDIX 2

LIST OF PARTICIPANTS

Working Group on Krill
(Southwest Fisheries Centre, La Jolla, California, USA 14 to 20 June 1989)

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APPENDIX 3

LIST OF DOCUMENTS

Working Group on Krill
(Southwest Fisheries Centre, La Jolla, California, USA, 14 to 20 June 1989)

Meeting Documents

WG-KRILL-89/1	Agenda for the First Meeting of the CCAMLR Working Group on Krill
WG-KRILL-89/2	Annotated Agenda for the First Meeting of the CCAMLR Working Group on Krill
WG-KRILL-89/3	Main Objectives of the First Meeting of the CCAMLR Working Group on Krill
WG-KRILL-89/4	Table of Krill Target Strengths from Everson et al., SC-CAMLR-VII/BG/30
WG-KRILL-89/5	Commercial Krill Fisheries in the Antarctic, 1973–1988 (D.G.M. Miller)
WG-KRILL-89/6	Size and Density of Krill Layers Fished by a Japanese Trawler in the Waters North of Livingston Island in January 1988 (Y. Endo and Y. Shimadzu)
WG-KRILL-89/7	Correspondence between the Convener of the Working Group for the Development of Approaches to Conservation of Antarctic Marine Living Resources and the Chairman of the Scientific Committee
WG-KRILL-89/8	Correspondence from the Convener of the Working Group for the CCAMLR Ecosystem Monitoring Program
WG-KRILL-89/9	Preliminary Study on Chromosomes of Antarctic Krill, *Euphausia superba* (P.V. Ngan et al.)
WG-KRILL-89/10	AMLR Hydroacoustic Survey System Description of Methods, A Case Study (M.C. Macaulay)

WS-KCPUE-89 Report of the Workshop on the Krill CPUE Simulation Study

WS-KCPUE-89/8 CPUE's, Body Length and Greenness of Antarctic Krill During 1987/88 Season on the Fishing Ground North of Livingston Island
(Y. Endo and T. Ichii)

References

1. CCAMLR-VII. Report of the Seventh Meeting of the Commission

2. SC-CAMLR-VII. Report of the Seventh Meeting of the Scientific Committee

3. SC-CAMLR-VI, Annex 4. Report of the Working Group for the CCAMLR Ecosystem Monitoring Program

4. SC-CAMLR-VII/BG/30. Target Strength of Antarctic Krill (*Euphausia superba*). I. Everson et al. (UK)

5. On the Biology of Krill, *Euphausia superba*, Proceedings of the Seminar and Report of the Krill Ecology Group. Schnack, S.B. (Ed.). Bremerhaven 12–16 May 1983, Ber. Polarforsch. Sond. (4) 1983.

6. Scales of Interaction Between Antarctic Krill and the Environment. E.J. Murphy et al. In: Antarctic Ocean and Resources Variability. Sahrhage, D. (Ed.), 1988. pp 120-130. Springer-Verlag, Berlin, Heidelberg.

7. Watkins, J.L., D.J. Morris, C. Ricketts and J. Priddle. 1986. Differences Between Swarms of Antarctic Krill and Some Implications for Sampling Krill Populations. Marine Biology Vol. 93, pp 137-146.

8. Greenlaw, C.F. 1979. Acoustic Estimation of Zooplankton Populations. Limnology and Oceanography 24, pp 226-242.

DEFINITION OF COMPOSITE INDEX OF KRILL BIOMASS

At the Workshop on the Krill CPUE Simulation Study (WS-KCPUE-89) the Composite Index was developed to monitor the abundance of krill in areas where the krill fishery is operating. The index utilises a number of measurements based on spatial dimensions of krill concentrations and krill swarms. It also utilises an estimate of density based on catch per fishing time or acoustic data. For more details see Appendix 7 of WS-KCPUE-89.

The Composite Index is defined as:

$$CI = N_c L_c^2 D_c r^2 \delta$$

where CI = Composite Index
N_c = number of concentrations in the area of interest
L_c = characteristic radius of concentrations
D_c = number of swarms per unit area in a concentration
r = characteristic radius of swarms in concentrations
δ = areal density of krill within swarms

DEFINITIONS OF ACOUSTIC TERMS

The acoustic backscattering cross section **σ** of a finite-size target ensonified by a uniform plane wave at a single frequency is defined as follows:

$$\sigma \;=\; \lim_{r \to \square} 4\pi r^2 \; \frac{\& \, P_{bsc} \&^2}{\& p_o \&^2}$$

where **r** is the range at which the backscattering pressure amplitude $\mathbf{p_{bsc}}$ is measured, and $\mathbf{p_o}$ is the pressure amplitude of the incident wave. Because this quantity often varies enormously due to changes in acoustic frequency, scatterer size, or scatterer orientation, it is convenient to use a logarithmic expression. This is done through the so-called target strength **TS**:

$$\overline{TS} \;=\; 10 \log \frac{\bar{\sigma}}{4\pi}$$

where **SI** units are used for **σ**.

2. Many surveying applications require averaging of the backscattering cross section. This is typically performed with respect to a distribution of krill sizes or orientations, for example. If the result of any averaging procedure is denoted $\bar{\sigma}$, then the corresponding mean or average target strength $\overline{\mathbf{TS}}$ is defined according to that of an individual datum, namely

$$\overline{TS} \;=\; 10 \log \frac{\bar{\sigma}}{4\pi}$$

3. An alternative quantity, denoted $\boldsymbol{\sigma_{bs}}$, is sometimes used. This is related to the above **σ** by the relation

$$\sigma_{bs} \;=\; \frac{\sigma}{4\pi}$$

In this case, **TS** is expressed by the equation

$$TS = 10 \log \sigma_{bs}$$

Caveat 1: Whether $\boldsymbol{\sigma}$ or $\boldsymbol{\sigma_{bs}}$ is used in any particular application, it is always necessary, in documenting work, to state which quantity is used.

Caveat 2: Averaging of the backscattering cross section $\boldsymbol{\sigma}$ must always be performed in the $\boldsymbol{\sigma}$ - or equivalent intensity domain. Average or mean target strengths are derived from $\bar{\boldsymbol{\sigma}}$.

A. NEXT-GENERATION ECHO-SOUNDER AND INTEGRATOR UNDER DEVELOPMENT IN NORWAY

(K. Foote)

The newest echo-sounder, the SIMRAD EK500 scientific echo-sounding system, will operate as many as three different split- or single-beam transducers simultaneously. Use of logarithmic amplifiers achieves a dynamic range of 160 dB. Time-varied gain is applied digitally. For each operator-specified depth channel and sailed-distance interval, the result of echo-processing is the echo-integral together with a histogram of resolved single-target target strengths. These numbers are tabulated for each depth channel and for each frequency on the hard-copy colour echo-gram.

The new postprocessing system, developed at the Institute of Marine Research, Bergen, the 'Bergen Echo Integrator', consists of a set of computer programs written in C. These are intended to be machine independent insofar as the operating system is UNIX and such other internationally accepted standard software as X-WINDOWS, GKS, and INGRES, for example, are available. Echo survey data can be stored with maximal or submaximal resolution, and presented and processed at will during or after the cruise. Interpretation of the echo-gram displayed on the screen is facilitated by operator-drawing of integration limits of arbitrary shape. Operator control of the coloration of displayed echo-gram by means of a joystick aids discernment of internal structure in scatterer concentrations.

References to the described echo-sounder and postprocessing system are the following:

Bodholt, H., Nes, H. and Solli, H. 1988. A new echo-sounder system for fish abundance estimation and fishery research. Coun. Meet. Int. Coun. Explor. Sea B: 11. Copenhagen.

Bodholt, H., Nes, H. and Solli, H. 1989. A new echo-sounder system. Proc. Inst. Acoust. 11(3): 123-130.

Knudsen, H.P. 1989. Computer network for fishery research vessels. Proc. Inst. Acoust. 11(3): 115-122.

More recent information may be obtained from the following:

H. Bodholt, SIMRAD Subsea A/S, PO Box 111, 3191 Horten, Norway.

H.P. Knudsen, Institute of Marine Research, PO Box 1870, Nordnes, 5024 Bergen, Norway

B. SOME DETAILS OF PROTOTYPE DUAL-BEAM ACOUSTIC SYSTEMS

(C.H. Greene)

Prototype dual-beam acoustic systems are presently used for krill research in other oceanic environments. These systems can be used to estimate the absolute number density, absolute biomass density and size distribution of krill. Information on these systems is presented in the following papers.

Greene, C.H., Wiebe, P.H., Burczynski, J. and Youngbluth, M.J. 1988. Acoustical detection of high density demersal krill layers in the submarine canyons off Georges Bank. Science 241: 359-361.

Greene, C.H., Wiebe, P.H. and Burczynski, J. 1989. Analysing zooplankton size distributions using high frequency sound. Limnol. Oceanogr. 34: 129-139.

Greene, C.H., Wiebe, P.H. and Burczynski, J. 1989. Analysing distributions of zooplankton and micronekton using high-frequency, dual-beam acoustics. Prog. Fish. Acoust. 11: 44-53.

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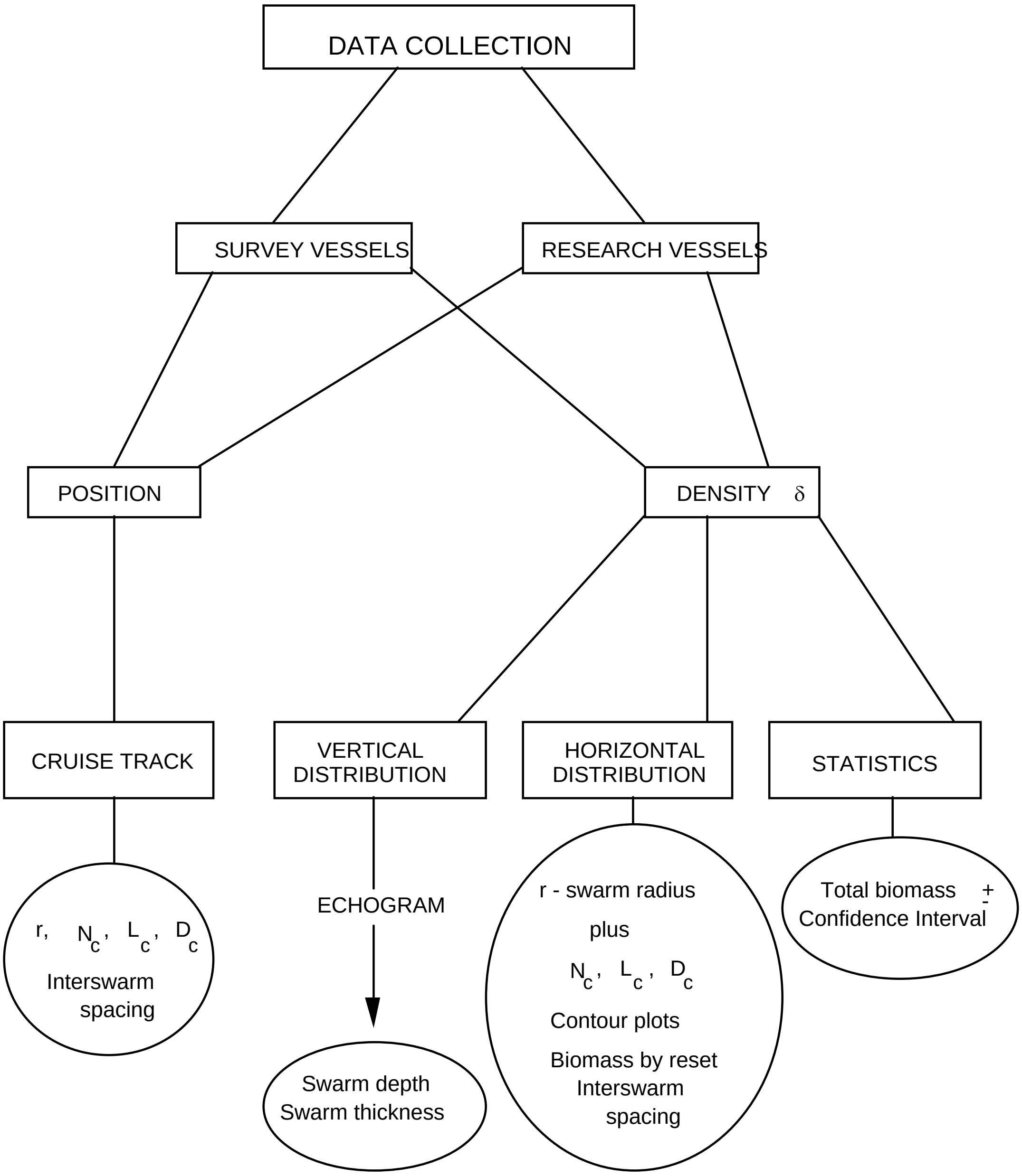
APPENDIX 7

SCHEMA FOR ACOUSTIC DATA COLLECTION AND ANALYSES

(See Appendix 4 for definitions)



APPENDIX 8

MINIMUM ANNOTATION STANDARD OF ECHO CHARTS FROM SURVEY AND RESEARCH VESSELS

Header for Each EchoChart

Vessel Name:

System Type:	Hull mounted
	Towed
	(Manufacturer and Model?)

Operating Frequency:

Echosounder Settings

(Settings that can change during run)

Paper Speed:

Recorder Gain:

Depth Range:

Set Time Annotation

(30 minute intervals)

Time:

Position:

APPENDIX 9

LOCAL

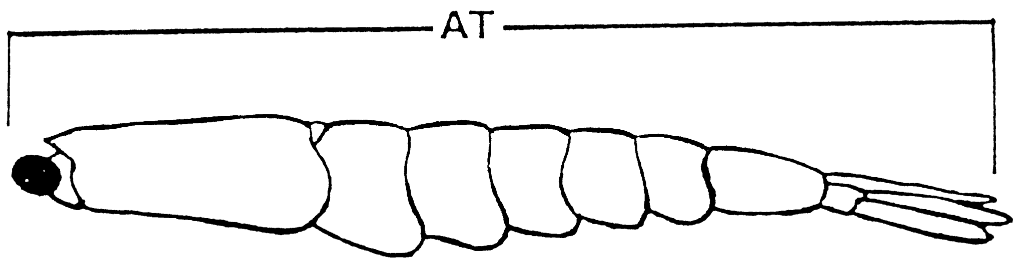
[resident population abundance]
- local reproduction
- depletion by natural sources (e.g. predation) and fishery

GLOBAL		LOCAL		GLOBAL
replenishment of resident population by advective transport	⇒	[resident population abundance] - local reproduction - depletion by natural sources (e.g. predation) and fishery	⇒	losses from resident population by advective transport

[global population abundance]

Assessment Strategy

- Monitor [resident population abundance] (fishery independent) density and size structure of concentrations
- Use stock assessment approach on resident population to examine its utility (recognizing problem of open system)
- Monitor fishery removal (amount and selectivity)
- Monitor natural sources of mortality (amount and selectivity)
- Can we measure advective transport inputs and outputs?



Suggested body length measurement (AT) for krill caught during commercial fishing operations (BIOMASS Handbook No. 4, Measurement of body length of *Euphausia superba* Dana)

Table 1: Acoustical analysis of krill concentrations

System Type	Types of Vessels[1]	Data Output	Methods of Data Analysis and Presentation	Parameters Estimated from Acoustical Data[2]						Comments and Caveats
				N_c	L_c	D_c	r	δ	Other spatial statistics[3]	
1. Echo-sounder	F,FS,SR R	Echo-gram	Record start and end of concentrations, number and size of swarms	√	√	√	√		√	Problems associated with • nondetection: - surface krill - minimum levels of detection • misidentification - other scattering sources - TVG problems
2. Echo-sounder with Integrator	SR	Echo-gram	Same as 1.	√	√	√	√		√	• Same as 1.
	(FS,R)	Relative Biomass Density	Mean volume backscattering strength from integrator					(√)		• Variability in scaling factor
		Absolute Biomass Density	Calculate biomass density from integrator output and scaling factor relating mean volume backscattering strength to biomass (from calibration experiments)					(√)		
		Absolute Number Density	Calculate number density from integrator output and mean backscattering cross section (from calibration experiments and simultaneous trawl data)					(√)		• Variability in mean backscattering cross section • Errors from trawl sampling • Reduced flexibility in post-processing
3. Echo-sounder with Integrator and ping by ping data storage	Same as 2.	Same as 2.	Same as 2., but added capability for improved post-processing	√	√	√	√	√	√	• Greater data storage requirements than 2. • Greater expense than 2.
4. Echo-sounder with Integrator ping by ping data storage, and dual- or split-beam capability	SR	Same as 2., but absolute number density and size distribution can be estimated entirely by acoustic methods	Same as 2., but mean backscattering cross section and size distribution are estimated by dual- or split-beam procedures of *in situ* target strength determination on acoustically resolvable krill	√	√	√	√	√	√	• Same as 3., but more data storage requirements and more expensive • Biases of dual- and split-beam techniques must be examined • Dual- and split-beam transducers must be deployed to resolve individual targets

Table 1 (continued)

5. Sonar (single beam and sector seaming with ping by ping data storage	FS,SR	Echo-gram	Same as 1., but also including indication of swarm conformation (i.e. shape and size)	√	√	√	√	(√)	√	• Expensive and requires specialist interpretation/ analyses

[1] Types of Vessels
F - Fishing vessel
FS - Fishing Survey vessel
SR - Scientific Research vessel
R - Resupply vessel

[2] See Appendix 4 for definitions

[3] Other swarm parameters include: depth layer/swarm thickness, interswarm distances (see paragraph 11)

( ) indicates additional research required

Table 2: Scientific nets used in the Southern Ocean for krill research

Gear	Advantage	Limitations
Polish German Krill trawls	- large sample size - little to zero net avoidance - deployed on a large number of trawlers = large data set	- net deployment restricted to larger research vessels - net selection for krill > 40 - 45 mm depending on trawl mesh size
RMT 1	(a) relatively simple to handle on most research vessels (b) electronic device enables to have real time net data on e.g. depth of net, filtered water volume (c) opening and closing device for vertical profiles, multiple version of the net available (d) effective on krill larvae sampling	- strong net avoidance of krill - especially unefffective for krill > 35 mm
RMT 8	(e) see (a) to (c) of RMT 1 (f) effective on relative abundance of krill (> 20 mm) for length and development stage compositions (g) working with conducting cable	- net selection for krill > 20 mm - net avoidance in daylight, factor unknown - difficult to handle when no A-frame available on the ship
Bongo	- see (a) and (d) under RMT 1 - two replicate samples at a time	- see RMT 1 - no real time information on depth of net - no opening/closing device
Neuston	- easy to handle on most ships - effective for late krill larvae during certain periods of the season	- impossible to handle during bad weather - restricted to surface sampling
MOCNESS* 1 10	- see RMT 1 (b) to (d) - see RMT 8 - working with conducting cables	- see RMT 1 - see RMT 8 - fixed net frame, difficult to handle on smaller vessels, requires large A-frame for deployment

Table 2 (continued)

IKMT 6' 12'	- simple to handle on most research vessels -	(a) unknown net avoidance and size selectivity (b) requires large A-frame for deployment - see IKMT 6' under (a)
Discovery net **	-	- see Bongo ?
Kaiyu Maru Midwater Trawl KYMT	- see RMT 8 (f)	- see RMT 8 - no opening/closing device
Netmot - * JKMT 5 m^2 (MIK trawl)	- capable of high speed tows (≅ 4 Kt)	- unknown net avoidance and selectivity - requires large A-frame for deployment
BIONESS (1m^2) *	- see MOCNESS 1	- see MOCNESS 1
ORI net (1.6 m^2)	- opening/closing device - easy to handle on research vessels	- no real time information on depth of net - see RMT 1

* not used frequently but may have potential or is under development
** out of use except for comparative studies

Table 3: Methods which could be utilized in monitoring rates of change in abundance and dristribution of krill.

Species	Krill, *Euphausia superba*			
Scales (1) Parameters	Global	Macro	Meso	Micro
Abundance Changes				
Absolute	A* N* (S)	A* N* (S)	A* N*	A* N*
Relative		C Pr	C Pr M	P M
Emigration/ Immigration		A N H	A N H	
Aggregation patterns		A* N* H	A* N* H V	A* N* H P V
Demography				
Sex		N*	N*	N*
Size/Age		B	B	B
Reproductive/ Development Stage				
Community structure				

Key:

A - Acoustics
B - Biochemical/genetic tracers
C - Fisheries catch dependent methods
H - Hydrographic measurements
M - Moored systems
N - Net sampling
P - Photography
Pr - Predator dependent methods
(S) - Satellite Imagery (future development)
V - Visual observations

* Techniques are developed but require further research on sampling design prior to implementation

(1) Definition of scales:

Global: 1 000 km
Macro: 100 - 1 000 km
Meso: 1 - 100 km
Micro: 0.01 - 1.00 km

Table 4: Definitions of krill concentrations produced by the Krill CPUE Simulation Study (7 to 13 June 1989, USA)

Type	Name	Qualitative Description	Inter-Aggregation Distance	Aggregation Diameter	Comment
1	Poor	Swarms widely spaced Diffuse aggregations	Several to 10's km	Several to 10's m	
2	Good Layer	Dense continuous layer	0	Few to 10's km	Both horizontal and vertical separation is possible
3	Good aggregation	Close groups of dense swarms	10's m	10 - 100's m	

ANNEX 6

REPORT OF THE WORKING GROUP ON FISH STOCK ASSESSMENT

(Hobart, Australia, 25 October to 2 November 1989)

REPORT OF THE WORKING GROUP ON FISH STOCK ASSESSMENT

(Hobart, Australia, 25 October to 2 November, 1989)

INTRODUCTION

The Meeting of the Working Group was held at the CCAMLR Headquarters, Hobart, Australia from 25 October to 2 November 1989. The Convener (Dr K.-H. Kock, FRG) opened the meeting and the agenda (Appendix 1) was adopted. A list of those attending is given in Appendix 2. The report was prepared by Drs J. Beddington, W. de la Mare, I. Everson, K.-H. Kock and K. Sullivan. A list of documents considered at the meeting is given in Appendix 3.

GENERAL MATTERS AND MATERIAL AVAILABLE

Research Vessel Exemption

2. During the past week the Secretariat had received notification that USSR was sending three research vessels (*Slavgorod*, *Borispol* and *Passat 2*) to the South Georgia region (Subarea 48.3) to undertake a fishery survey lasting one month. The Executive Secretary had responded drawing attention to the requirements to provide information to the Commission six months in advance of research cruises operating under the scientific research exemption provisions (CCAMLR-V, paragraph 60). During the meeting a further message was received indicating that the USSR had withdrawn the three vessels from Subarea 48.3. No information on research objectives or survey design was available to the meeting.

3. Where fishing was according to a randomised design it was clear that the total catch was unlikely to be large. It was noted, however, that target or directed fishing, even for research purposes, by such a group of vessels might result in significant catches being made.

4. The Working Group recommended that the Scientific Committee consider the operation of the Research Vessel Exemption Provisions (CCAMLR-V, paragraphs 59 and 60) paying particular attention to how plans should be circulated, catches should be reported and whether research vessel catches should be considered as part of a TAC.

Catch and Effort Statistics

Statistical Area 48 (Atlantic Ocean Sector)

5. Small catches of *Notothenia gibberifrons* and *Champsocephalus gunnari* had been reported from Subareas 48.1 and 48.2.

6. The largest catches were reported from Subarea 48.3. Prior to the closure of the fishery on 4 November 1988 (Conservation Measure 11/VII) 21 356 tonnes of *C. gunnari*, 838 tonnes of *N. gibberifrons* and 152 tonnes of *Notothenia rossii* had been taken. In addition 13 016 tonnes of *Patagonotothen brevicauda guntheri* were caught during the season.

7. The USSR had undertaken an experimental fishery for *Electrona carlsbergi* (*Myctophidae*) in the Polar Frontal Zone. The total catch of these species within the CCAMLR Convention Area was 30 000 tonnes. Catch rates of 70 to 80 tonnes a day had been achieved during a study to determine the distribution and size of fishable concentrations. Concentrations of *E. carlsbergi* were also found well north of the CCAMLR Convention Area.

8. Longline fishing for *Dissostichus eleginoides* was undertaken by a small fleet of USSR vessels operating in the vicinity of South Georgia and Shag Rocks (Subarea 48.3). A total of 4 138 tonnes had been caught mainly from water deeper than 500 metres. Details of the fishery were not available to the meeting.

9. With respect to the above, the Working Group noted that an accumulated catch of 5 756 tonnes of *D. eleginoides* had been taken from this subarea between 1977 and 1988. Experience in other fisheries outside the CCAMLR Convention Area indicates that assessment of longline fisheries is difficult with little indication of overfishing becoming apparent until the stock is near to collapse.

10. Since analysis of catch-per-unit-effort indices is the only proven method for assessing longline fisheries, it was agreed that appropriate data should be collected as a matter of urgency. The most effective effort indices should include:

- Number and size of hooks on the line;
- The spacing of hooks on the line;
- The time the longline is set (soak time) and recovered;

- Fishing depth;
- Type of bait;
- Precise fishing location (i.e. position) as suitable sites often cover a very restricted area;
- Target species and catch;
- Discarded species and catch; and
- Incidental mortality.

11. Concern was expressed that a longline fishery in the Convention Area might cause significant mortality to certain predators, particularly albatrosses and large petrels, as had occurred in other areas of the world. It was agreed that advice should be sought from the Scientific Committee on data that should be collected to quantify incidental mortality.

12. Currently, CCAMLR has no agreed reporting procedure for longline fisheries. The Working Group recommended that the Secretariat be asked to prepare a suitable data collection format based on those in use in other fisheries agencies and taking account of the items specified above. Given the concerns expressed in paragraph 9, the Working Group agreed that this should be completed for this year's Scientific Committee meeting so data collection procedures from longline operations could be implemented for the 1989/90 season.

Statistical Area 58 (Indian Ocean Sector)

13. The largest reported catches were taken in Division 58.5.1 (Kerguelen) where 23 000 tonnes of *C. gunnari* and 1 500 tonnes of *Notothenia squamifrons* were caught.

14. It was confirmed that catches reported as being of *C. gunnari* from Division 58.4.2 were in fact *Chaenodraco wilsoni*. It was agreed that the STATLANT records should be amended accordingly.

Statistical Area 88 (Pacific Ocean Sector)

15. Fishing on *E. carlsbergi* only was reported from this area. The total reported catch was 1 110 tonnes.

Size and Age Composition Data

16. Length composition data had been provided for the major fisheries. The bulk of the data were from research vessel catches; relatively few data sets were from the commercial fishery. It was again emphasised that more data from the commercial fishery would allow a considerable improvement in the stock assessments.

Age Determination

17. The results of the CCAMLR Otoliths/Scales/Bones Exchange Scheme were outlined by Dr Kock, the organiser (SC-CAMLR-VIII/BG/46). Whilst in some cases the degree of agreement had been good, there were large differences between the results of some workers. These were not necessarily related to the experience of the worker. It was concluded that age/length keys provided by different workers could not be calibrated effectively and that age/length keys from a single source should be used when analysing the fishery of a particular stock. For species such as *C. gunnari*, where there was reasonable consistency in age/length keys for fish aged one to three, it was thought that this was likely to cause fewer problems for stock assessment.

18. It was felt that there was little need to continue the exchange scheme as individual inconsistencies of interpretation could only be resolved by getting together at a Workshop.

19. A comparison of age determination using otoliths and scales from *N. gibberifrons* (WG-FSA-89/13) indicated that scales tended to underestimate age by one year. This was thought to be due to a difference in timing of the formation of the nucleus in each structure.

20. A new technique for age determination of *C. gunnari* involving clearing freshly extracted otoliths with glycerine and storing them in alcohol vapour was described (WG-FSA-89/19).

Other Biological Information

Reproduction

21. Length at first spawning of *C. gunnari* from the South Orkney Islands and the Antarctic Peninsula is approximately 10 cm greater than at South Georgia. There is also a clear relationship between fecundity and location with fewer eggs being produced at the more southerly sites (SC-CAMLR-VIII/BG/16).

22. Although spawning occurs annually in *C. gunnari* around South Georgia not all fish spawn each year. It is estimated that the true spawning stock biomass is only about 80% of the total stock of fish of spawning size. Estimates of spawning stock biomass must therefore be reduced to take account of this factor (SC-CAMLR-VIII/BG/16).

23. The gonad maturity scales used for Antarctic fish thus far are not fully applicable to all species. A five grade scale described by Everson (1982) for use with Nototheniids, based on observations of *Notothenia neglecta*, has been used for all Antarctic fish in recent years. Differences noted between gonad maturity stages of Nototheniidae and Channichthyidae have required the designation of an additional scale for the latter group (WG-FSA-89/7). This channichthyid maturity scale was produced based on observations on the three species, *C. gunnari*, *Chaenocephalus aceratus* and *Pseudochaenichthys georgianus.* It was recommended that these two scales be used for future assessments, both are set out in Appendix 4.

24. A survey of larval and juvenile fish during the period December 1986 to March 1987 in the Bransfield Strait area had indicated generally low levels of abundance of all species (SC-CAMLR-VIII/BG/36). Avoidance was considered to be a major problem with Bongo and Nansen nets used in the survey.

Estimation of Natural Mortality, M

25. Two types of estimation methods were tested:

(i) Direct methods based on age composition data representing the virgin stock, i.e. data collected before fishing started; and

(ii) Indirect methods or comparative methods, using average values of M estimated for species with similar physiological characteristics and environment.

26. The direct methods are considered the most reliable ones, if based on unbiased data representing a stock in equilibrium, i.e. the average age distribution for several years.

27. This type of data was available for *C. gunnari* in South Georgia waters (WG-FSA-89/20). Using various direct methods (see paragraph 25(i) above) a value of M = 0.5 per year was found. This value, however, is outside the expected range for a species with the biological characteristics of *C. gunnari* and further examinations of the basic data (which were not available to the Working Group) are recommended.

Mesh Selection

28. Results from selectivity experiments undertaken by Poland, Spain and USSR had been discussed during the 1988 Meeting of the Working Group (SC-CAMLR-VII/10, paragraphs 14 to 16). The analyses have been completed and presented in SC-CAMLR-VIII/BG/20 Rev. 1 and are summarised below.

Champsocephalus gunnari

29. The Selection Factor (SF) of 2.95, obtained in the South Georgia area using mesh sizes of 68 and 88 mm, seems appropriate for calculations of mesh size in the commercial trawl fishery for *C. gunnari*.

30. This SF, referred to a nominal mesh of 80 mm, adopted by CCAMLR in 1984 as the minimum mesh size for *C. gunnari*, gives an L_{50} of 23.6 cm. This length is around the mean length at 50% maturity in the South Georgia area (23.4 cm, according to Kock, Duhamel and Hureau, 1985; Balguerias and Quintero, 1987 and Kock, 1989), and well below the length of first spawning, which is estimated at 27 cm (SC-CAMLR-VIII/BG/16). The application of SF = 2.95 corresponds in this case to the minimum mesh size of 92 mm. A mesh size of 108 mm would then correspond to the age at first capture of 4 years (i.e. around 32 cm), which was proposed as the optimum under conditions of high fishing mortality (SC-CAMLR-VII/10).

31. Using the mean SF from South Georgia to calculate the minimum mesh sizes for *C. gunnari* from the South Orkney and South Shetland areas, and applying the length at first spawning estimated at 35 cm (SC-CAMLR-VIII/BG/16), results in the minimum mesh size of 119 mm.

Notothenia gibberifrons

32. Assuming the mean SF of 2.62 for *N. gibberifrons* for the whole of Statistical Area 48, and applying it to the mean lengths at 50% maturity for this species from South Georgia (32.9 cm) as well as from South Orkney Is, Elephant Is and South Shetland Is (29.9cm), gives mesh sizes of 126 and 114 mm respectively. It should be recalled, however, that SF's obtained for *N. gibberifrons* vary considerably between the various areas studied and there is no clear relationship between mesh size increase and growth of the L_{50}. These calculated meshes ought therefore to be taken as provisional figures.

Patagonotothen brevicauda guntheri

33. A Selection Factor (SF) of 3.21 referred to 16 cm, which is the 50% length at maturity of *P.b. guntheri* (SC-CAMLR-VIII/BG/27, WG-FSA-89/21), corresponds to the minimum mesh of 50 mm for this species.

Chaenocephalus aceratus and *Pseudochaenichthys georgianus*

34. Selection parameters for *C. aceratus* differ considerably for various meshes and codends tested and are mostly rough estimates from poorly defined selectivity ogives. It is therefore not possible to advise on an appropriate mesh size. Selectivity data available for *P. georgianus* are also inadequate for the designation of a minimum mesh size.

Summary Conclusions

35. Assuming that the actual size of the twine mesh in commercially used codends is on the average 10% greater than the nominal mesh (SC-CAMLR-VII/BG/11), the introduction of the following mesh sizes in the commercial fishery in Statistical Area 48 should be considered:

(a) Subarea 48.3

(i) Fishery targeted at *C. gunnari*
80 mm, to protect immature fish, or
90 mm, to protect first spawners, or
100 mm, to give an age at first capture of 4 years;

(ii) Fishery targeted at *P.b. guntheri*
50 mm, to protect immature fish;

(iii) Mixed fishery (not targeted at *C. gunnari* or *P.b. guntheri*)
120 mm extended to include *N. gibberifrons*, *C. aceratus* and *P. georgianus* (in addition to *N. rossii* and *D. eleginoides*, which have had such a mesh regulation since 1984 - Conservation Measure 2/III), to ensure better protection of immature fish;

(b) Subareas 48.1 and 48.2
110 mm, to ensure protection of first spawners of *C. gunnari* and immature *N. gibberifrons*.

In addition to the above, the provision should be included that chafers will not be used and codends will be diamond shaped mesh made of twine, no thicker than 4.5 mm.

36. Further research on mesh selectivity was recommended in order to improve the applicability of these selection factors. It was stressed that such studies needed to reflect selectivity in the commercial fishery and should therefore be undertaken using commercial fishing gear and techniques independently of biomass surveys.

37. It is worth noting that the mean SF of 3.5 for *C. gunnari* and *N. gibberifrons,* obtained in the first Polish experiment using the 60 and 100 mm mesh tape netting, is considerably higher than that of the twine netting currently in commercial use. One of the properties of the tape netting is the constant rectangular shape of meshes (SC-CAMLR-V/BG/29). Satisfactory parameters of fish selection, obtained for this kind of net, should encourage further experiments with this ‘open mesh’ netting.

38. Recent reports to ICES have indicated that fish which pass through the meshes of a net may be subject to high mortality. No information was available to indicate if this is a

significant problem for Antarctic fish species. It was recommended that studies be undertaken to quantify this form of fishing mortality.

39. Although the Working Group agreed that further work was necessary it was felt that the analyses presented were now at a stage when selection factors could be used as a guide in introducing new mesh sizes.

Other Information

Larval Fish Key

40. A key and catalogue of Antarctic fish larvae have been prepared by A. Kellermann (FRG) and A.W. North (UK) and were expected to be published in January 1990. Funds were provided by CCAMLR for the project.

Bibliography

41. A bibliography of Antarctic fish has been prepared by K.-H. Kock and is available as a hard copy and on disc from Bundesforschungsanstalt für Fischerei, Informations und Dokumentationsstelle, Hamburg, FRG.

Assessments Prepared by Member Countries

Statistical Area 48 (Atlantic Ocean Sector)

Standing Stock Estimation

42. The results of two trawl surveys around South Georgia were presented, one undertaken by USA from the research vessel NOAA *Surveyor* during January and a joint UK/Polish survey during February using RV *Profesor Siedlecki* (SC-CAMLR-VIII/BG/35 and WG-FSA-89/6 respectively).

43. The USA study was undertaken using a newly developed small bottom trawl which had a narrower swept area and lower headline height than trawls used commercially. Operational constraints meant that the net could only be fished down to a maximum depth of 250 m.

44. Two methods of analysing the survey data for abundance estimation had been used. The traditional stratified random sampling method had given estimates of mean abundance and variance for some species similar to those from previous surveys. Using the Kriging method, similar estimates of abundance were obtained but with a very much lower variance. The Kriging method requires fitting one of three models to the distribution of two parameters on a semivariogram. Abundance estimates derived from this method assume that there is zero variance about the model chosen. It was concluded that the Kriging method gives an unrealistically low estimate of variance and was therefore inappropriate in the current circumstances.

45. The UK/Polish survey had been undertaken in the same way and using the same gear as on two previous surveys undertaken jointly by USA and Poland. A stratified random sampling method was used for the design and analysis of the data. This survey was therefore directly comparable with the two previous ones and it was agreed could be used for current standing stock estimation.

Parameter Estimation

46. Growth and natural mortality were estimated for *C. gunnari* at South Georgia (WG-FSA-89/20). Bertalanffy growth parameters were consistent with earlier estimates given by Kock (1981) and Kochkin (1985).

47. Natural mortality had been estimated by five methods using both direct and indirect methods. The direct method used data pooled over four seasons. It was felt that variations in recruitment, evident from other analyses undertaken in previous years by the Working Group, meant that these analyses could give a misleading impression of M and that a year by year analysis would be more appropriate. USSR scientists were requested to provide the data for such analyses for the next meeting.

48. Data from recent years in both the South Georgia and Kerguelen fisheries indicated that mortality of the older age classes was very high although no explanation, such as a high post-spawning mortality, was forthcoming. Some indication might be forthcoming from a consideration of condition factors throughout the year.

49. Several different methods are available for estimating ‘M’ of which those using age composition data directly were the best. The Working Group considered that the Heincke estimator of ‘M’ should be used. The value for this parameter calculated from the data in WG-FSA-89/20 is 0.56. The Working Group agreed that this value and the one agreed last year (0.35) should be used for subsequent assessment analyses.

50. Growth and natural mortality were estimated using data from the earliest years of the fishery for *P.b. guntheri* at South Georgia (WG-FSA-89/18). The values of the von Bertalanffy growth parameters provided a close fit to observed values and were used for analysis at the Working Group.

51. The age data presented in this paper were used to estimate an average value of M using Heincke’s estimation, under the assumption that the age data are representative of an unfished population in equilibrium. The estimate obtained was M = 0.94. However, the age data come from a single year and hence do not average out any fluctuations between age classes from variable recruitment. This reduces the reliability of the estimated value of M. In addition, the age data suggest the possibility of age dependence in natural mortality. While the Heincke estimator correctly estimates the average natural mortality rate in a virgin stock, this is not necessarily the average natural mortality in the stock under exploitation.

52. Pauly’s method (paragraph 25) was used to make an independent prediction of the value of M. The result was M = 0.45.

53. Estimates of the age and size at which 50% of the Shag Rocks population of *P.b. guntheri* reach sexual maturity were provided in two papers. Age at sexual maturity can be used to estimate M by the method of Rikhter and Efanov. This information is summarised below:

Length at Sexual Maturity (cm)	Age at Sexual Maturity (years)	M	Reference
15.6 - 16.5	3.7*	0.44	Lisovenko and Pinskaya (cited in WG-FSA-89/21)
16.0	3.7*	0.44	Balguerias and Quintero (SC-CAMLR-VIII/BG/27)
12 - 14	2.5	0.63	Shlibanov (WG-FSA-89/21)

* Estimated from Bertalanffy parameters given in WG-FSA-89/21.

Status of Stocks

54. Analyses of the status of the three target species, *C. gunnari*, *N. rossii* and *P.b. guntheri* in the Atlantic sector, were presented in SC-CAMLR-VIII/BG/18. These indicated that the stock size of *C. gunnari* around South Georgia was 68 700 or 86 800 tonnes (depending on which of the two data sets are used) at the beginning of the 1988/89 season. The authors suggested that further protection of the stock would be achieved by bringing forward the closed seasons from 1 April to 1 March to protect prespawning aggregations of females and would be warranted. Stock size in *N. rossii* seems to be still less than 5% of the pristine level. Trajectories of stock size of *P.b. guntheri* were largely dependent on the rate of natural mortality M chosen. Values of M = 0.8 indicate a decline in stock size and recruitment whereas M = 0.4 would indicate only minor fluctuations in stock size and recruitment since the onset of fishing.

55. An assessment of the *C. gunnari* stock at South Georgia using Virtual Population Analysis (VPA) was presented (WG-FSA-89/8). The current standing stock used in the analysis was based on the UK/Polish survey in February 1989 and the analysis had been tuned using biomass estimates from other surveys. The paper described several problems, which were encountered in the preparation of other input data because detailed catch information for this stock was not available from all fishing countries of CCAMLR, especially for the early period of the fishery. Problems were also encountered with some age/length keys where ambiguities were found in separate published descriptions of the same data set; such data were not included in the analysis.

56. The results indicate that the current biomass level of *C. gunnari* is very much less than its peak value as estimated from VPA and that the catch levels observed in recent years cannot be sustained.

57. During discussion the point was made that only two age/length keys were used to calculate *C. gunnari* catch age composition for all years of the fishery. However, age/length keys from one year may not reflect the age composition of catches in other years. According to Ricker this can lead to bias in age composition of catches (Whestreim and Ricker, 1978).

58. Analyses reported in SC-CAMLR-VIII/BG/18 using different age/length keys had come to essentially the same conclusions as this study. The differences caused by using different age/length keys were therefore considered only of minor importance in this particular case.

59. In WG-FSA-89/8 data from four trawling surveys have been used for tuning. Trawling surveys have a large standard error. For example, the estimate of abundance of *C. gunnari* from the UK/Polish survey has a coefficient of variation of 49.9%. Hence estimates of terminal fishery mortality based on an individual survey will have high uncertainty (especially for the 2 to 3 age classes).

60. An assessment of *P.b. guntheri* in Subarea 48.3 using VPA was presented in WG-FSA-89/21. Information on growth and natural mortality were as described in WG-FSA-89/18. The estimated current standing stock was 117.5 thousand tonnes and a Total Allowable Catch (TAC) at $F_{0.1} = 1.12$ of 28 300 tonnes was derived.

61. During discussion it was noted that the mean weight at age used for the analysis changed dramatically after the 1985/86 season. The reported mean weight at age for most year classes had almost doubled after that time. Such an increase seems biologically unlikely and could be the result of problems in methods in ageing.

62. The annual catches used for the analysis were, for the most part, higher than those reported to CCAMLR (SC-CAMLR-VII/10, Table 2). The catch data used in WG-FSA-89/21 were calculated by multiplying the number at age by the mean weight at age. These calculated values differ from the reported catch by a factor equal to the difference between the mean weight of fish of a given year class in the month in which they are caught and the mean weight of fish of that year class over the year. It was agreed that the catches reported to CCAMLR in the standard formats should be used for the analyses.

63. It was noted that there had been some changes in the reported classes of fishing vessels over the period of the study. It was confirmed that STATLANT 08B data reported by USSR from 1983 to 1986 with vessel code of 7 should be attributed to vessel code 10 (2 000 – 4000 tonnes). The CCAMLR Data Manager was requested to make the appropriate changes to the records in consultation with the USSR Data Manager.

64. Clarification was sought for the differences noted in WG-FSA-89/21 between the length at sexual maturity for *P.b. guntheri*.

65. An assessment of *C. gunnari* at South Georgia using VPA was presented in WG-FSA-89/22. Using the Laurec-Shepherd method of tuning the VPA and data from Soviet fishing vessels, a value for biomass of 139 900 tonnes was obtained.

66. Input data on growth and mortality were derived from WG-FSA-89/20 and have been commented on in paragraph 42 and 43 of this report. Six further points were made in discussion of this paper.

(i) The effort time series chosen to tune the VPA was derived from midwater trawl data. An alternative time series was available for bottom trawls, but was not used as there was a data point missing. The series used showed effectively no decline over the period. By contrast the other series indicated a decline in CPUE to about 25% of the original level. The use of a series which shows no trend to tune the VPA results in a very high estimate of stock size. In essence, catches are seen by the estimation technique to be having little effect on the stock, hence the stock must be large. If the other CPUE series had been used it is likely that a much smaller stock estimate would have been obtained. This would be in accord with the survey estimates which indicate recent stock levels of around one third of the estimate in WG-FSA-89/22.

(ii) The data on catch at age for 1987/88 were different from the catch at age presented for the USSR fishery by Borodin and Kochkin (WG-FSA-88/32) although data for all other years were the same. The effect of the new data was to raise the CPUE for that year and hence estimates of recent stock size. The Working Group agreed that there was a need to resolve this problem.

(iii) The point was made that in October 1988 the fishery appears to have concentrated on two year old fish. However, the estimate of partial recruitment used comes from a period when other age classes were abundant in the fishery, with the result that two year olds were then not specifically targeted by the fishery. Accordingly, applying this historical partial recruitment estimate to the recent predominantly two year old catches could lead to substantial over-estimates of biomass for the coming season.

(iv) Catch and effort data used for this study were taken from SC-CAMLR-VII/10, paragraph 24 which gives no catch and effort data for bottom trawl fishing during 1985/86. Consequently these data are missing from subsequent analyses and from the paper currently under consideration. However, these missing data have been supplied to CCAMLR in the STATLANT 08 format and were also used in another study reported to this meeting of the Working Group (WG-FSA-89/8).

(v) The STATLANT data also indicated that there had been a change in the size of vessels during the period. It was explained that an incorrect code had been used to report the same size of vessel (see paragraph 63).

(vi) The CPUE data used for the assessment came from pooling different sets of months in different years and hence may not be compatible.

(vii) There are consistent differences between the age composition of the catches obtained using midwater trawls and bottom trawls. Midwater trawls catch a much higher proportion of one and two year old fish than bottom trawls. These differences need to be incorporated into assessments involving CPUE.

Potential Yield

67. Two papers (SC-CAMLR-VIII/BG/42 and SC-CAMLR-VIII/BG/47) were tabled in response to the request by the Commission for advice on the likely trajectories of catch and total biomass under different patterns of fishing and mortality (CCAMLR-VII, paragraphs 113 and 114).

68. An analysis was made of the potential yield of *C. gunnari* around South Georgia under varying recruitment (SC-CAMLR-VIII/BG/42). The simulations indicated that at levels of fishing mortality equal to the maximum yield per recruit (F_{max}) or $F_{0.1}$, the expected yield of *C. gunnari* would be in the region of 20 000 to 40 000 tonnes per annum once recovery of the stock occurred. At conservative, sustainable levels of harvesting the

variability in catches between years is lower than when harvesting rates are high, and the probability of the spawning stock falling to dangerously low levels, is reduced. Closure of the fishery for at least one year would have substantial benefits in increased yields and decreased uncertainty.

69. The paper SC-CAMLR-VIII/BG/42 used the results of WG-FSA/89/8 as a basis for its analysis on the variability of recruitment and the variation of recruitment with stock size. The main criticisms of this paper were that it assumed recruitment was a random variable with a log normal distribution. Similar analyses, reported in another paper (SC-CAMLR-VIII/BG/18) which had taken account of cyclical changes in standing stock and recruitment, indicated essentially similar trends in standing stock size. On balance it was considered that the analyses reported in SC-CAMLR-VIII/BG/42 had presented an optimistic view of the implications of different management possibilities as it assumed that stock size and fishing mortality could be assessed without error.

70. A further study (SC-CAMLR-VIII/BG/47) examined the effects of a number of harvesting strategies on *C. gunnari* for a period of 30 years. The strategies chosen were:

- different levels of constant fishing mortality ($F_{0.1}$, F_{max}, 2 x F_{max});
- harvesting constantly at 50% $F_{0.1}$ with an increase of F 3 or 5 years after a good recruitment;
- pulse fishing at an interval of 3 years with no fishing in between; and
- a shift in partial recruitment values due to changes in net selectivity.

Recruitment was assumed to follow the historical pattern.

71. The study indicated that pulse fishing was the least preferable strategy. In the absence of regular recruit surveys, constant fishing at $F_{0.1}$ is most likely to be the most profitable and least risky strategy compared to higher levels of fishing mortality. The establishment of regular recruit surveys would offer the possibility of adjusting fishing mortality to the strength of the incoming year class. An increased F should not occur until at least four years after a good recruitment. Decreased partial recruitment of the youngest age classes as a result of a one year forward shift in partial recruitment values would not alter yield significantly when fishing at $F_{0.1}$ and F_{max} but would lead to a higher spawning biomass.

72. These two studies, although based on different approaches, were seen as providing essentially similar advice with regard to the South Georgia, *C. gunnari* fishery (i.e. a pause of 1–2 years to let the spawning stock recover and a conservative fishing mortality rate not higher than $F_{0.1}$).

Comparison of Semipelagic and Bottom Trawls

73. Preliminary observations on the suitability of semipelagic trawl gear in the *C. gunnari* fishery were described in SC-CAMLR-VIII/BG/26. The semipelagic trawl used during the 'Antartida 8611' expedition had been more effective in catching *C. gunnari* than bottom trawls. The semipelagic net was very much less effective for catching *N. gibberifrons*.

74. It was agreed that estimates based on haul by haul data, collected, if possible, at the same time, would provide better indicators of the relative effectiveness of various types of trawls (bottom, semipelagic or midwater), because of the unknown vertical distribution of various age groups of *C. gunnari* as well as the patchiness observed in the horizontal distribution of the several Antarctic fish species. Such values could also be used to estimate differences in the by-catch taken using these types of gear.

Statistical Area 58 (Indian Ocean Sector)

Standing Stock Estimation

75. No new demersal fish surveys from the Kerguelen region were reported. Previous surveys have indicated that *N. rossii* is still at a low level although trammel net hauls in the coastal region indicate that there is an increase in juveniles of this species. *C. gunnari* stock is subject to cyclical fluctuation in recruitment while the *N. squamifrons* stock appears to be declining (WG-FSA-89/9).

Parameter Estimation

76. Growth and natural mortality of *N. squamifrons* were described from three locations in the Indian Ocean sector (WG-FSA-89/16 and WG-FSA-89/17). Parameters of the von Bertalanffy growth equation were similar to those reported earlier (Duhamel, 1987). For discussion of natural mortality see Appendix 5.

ASSESSMENTS

(Summary Assessments are provided in Appendix 10)

Statistical Area 48

Subarea 48.3 (South Georgia)

77. The history of catches around South Georgia is given in Table 1. This demonstrates how fishing has shifted from one species to another which in conjunction with a high variability in recruitment of *C. gunnari* has lead to a high variability in annual catches. The 1988/89 catch was only slightly below that in 1987/88. Catch of *C. gunnari* exceeded the $F_{0.1}$ and F_{max} levels estimated by the Working Group in 1988 by approximately 10 000 tonnes and 3 000 tonnes respectively but was well below the levels of 1987/88. Catch of *P.b. guntheri* exceeded the TAC of 13 000 tonnes set by the Commission in 1988 (Conservation Measure 12/VII) by 16 tonnes. However, catches of *D. eleginoides* and myctophids (*Electrona carlsbergi*) increased by factors of more than 2, to 4 138 and 29 673 tonnes respectively. For the first time longlining has been used inside the Convention Area to catch *D. eleginoides*.

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

Split year	SSI	ANI	SGI	LXX	TOP	NOG	NOR	NOS	NOT	OTHERS	TOTAL
1970	0	0	0	0	0	0	399704	0	0	0	399704
1971	0	10701	0	0	0	0	101558	0	0	1424	113713
1972	0	551	0	0	0	0	2738	35	0	27	3351
1973	0	1830	0	0	0	0	0	765	0	0	2595
1974	0	254	0	0	0	0	0	0	0	493	747
1975	0	746	0	0	0	0	0	1900	0	1407	4053
1976	0	12290	0	0	0	4999	10753	500	0	190	28732
1977	293	93400	1608	0	441	3357	7945	2937	0	14630[a]	124611
1978	2066	7557	13015	0	635	11758	2192	0	0	403	37626
1979	464	641	1104	0	70	2540	2137	0	15011	2738[b]	24705
1980	1084	7592	665	505	255	8143	24897	272	7381	5870	56664
1981	1272	29384	1661	0	239	7971	1651	544	36758	12197[c]	9167
1982	676	46311	956	0	324	2605	1100	812	31351	4901	89036
1983	0	128194	0	524	116	0	866	0	5029	11753[d]	146482
1984	161	79997	888	2401	109	3304	3022	0	10586	4274	104742
1985	1042	14148	1097	523	285	2081	1891	1289	11923	4238	38517
1986	504	11107	156	1187	564	1678	70	41	16002	1414	32723
1987	339	71151	120	1102	1199	2844	216	190	8810	1911	87882
1988	313	34620	401	14868	1809	5222	197	1553	13424	1387	73794
1989	1	21 359	1	29673	4 138	838	152	927	13016	55	70160

[a] Includes 13 724 tonnes of unspecified fish caught by the Soviet Union
[b] Includes 2 387 tonnes of unspecified Nototheniidae caught by Bulgaria
[c] Includes 4 554 tonnes of unspecified Channichthyidae caught by the GDR
[d] Includes 11 753 tonnes of unspecified fish caught by the Soviet Union

78. Information from two fishery-independent surveys carried out by UK/Poland (WG-FSA-89/6) and the US (SC-CAMLR-VIII/BG/35) was available to the Working Group. However, both vessels involved used very different bottom trawls. The UK/Polish survey used the same commercially-sized trawl as during the previous US/Polish surveys whereas the US survey used a trawl with a mouth opening of only $^1/_4$ of that of the Polish trawl. This may have biased the catches considerably towards smaller species and smaller individuals. Furthermore the US survey covered only part of the depth range (50 – 250 m) of the commercially exploited species. After extensive discussion the Working Group decided that it would only take estimates from the UK/Polish survey into account in its assessments.

79. The Working Group noted that the Member's Activities Report of the USSR contained biomass estimates of the commercially exploited species around South Georgia. However, the Working Group was unable to include these estimates in the assessments as no descriptions were available on how the estimates were obtained. The Working Group recommended these USSR results be submitted to next year's meeting for further consideration.

Notothenia rossii in Subarea 48.3

80. The Commission's conservation measures have aimed to keep the catches of the species to as low a level as possible. Reported catches in 1988/89 were 152 tonnes, 45 tonnes below the 1987/88 level.

81. There were no new data available from the commercial fishery. However, the biomass estimate from the joint UK/Polish research survey of 2 439 tonnes which was in line with biomass estimates from previous US/Polish surveys of 1 049 to 4 582 tonnes indicates that the stock remains at a very low level.

82. Although the reduction in stock size to levels below 5% of the pristine state must be having an effect on recruitment the apparent, however slow, recovery of the Kerguelen population of *N. rossii* after the cessation of directed fishing since 1984 (WG-FSA-89/9) indicates that there may be ecological factors influencing the recovery of the South Georgia population. Increased predation by fur seals (*Arctocephalus gazella*) which started to recolonise the mainland of South Georgia in the 1970's in increasing numbers might be among the reasons for continuous low recruitment. Food studies on fur seals indicate that they feed principally on *E. superba*. However, the proportion of fish, including *N. rossii*, in the diet increases in winter (SC-CAMLR-VIII/BG/18 for references).

83. In view of the low level at which the stock has been for a number of years, its status needs to be carefully monitored. Biomass estimates and age length keys from recent years were available from research vessels surveys. However, the Working Group noted with concern that there is a lack of data from the commercial fishery. Albeit its annual catch has been comparatively small after the establishment of conservation measures by the Commission, the Working Group strongly recommended that biological information (length composition, age length keys) should be collected and provided to the Working Group to assist in assessing the present status of the stock.

Management Advice

84. In view of the current low level of the stock *N. rossii*, all conservation measures should be kept in force.

Champsocephalus gunnari in Subarea 48.3

85. The total catch in 1988/89 was 21 356 tonnes which was taken in 35 days after the reopening of the fishery on 1 October 1988. As a result of catches reported to CCAMLR-VII, the Commission adopted Conservation Measure 11/VII which prohibited directed fishery on *C. gunnari* from 4 November 1988 to 20 November 1989. Catches taken before the closure of the fishery were already above the level corresponding to F_{max} and over twice the catch level at $F_{0.1}$, the preferred target fishery level decided by CCAMLR-VI.

86. Throughout the history of the fishery, catches have fluctuated in accordance with the appearance of strong year classes in the population, and the subsequent movement of these cohorts through the fishery. However, the fishery was regulated for the first time by CCAMLR in 1987/88, when a TAC of 35 000 tonnes was set. In that year the TAC was almost fully taken, with reported catches of 34 632 tonnes. This catch mainly comprised fish from the strong 1983/84 and 1984/85 cohorts. These two year-classes had been largely fished out by 1988/89 when the catch was dominated by the 1986/87 cohort (aged 2 years).

87. The UK/Poland trawl survey (WG-FSA-89/6) in 1989 gave a stock biomass estimate of 21 069 tonnes. This compares to 50 414 tonnes for a similar survey in 1986/87 and 15 086 tonnes in 1987/88. As these three surveys all used the same bottom trawl nets the results are fairly comparable. However, they are all thought to under-represent the abundance of 1 and 2 year old fish which are probably found higher in the water column. An earlier survey in 1986/87 with a semipelagic trawl gave an estimate of stock size of 151 293 tonnes.

88. The series of catch and effort statistics from the Soviet fishery using bottom and midwater trawls was updated to 1988/89. Some Members expressed the view that the CPUE estimated for the last two years when the fishery has been regulated may not be directly comparable with the data from earlier years. Other Members stated that these CPUE are reliable enough to be used.

89. Yield-per-recruit calculations in last year's Working Group report (SC-CAMLR-VII, Annex 5) show that improvements in yield can be achieved by exploiting the fish at older ages than currently. The pattern of fishing has varied in recent years, with the effective age at first capture now at 2 years. An increase in the mesh size to 110 mm would theoretically increase the age of first capture to the optimum of 4 years (see paragraphs 30 to 36). This would also provide protection to the first time spawners, thereby increasing the spawning stock biomass, and also result in higher catch rates. For a value of natural mortality $M = 0.35$, it would increase the value of $F_{0.1}$ from 0.245 to 0.455. For a value of natural mortality $M = 0.55$, it would increase the value of $F_{0.1}$ from 0.384 to 0.766. F_{max} is not found for most of these cases.

90. There were two assessments of the stock of *C. gunnari* which are described in detail in WG-FSA-89/27 and WG-FSA-89/22 Rev. 1.

91. WG-FSA-89/27 based the assessment on the UK/Polish survey in 1988/89 and presented a calibration of the surveys made by the US/Polish teams in 1986/87 and 1987/88 which permitted a correction to be made for the possible under-representation of 1 and 2 year old fish in the surveys. Terminal F values were then derived for the corrected age compositions and VPA runs produced for two values of natural mortality, M = 0.35 and 0.55. For comments on the reliability of the biomass estimates from this survey prepared by the USSR Delegation, see Appendix 6.

92. WG-FSA-89/22 Rev. 1 used the Laurec-Shepherd method for tuning VPA to catch and effort data. An interpolation had been made for the year 1984/85 as data were considered by the authors to be unreliable. The interpolation was made on the basis of a rough calculation of the average of the preceding and succeeding year's CPUE. The only consistent time series was for October where CPUE data were available for each year (see Table 2). For comments on the reliability of the use of CPUE data in VPA tuning prepared by the UK Delegation, see Appendix 7.

Table 2: CPUE for *C. gunnari* (tonnes/hours) for USSR in Subarea 48.3, bottom trawl. Monthly catch of *C. gunnari* ε 75% of total catch (<75% in brackets).

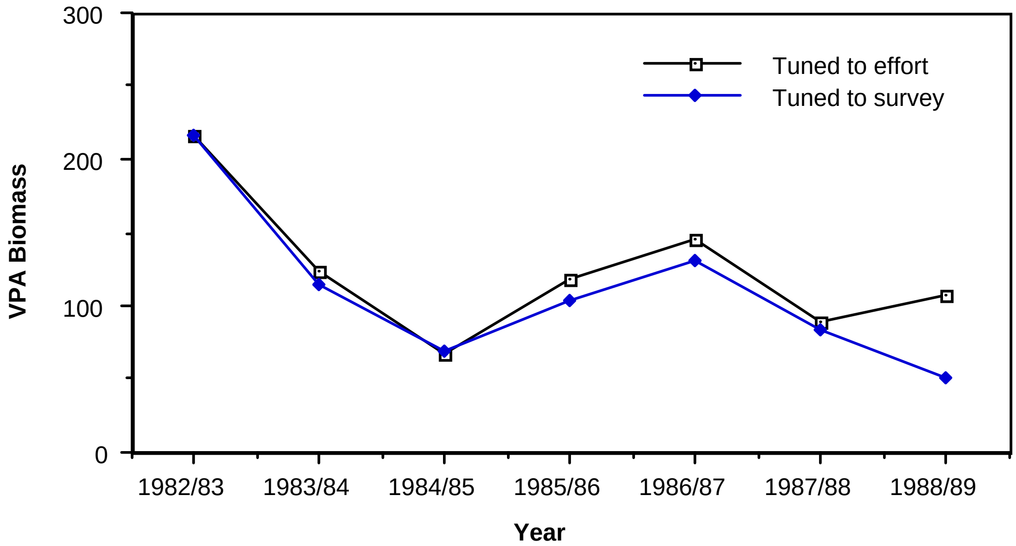
Split-Year	1983	1984	1985	1986	1987	1988	1989
July		2.372	4.442			1.675	
August						1.969	
September			(0.263)		2.875	(1.944)	
October	5.556	8.444	[0.261]*	2.358	2.992	2.018	3.207
November		4.820			(0.389)	(1.185)	(1.299)
December		(0.402)			3.117	(0.192)	
January	4.461	(0.408)			2.080	(0.387)	
February	10.740	6.828			2.255	(0.306)	
March	9.519	4.667			2.355	(0.594)	
April	7.683				2.268		
May	4.699			1.422	2.804		
June	1.457	4.955			2.821		
(July)		4.442					

* Interpolated value

93. The results of the two analyses can be readily summarised in Figure 1.

Figure 1

C. gunnari (Subarea 48.3)
VPA Biomass Analysis



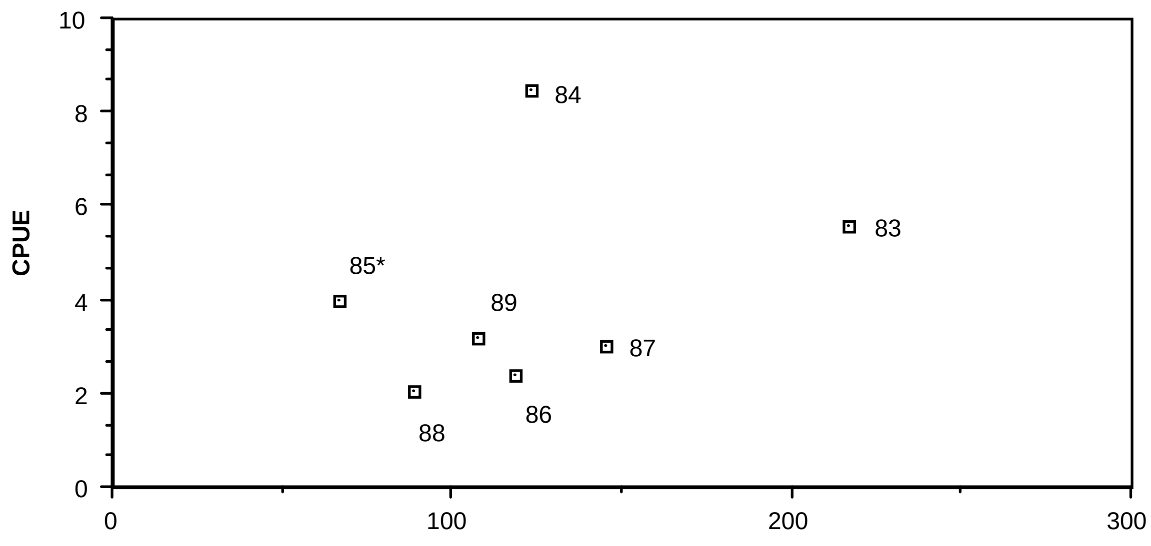
94. In essence, they differ only in the estimation of abundance for the 1988/89 season. There are problems with both techniques. The estimates of stock biomass from trawl surveys

have a high level of uncertainty, the coefficient of variation of the 1988/89 survey estimate was around 50%. Accordingly the stock size could be substantially above or below the estimate.

95. In principle, the tuning method should involve statistical averaging and hence decrease the level of uncertainty used. The method implicitly assumes a linear relationship between stock size and CPUE, however, while Figure 2 illustrates the relationship derived from the results presented in WG-FSA-89/22 Rev. 1 effectively similar results would be obtained from WG-FSA-89/27. There is a poor relationship, $r^2 = 0.1$, between CPUE and biomass and the interpolated value for 1985 does not appear to be reasonable. The view was expressed that a more appropriate comparison of the adequacy of the tuning method would be to compare the relationship between fishery mortality and effort. Another view was that there were sufficient free parameters in the method to ensure that this relationship was guaranteed to be close and that the comparison of CPUE and biomass was a sensible measure of the reliability of the results. The Working Group could not agree on a way of assessing the reliability of these results.

Figure 2

C. gunnari (Subarea 48.3)
Biomass and CPUE Relationships



VPA -
or Estimated Biomass

Management Advice

96. The large differences between the two analyses for the final year pose serious problems in presenting management advice to the Commission.

97. The TAC's at different target F levels that have been derived from the two assessments are given in Table 3. They differ substantially.

Table 3: TAC levels (tonnes) for *C. gunnari*, Subarea 48.3, calculated from assessments presented in WG-FSA-89/27 and WG-FSA-89/22 Rev. 1 (M = 0.35).

	Assessment presented in WG-FSA-89/27	Assessment presented in WG-FSA-89/22 Rev. 1
$F_{0.1} = 0.313$	6 545	22 235
$F_{max} = 0.645$	11 961	40 273

98. In essence, if the trawl survey and the analysis based on it is correct, a TAC based on the CPUE tuned VPA will lead to a substantial depletion of the stock.

99. If the analysis based on the CPUE tuned VPA is correct and a TAC is set on the basis of the trawl survey results, the stock will increase substantially.

Notothenia gibberifrons in Subarea 48.3

100. The total catch in 1988/89 decreased to 838 tonnes compared to the previous year when 5 219 tonnes were caught. The closure of the fishery around South Georgia from 4 November 1988 prevented further exploitation of *N. gibberifrons*. Catches in the 1988/89 year were mainly by-catch of the *C. gunnari* fishery, although directed fishing has occurred in previous years. Despite the reduction in catch in 1988/89, the catch was higher than the level corresponding to F_{max}, and nearly twice the level at $F_{0.1}$.

101. This species has many age classes in the population and has low productivity. The stock was much more abundant in the early 1970's than it is now. Trawl survey estimates in 1984/85 (15 762 tonnes) and 1986/87 (13 544 tonnes) were higher than the more recent surveys (7 189 tonnes in 1987/88, 8 510 tonnes in 1988/89). This series suggests that abundance was reduced by catches in 1986/87 and 1987/88.

102. The results of the trawl surveys were used to calibrate the VPA up to 1987/88. It is apparent from the VPA results that biomass has continued to decline. The VPA suggests that

current biomass is only 20% of the level during the mid 1970's. The VPA is also useful in determining the size of recruiting age classes to the population. A strong relationship between stock size and recruitment was found for the period 1978 to 1986 (Figure 3).

N. gibberifrons (Subarea 48.3)
Stock Recruitment Relationship

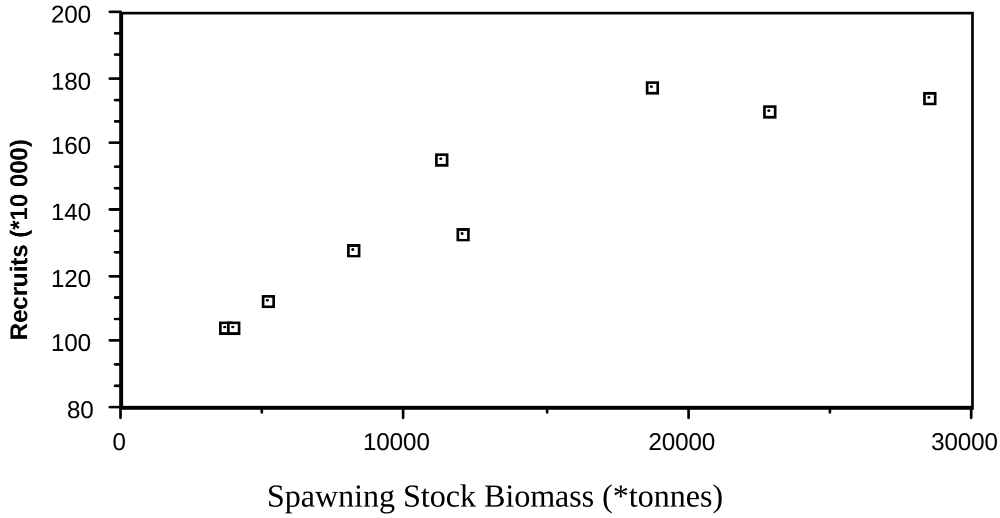


Figure 3: Number of 2 year old recruits each year from 1978 to 1986 plotted against the Spawning Stock Biomass (SSB) two years previously (from VPA results M = 0.125).

Management Advice

103. Because of the current stock size and the evidence for a stock recruitment relationship, it is inappropriate to recommend catches at the level of $F_{0.1}$. Catches should be kept to a minimum to increase the stock size as much as possible. The Working Group recommended that there should be no directed fishery for *N. gibberifrons* and by-catch should be restricted to not more than 300 tonnes.

Pseudochaenichthys georgianus in Subarea 48.3

104. Except in 1977/78 when 13 000 tonnes were reported, this species has usually been taken as a by-catch. Some additional catches in the late 1970's and early 1980's, however, may have been contained in categories 'channichthyids nei' and 'marine fishes nei'. Annual catches in the most recent five years were less than 1 000 tonnes. No catches were reported

in 1988/89. However, some catches were mentioned in the Member's Activities Report of the USSR (CCAMLR-VIII/MA/8).

105. Research vessel surveys in 1984/85 (FRG), 1986/87, 1987/88 (joint US/Polish) and 1988/89 (joint UK/Polish) have provided biomass estimates of 8 134 tonnes, 5 220 tonnes, 9 461 tonnes and 8 278 tonnes respectively which are all well below the level prior to exploitation and in the first years of fishing. Length frequency data indicate a considerable variation in year class strength which may explain some variation in the biomass estimates.

106. No VPA analyses could be attempted. Yield-per-recruit calculations assuming knife-edge recruitment have been carried out on data from the late 1970's available in scientific literature (Kock et al., 1985). These indicate a value of $F_{0.1}$ of around 0.3. Using a mean biomass of approximately 8 000 tonnes from the research vessel survey data this would correspond to a catch of approximately 1 800 tonnes. It is unlikely, however, that this catch could be taken without a substantial 'by-catch' of other species (*C. gunnari*, especially *C. aceratus* and *N. gibberifrons*) which would exceed the catch of *P. georgianus*.

Chaenocephalus aceratus in Subarea 48.3

107. Reported catches have been relatively small in all years, exceeding 2 000 tonnes only in 1987/88. Some additional catch, however, might have been contained in the categories 'channichthyids nei' and 'marine fishes nei' in the late 1970's/early 1980's. Biomass estimates obtained during research vessel surveys of the FRG (1984/85), joint US/Polish (1986/87 and 1987/88) and UK/Polish (1988/89) were 11 542 tonnes, 8 621 tonnes, 6 209 tonnes and 5 770 tonnes respectively. This indicates a continuous decline in biomass although catches in those years were only in the order of a few hundred tonnes. Biomass estimates are substantially lower than for the period prior to fishing or the early years of fishing.

108. No VPA calculations have been attempted. Applying earlier estimates of $F_{0.1}$ of around 0.16 (Kock et al., 1985) to the most recent biomass estimates of 6 000 tonnes gives a TAC for 1989/90 of approximately 800 tonnes. Given the rather even distribution of this species over the area and its co-occurrence with other species (e.g. *N. gibberifrons* and *P. georgianus*) it is unlikely that this catch could be taken without a substantial 'by-catch' of these species.

Management Advice for *Pseudochaenichthys georgianus* and *Chaenocephalus aceratus*

109. In view of the 'by-catch' problem associated with the catch of these species, it's likely detrimental effects on other species with a low stock size (e.g. *N. gibberifrons*) and an apparent stock-recruitment relationship in the case of *C. aceratus*, the Working Group recommended that no directed catches of these species be taken and by-catches be reduced to a minimum to allow the recovery of these stocks.

Notothenia squamifrons in Subarea 48.3

110. *N. squamifrons* inhabit the deeper parts on the shelf and the upper slope around South Georgia including Shag Rocks. Catches of this species have been reported as early as 1971/72 and almost each year thereafter. Annual catches usually vary between several hundred and a few thousand tonnes.

111. Despite the comparatively long catch history virtually no information on length and age of fish in the catch has been submitted to CCAMLR. Length compositions were available from the Spanish research vessel survey in 1986/87, the US/Polish surveys of 1986/87 and 1987/88 and the joint UK/Polish survey in 1988/89. Catches in 1986/87 consisted primarily of adults (> 30 cm) whereas in the other years juveniles (< 30 cm) predominated in the catches. Biomass estimates were 13 950 tonnes (1986/87), 409 tonnes (1987/88) and 121 tonnes (1988/89). These estimates, however, may be biased to an unknown extent as the surveys covered only part of the bathymetric range of the species.

112. Biological characteristics of the closely related Kerguelen population indicate that *N. squamifrons* is a long living species with a larger number of age classes present in the fishery. No information on recruitment or mortality estimates for this species at South Georgia was available to the Working Group to assess the state of the stock.

113. Due to the catch restrictions likely to be imposed on other species in the area, *N. squamifrons* may be of growing interest to the fishery in the near future. Information on length and age of historical and current commercial catches as well as biomass estimates from research vessel surveys are urgently needed to assess the state of this stock.

Management Advice

114. As the status of this stock is unknown, the Working Group was unable to recommend a TAC.

Dissostichus eleginoides in Subarea 48.3

115. Catches of *D. eleginoides* have been reported since 1976/77. Until 1985/86 they made up several hundred tonnes annually except in 1977/78 when 1 920 tonnes were taken. Most of the catches were probably obtained in the Shag Rocks/Black Rocks area where the species is a common by-catch in the fishery on *P.b. guntheri*. Since 1985/86 annual catches have gradually increased from 564 tonnes to 4 138 tonnes in 1988/89. Up to 1987/88 the fishing was trawl-based. In 1988/89 longlining was introduced and almost all catches were reported to have been taken by that fishery.

116. No information on the length and age composition from the commercial catches (past and recent) has been available to the Working Group. Length compositions from research vessel surveys of the FRG in 1975/76, 1977/78 and 1984/85 indicate that the trawl fishery was almost entirely based on juvenile specimens with a few adults present in the catches. As longlining is highly size selective it is likely that the proportion of adults in the catches has increased substantially.

117. Biomass estimates were available from recent surveys of the FRG (1984/85), joint US/Polish (1986/87 and 1987/88) and UK/Polish (1988/89). They were 8 159 tonnes (1984/85), 1 208 tonnes (1986/87), 409 tonnes (1987/88) and 306 tonnes (1988/89). Estimates, however, are not directly comparable as the 1984/85 value included the Shag Rocks area which was omitted during the other surveys. As the surveys covered only the upper part of the bathymetric range of the species, biomass estimates, even that including Shag Rocks, are likely to be underestimates.

118. The species is a long living fish which may reach 25 to 30 years. *D. eleginoides* becomes mature at 8 to ten years. The slow growth rate and long life span implies that yield-per-recruit and sustainable yield as a proportion of unexploited biomass are very small.

119. Due to lack of relevant information from commercial catches and certain gaps in the knowledge of the biology of the species, the Working Group was unable to assess the state of

the stock. This presents problems as the catch has increased by a factor of 4 in the last two years (see paragraphs 8 and 9).

Management Advice

120. Even in the absence of information on the stock size it is possible to calculate the yield for different levels of the unexploited stock size (using, for example, the Gulland formula yield equals half the product of mortality and unexploited biomass). Natural mortality is estimated to be 0.06 (Kock, Duhamel and Hureau, 1985).

Biomass	Sustainable Yield
8 000 tonnes	240 tonnes
40 000 tonnes	1 200 tonnes

As the figure of 40 000 tonnes is some five times the stock estimate obtained by the FRG survey in 1984/85, this could be considered as a reasonable upper limit until further data become available.

Patagonotothen brevicauda guntheri in Subarea 48.3

121. Total catch was regulated by a TAC of 13 000 tonnes in 1988/89 (Conservation Measure 12/VII). This was intended to keep the catch at a level similar to that of the previous year. Total reported catch was 13 016 tonnes taken by the Soviet directed fishery in the area of Shag Rocks. Age composition data show that the catch was largely based on ages 2 to 4 as in previous years.

122. Catch and effort statistics were available from Soviet BMRT vessels from 1978/79 to 1988/89 and a biomass estimate of 81 000 tonnes was available from the Spanish survey in 1986/87.

123. There is much uncertainty about the rate of natural mortality for this species, however, it is unlikely to be higher than 0.7 (see Appendix 5). Yield-per-recruit calculations were carried out using two different values of natural mortality. For $M = 0.48$, $F_{0.1}$ was equal to 0.559, while for $M = 0.63$, $F_{0.1}$ was calculated at 0.783.

124. An assessment was presented at the meeting (WG-FSA-89/21) using the catch and effort data to calibrate the VPA. Natural mortality was assumed to be 0.9 in this assessment. Problems with the weight at age data used in the last three years resulted in overestimation of the biomass in these years. The assessment indicates a downward trend in stock size over the 11 year time series from 160 000 to about 100 000 tonnes. The biomass estimate for 1988/89 was 103 000 tonnes which indicated a decline in stock size over the time series from about 160 000 tonnes from 1978 to 1980. This effect may in part be due to the high value of natural mortality used in the assessment, which causes the estimates of biomass and recruitment in the early years to be inflated. This was shown to be the case in SC-CAMLR-VII/BG/18.

125. Assessments were also carried out using the biomass estimate from the trawl survey to calibrate the model. The partial recruitment pattern in the last year and assumed terminal fishing mortality were varied by trial and error, until the VPA biomass estimate in 1986/87 matched the trawl survey estimate of 81 000 tonnes. Two alternative runs of the model were completed with natural mortality values of 0.48 and 0.63 respectively. From these runs it is apparent that the projected biomass in 1989/90 is particularly sensitive to the value assumed for M.

126. It is possible to look at the effect on recruitment and projected biomass of varying natural mortality rates.

VPA Calibration Technique	Natural Mortality	Biomass 1989/90 (tonnes)	Proportion of biomass from 1 and 2 year old fish
Trawl survey 1986/87	0.48	130 000	27%
	0.63	90 000	50%
Catch and effort data	0.9	106 000	68%

As the rate of natural mortality is increased, the mean level of recruitment estimated in the VPA is increased. Therefore the projections depend more on the assumptions concerning recruitment for higher values of M. Given the paucity of independent information on the stock and the uncertainty over M, it is difficult to choose between the alternative interpretations of historical stock size.

Management Advice

127. Uncertainty in the value of natural mortality and the lack of any time series showing trends in biomass levels prevent accurate assessment of the current stock size. In the absence of reliable estimates of natural mortality to evaluate the alternative analyses and in the absence of information on current stock size, catch levels should not be based on VPA results, using $F_{0.1}$ calculations and assumptions about recruitment. The current status of this stock is unknown.

Subarea 48.2 (South Orkney Islands)

128. Catches in Subarea 48.2 were only substantial in the late 1970's when two very abundant year classes of *C. gunnari* were fished (Table 4). Most of these fish, in particular in 1977/78, were still juveniles. Since then catches of all species have been usually in the order of a few thousand tonnes except in 1982/83 – 1983/84 when 18 412 and 15 056 tonnes were taken.

Table 4: Catch by species in Subarea 48.2

	Champsocephalus gunnari	*Notothenia gibberifrons*	*Notothenia rossii*	Pisces nei	Total
1978	138 895	75	85	2 603	141 659
1979	21 439	2 598	237	3 250[1]	27 524
1980	5 231	1 398	1 722	6 217[2]	14 548
1981	1 861	196	72	3 274	5 403
1982	557	589		2 211	3 357
1983	5 948	1		12 463[3]	18 412
1984	4 499	9 160	714	1 583	15 956
1985	2 361	5 722	58	531	8 672
1986	2 682	341		100	3 123
1987	29	3		3	35
1988	1 336	4 469			5 805
1989	532	601		1	1 134

[1] Mainly Chaenocephalus aceratus
[2] Pseudochaenichthys georgianus and unidentified Nototheniids and Channichthyids
[3] Unknown species

129. The only species for which catch figures have been submitted were *C. gunnari* (532 tonnes) and *N. gibberifrons* (601 tonnes). Other species present in the catches have been *N. kempi*, *P. georgianus* and *N. rossii* (CCAMLR-VIII/MA/8) but catches of these species have not been specified in the STATLANT 08A and 08B forms.

130. No new data (length compositions, age length keys, biomass estimates) were available to the Working Group, therefore the Working Group was unable to carry out new assessments.

131. An assessment provided by Kock and Köster (SC-CAMLR-VIII/BG/18) based on a limited time series from 1977/78 to 1985/86 showed a substantial downward trend in the stock of *C. gunnari* since the onset of fishing. Stock size seems to be less than 10 000 tonnes at present. Biomass estimates from research vessel surveys in 1984/85 (FRG) and 1986/87 (Spain) were 3 669 and 1 179 tonnes respectively. From 1982/83 onwards the VPA suggest that recruitment was obviously low although there are some indications that recruitment values obtained from the VPA may be artefacts.

132. An assessment on the stock of *N. gibberifrons* during last year's meeting, using a rather poor database, did not indicate a severe impact of fishing on the stock since exploitation started in 1978/79, in particular if natural mortality is low.

133. To provide improved assessments of both stocks, *C. gunnari* and *N. gibberifrons*, length and age data from the catches since the mid 1980's are needed. An estimate of current stock biomass from a research vessel survey is also highly desirable.

Management Advice

134. Due to the lack of data the Working Group was unable to recommend a TAC for either species. In case, however, the recruitment failure in *C. gunnari* is real, the stock should be protected until evidence to the contrary is available.

Subarea 48.1 (Antarctic Peninsula)

135. Catch history in the Peninsula region has a similar history to that around the South Orkney Islands: large catches were obtained in the late 1970's when concentrations of *C. gunnari* (mostly juveniles) (1978/79), *N. rossii* (1979/80) and *Chaenodraco wilsoni* (1978/79 and 1979/80) were exploited. Catches have only been sporadic since then. Reported catches in 1988/89 were 140 tonnes of *C. gunnari* and 665 tonnes of *N. gibberifrons* (Table 5).

Table 5: Catch by species in Subarea 48.1

	Champsocephalus gunnari	*Notothenia gibberifrons*	*Notothenia rossii*	Pisces nei	Total
1979	35 930	3 280	470	12 516[1]	52 196
1980	1 087	765	18 763	5 536[1]	26 151
1981	1 700	50		4 266[2]	6 016
1982					
1983	2 604			16	2 620
1984					
1985					
1986					
1987	75	55		7	137
1988		1		1	2
1989	140	665		17	822

[1] Mainly Chaenodraco wilsoni
[2] Unknown species

136. No information on age and length in the catches was available to the Working Group. Due to the sporadic catches in recent years and the resulting significant gaps in the time series of length and age data, the Working Group was unable to provide any new assessments of the stocks.

137. Elephant Island is one of the most important fishing grounds in the Peninsula subarea. Biomass estimates obtained from research vessel surveys of the FRG in 1984/85, 1985/86 and 1987/88 in the area were in the order of 1 000 tonnes for *C. gunnari*. This and the low catches, if any, in the most recent years does indicate that stock size is obviously at a low level. Biomass of *N. gibberifrons* seems to be higher. It was estimated at 25 000 tonnes during an FRG research vessel survey in 1984/85.

138. Due to the sporadic nature of the fishery it would be extremely difficult to reconstruct the historical fishing pattern in *C. gunnari* by VPA analysis. One way to overcome this may be to combine age length data and biomass estimates of this species from Subareas 48.1 and 48.2 as has been done by Kock and Köster (SC-CAMLR-VIII/BG/18).

139. To improve assessment of the stock of *N. gibberifrons* age and length data from the recent catches are needed. A research vessel survey to provide a current biomass estimate is also desirable.

Management Advice

140. Due to the absence of data, the Working Group was unable to recommend a TAC.

Statistical Area 58

141. In this area fishing takes place only in Subareas 58.4 and 58.5.

142. No results from mesh selectivity investigations are available for Statistical Area 58. Such results are necessary to formulate recommendations based on yield-per-recruit analyses of major stocks.

143. A summary of catches reported from Statistical Area 58 is given in Table 6. Up to the 1979/80 season very few data are available that give the subarea of capture. From that time onwards reported catches have been largely from Division 58.5.1 (Kerguelen), with small catches of *N. squamifrons* from Division 58.4.4 (Ob and Lena Banks). Detailed analyses have therefore been restricted to these stocks, but some information is available from other subareas discussed at the Working Group's last meeting (SC-CAMLR-VII, paragraphs 69 and 70, pages 114 to 116).

Subarea 58.4

144. The reporting of catches of *P. antarcticum* in Subarea 58.4 is still not sufficiently detailed to establish where such catches are taken and whether these are from one or more stocks. Both fine-scale reporting and analysis of catch levels is required to establish the distribution of *P. antarcticum* stocks in Subarea 58.4 as a whole. Some reported catches in 1985 and 1986 indicate possible commencement of a fishery for the species but available data are insufficient to assess stocks. Catch levels since 1987 have, however, been low.

145. Review of available catch statistics for Divisions 58.4.1 and 58.4.2 indicate possible incorrect reporting of catches. For example, it is probable that fish reported as *C. gunnari* for 1980 and for 1985 to be present in the catch summaries (SC-CAMLR-VIII/BG/2, pages 47 to 48) for Subarea 58.4, were *C. wilsoni*. It is therefore recommended that care should be taken in the future to report catches by species correctly.

Division 58.4.4 (Ob and Lena Banks)

146. Catches of *N. rossii*, *N. squamifrons*, and *D. eleginoides* are reported from the whole of Subarea 58.4 (see Table 6). Only *N. squamifrons* has been caught in significant amounts to date.

Notothenia squamifrons in Division 58.4.4

147. Catches, shown in Table 6, are variable and appear to be largest when less effort is required in the Kerguelen fin fishery or the krill fishery further to the South. It appears that the fish on these two seamounts should be assessed as separate stocks, but unfortunately the historical total catch data submitted to CCAMLR cannot be apportioned between them.

148. Some historical and recent data have been submitted by the USSR giving length frequencies, age/length keys and age compositions separately for Ob and Lena Banks. The USSR also reported in their Member's Activity Report the results of trawl surveys which gave biomass estimates of 21.25 ± 11.44 and 12.76 ± 4.34 thousand tonnes for Ob and Lena Banks respectively. The Working Group recommended that the basic survey data and details of the survey design be made available for consideration and analysis at the meeting of the Working Group in 1990.

149. The lack of separate catch data for each seamount precluded VPA assessments. There was insufficient information on which to assess current recruitment.

Management Advice

150. The Working Group drew attention to the increases in catches over the last two seasons. Lacking an assessment the Working Group is unable to give specific management advice. The submission of the recent survey data and historical catch data is recommended in order to carry out the necessary assessment at next year's meeting.

Table 6: Total catches by species and subarea in Statistical Area 58. Species are designated by abbreviations as follows: ANI (*Champsocephalus gunnari*), LIC (*Channichthys rhinoceratus*), TOP (*Dissostichus eleginoides*), NOR (*Notothenia rossii*), NOS (*Notothenia squamifrons*), ANS (*Pleuragramma antarcticum*), MZZ (Unknown), SRX (*Rajiformes spp.*).

Split	ANI			LIC	TOP				NOR			NOS			ANS		MZZ			SRX
Year	58	58.4	58.5	58.5	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	
1971	10231				XX				63636			24545					679			
1972	53857				XX				104588			52912					8195			
1973	6512				XX				20361			2368					3444			
1974	7392				XX				20906			19977					1759			
1975	47784				XX				10248			10198					575			
1976	10424				XX				6061			12200					548			
1977	10450				XX				97			308					11			
1978	72643		250	82	196	-	2	-	46155			31582		98	234		261			
1979	*101				3	-	-	-				1307					1218			
1980		*14	1631	8		56	138	-			1742		4370	11308				239		
1981			1122	2		16	40	-		217	7924		2926	6239				375	21	
1982			16083			83	121	-		237	9812		785	4038		50		364	7	
1983			25852			4	128	17			1829		95	1832		229		4	17	1
1984			7127			1	145	-		50	744		203	3794					**611	17
1985		*279	8253			8	6677	-		34	1707		27	7394		966		11	7	4
1986		*757	17137			8	459	-		-	801		61	2464		692				3
1987		*1099	2625			34	3144	-		2	482		930	1641		28		22		
1988		*1816	159			4	554	488		-	21		5302	41		66				
1989		*306	23628			35	1630	21			245		3660	1825		47		23	24	

* Probably wrong identification (might be *C. wilsoni*)

** Mainly RAJIDS

NB Before 1979/80 catches reported in Area 58 mainly concern Division 58.5.1 (Kerguelen Subarea)

Subarea 58.5

Division 58.5.1 (Kerguelen)

Champsocephalus gunnari in Division 58.5.1

151. There are two separate stocks in Division 58.5.1, Skif Bank and the Kerguelen Shelf. No fishing occurred on Skif Bank in the 1989 season and no reassessment has been undertaken.

152. On the Kerguelen Shelf catches have been variable and closely reflect a three year cycle in recruitment over the last decade. Over this period, fishing has occurred on only one cohort at a time, with large catches taken as the fish reach three years of age. This occurred in 1983, 1986 and again in 1989.

153. Length and age data are available from both Skif Bank and the Kerguelen Shelf, along with CPUE data since 1981. Data were available from two surveys carried out by the USSR in 1987 and 1988. The data from the 1987 cruise were not used because the fish in the current cohort were at that time in the pelagic phase. The 1988 survey data were re-stratified to reduce bias arising from non-random sampling in the survey. A full description of reasons for re-stratifying and the results from the subsequent analyses are given in Appendix 8. The estimate of biomass for the current cohort last year, at age three, was 244 thousand tonnes (which can be compared with the estimate of 429 thousand tonnes obtained before re-stratifying).

154. The CPUE data since 1980, in terms of number of fish caught from each cohort per hour of fishing, are shown in Figure 4. These data indicate that it is unlikely that the current cohort is substantially stronger than its two predecessors, and if anything it may be slightly weaker. However, it is possible that some form of non-linear relationship between CPUE and biomass may be masking differences between the strengths of the various cohorts.

Catch Per Unit Effort for *C. gunnari*
on the Kerguelen Shelf

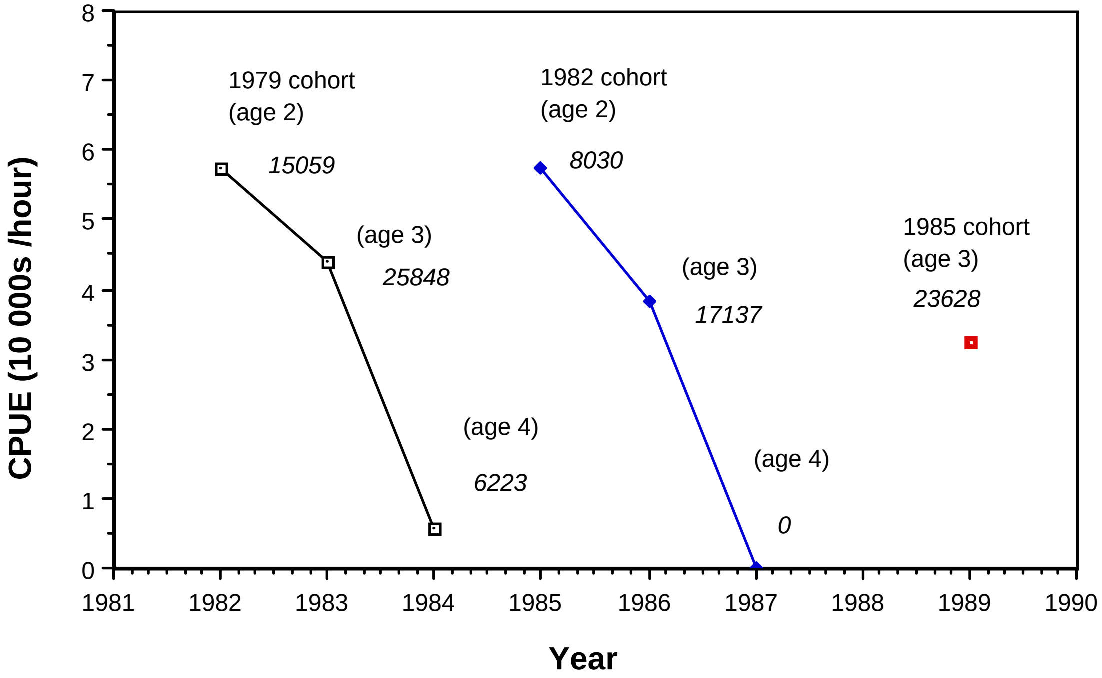


Figure 4: Yearly values of CPUE index for the *C. gunnari* Kerguelen Shelf stock in the northeast sector of Division 58.5.1 (Duhamel, 1987). Years are conventional notation for split-years. Cohorts and ages are labelled. Numbers in italics are catch (t).

155. The cohort analysis carried out at last year's meeting was updated as far as possible, and this is shown in Table 7. The analysis assumes that each cohort was extinguished by fishing by age five. The resultant cohort biomass estimates for the previous cohorts at age 2 (the same as the age of the most recent cohort at the time of the survey) cover the range 23 to 45 thousand tonnes.

Table 7: *C. gunnari*, Division 58.5.1 updated cohort analysis. Calculation utilising mean length at age and length weight relationship $W_t = 0.0088 L_t^{3.4163}$ from Duhamel (1987) and WG-FSA-89/9.

Natural Mortality 0.35

Catches (Numbers of fish)

	Ages →			
Year	1	2	3	4
1981	3 624 733	0	0	0
1982	0	209 330 540	0	0
1983	0	0	197 917 300	0
1984	0	0	0	30 757 800
1985	0	99 665 427	0	0
1986	0	0	122 514 360	0
1987	0	0	0	0
1988	0	1 182 608	0	0
1989	0	0	169 942 929	0

Fishing Mortality

	Ages →			
Year	1	2	3	4
1981	0.005	-	-	-
1982	-	0.49	-	-
1983	-	-	1.86	-
1984	-	-	-	NA
1985	-	0.52	-	-
1986	-	-	NA	-
1987	-	-	-	-
1988	-	-	-	-
1989	-	-	?	-

Stock Abundance (Numbers of fish)

	Ages →			
Years	1	2	3	4
1981	920 856 596	-	-	-
1982	-	645 873 868	-	-
1983	-	-	279 415 631	-
1984	-	-	-	30 757 800
1985	-	292 582 215	-	-
1986	-	-	122 514 360	-
1987	-	-	-	-
1988	-	-	-	-
1989	-	-	NA	-

Table 7 continued

Stock Biomass 1000’s tonnes

	Ages →			
Years	1	2	3	4
1981	-	-	-	-
1982	-	45 238	-	-
1983	-	-	35 709	-
1984	-	-	-	6 223
1985	-	23 251	-	-
1986	-	-	1 7137	-
1987	-	-	-	-
1988	-	?	-	-
1989	-	-	?	-

156. It is therefore difficult to reconcile the biomass estimate in 1988 with the lack of apparent difference in CPUE between the recent cohort and its predecessors, which were estimated to have much lower biomasses. The range of possible explanations includes, upward bias in the survey estimate, non-linearity in the CPUE, or downward bias in the cohort analysis. The survey estimate could still be biased upward because of failure to fully account for non-random sampling in the stratification, or because of underestimation of the area swept by the surveys, possibly due to herding effects by the trawl doors and warps.

157. Conversely, the cohort estimates would be biased downwards if the exhaustion of the cohorts was due to high rates of natural mortality after age four rather than by fishing. It was suggested that this could be caused by spawning stress, which could result in the disappearance of older fish that escaped the fishery but died after spawning. The existing data are unable to show which of the explanations is the more likely.

158. A further survey is recommended for 1990 to assess the strength of the incoming cohort. This should be carefully designed to take into account the information now available on the distribution of the stock over the shelf area. Further re-analysis of the 1988 survey, with fine scale stratification using density concentration information is recommended (see Appendix 8). Studies on the spawning grounds are recommended to help determine whether this species is subject to high post-spawning mortality. Age/length keys and length frequency data from catches prior to 1980 are required for a full stock assessment.

Management Advice

159. Because the stock in the last decade has consisted of only one cohort every three years it should be managed with caution until further information can be collected which could determine whether high post-spawning or similar natural mortality might explain the exhaustion of the cohorts. It would be prudent to assume, on the basis of the CPUE data, that the current cohort in the fishery is of comparable strength to the preceding strong cohorts of 1979 and 1982. Thus, the biomass of the 1985 cohort during the 1989 season could have been of the order of 23 to 45 thousand tonnes, and thus substantially affected by the catch of 23 thousand tonnes. A low level of fishing mortality should help to resolve the question whether high natural mortality is the cause of cohort exhaustion. If substantial survival proves possible in fish of the current age, it will have the desirable effect of increasing the number of year classes in the fishery and could lead to cohorts recruiting to the fishery more frequently than the current three year interval. Accordingly, the catch level in 1990 could be no higher than occurred on the preceding cohorts at age four, that is, in the range of 0 to 6 000 tonnes.

Dissostichus eleginoides in Division 58.5.1

160. The fishery is trawl based, occurring on a concentration in a relatively small area on the west coast in water 300–600 m deep. Large catches began in 1985 when this concentration was discovered. In 1986 and 1988, effort in this fishery was low because of the diversion of effort to fishing for *C. gunnari*. In years when the fishery was significant, the catch has declined from 6 677 tonnes to 1 630 tonnes/year.

161. The biomass of *D. eleginoides* was estimated from the USSR 1988 survey (WG-FSA-88/22 Rev. 1) to be, after re-stratification, 27 200 tonnes in the total area around Kerguelen Island. Of this, 19 000 tonnes was estimated to be in the western sector.

162. CPUE data are available since 1984/85 (see Table 8).

Table 8: CPUE data from the fishery for *D. eleginoides* on the Kerguelen shelf (Division 58.5.1)

	1984/85	1985/86	1986/87	1987/88	1988/89	
CPUE	2.50	1.41	1.79	0.78	1.64	(tonnes/hour)

163. No estimates of fishing mortality for this species are available.

164. No data are available concerning trends in recruitment for this species.

165. A lack of information on various stock parameters makes it very difficult to assess the state of this stock, in particular length-frequency and age/length data are needed.

Management Advice

166. *D. eleginoides* is a long-lived species with probable low productivity. An assessment of the stock is urgently required to estimate the level of catch to stabilise the stock. Adding the cumulative catch to the survey estimate gives a rough estimate for the unexploited biomass of 38 000 tonnes. Applying the Gulland rule (see paragraph 120) to this estimate gives a TAC of 1 100 tonnes.

Notothenia rossii in Division 58.5.1

167. There was a steady decline in catches from high level at the start of the fishery in 1970/71 to a low of 97 tonnes in 1976/77, with an isolated high catch in 1978, just before the declaration of an EEZ. After a closure of the area from July 1978 to October 1979, the fishery recommenced at a moderate level, and then declined to low catches. Only the adult part (age 5+ years) of the stock has been exploited. Since 1985 directed fishing has been prohibited and by-catches have declined steadily.

168. No new data derived from catches have become available since 1988 because of the prohibition of directed fishing on this stock. A biomass estimate of 13.8 thousand tonnes was obtained from re-stratifying the USSR survey (WG-FSA-88/22, Rev. 1).

169. A program to study pre-recruits in coastal waters has been conducted since 1982. This program will assist in stock assessment and has been useful in detecting changes in the abundance of the juvenile portion of the stock. Regular experimental fishing with trammel nets has been used to detect variation in abundance of this part of the stock, based on catches of age classes 2 and 3. A gradual increase in abundance has been observed from 1984 to 1988 with an average growth rate in year class strength of 36.3% (WG-FSA-89/9). An increase in recruitment to the mature shelf stock could be detectable in a few years.

Management Advice

170. Conservation measures (no directed fishery) will be continued into the beginning of the 1990's for the adult stock. Trends in the abundance of juvenile part of the stock need to continue to be monitored. Biomass surveys will be required to establish that the stock has made a substantial recovery prior to any resumption of exploitation.

Notothenia squamifrons in Division 58.5.1

171. It is not possible to separate catches taken in Subarea 58.5 from those in Subarea 58.4 prior to the declaration of the EEZ around Kerguelen by France in 1978. Since 1980 there has been a steady decline in catches, but with a small increase in 1984 and 1985. This is probably the result of redirection of fishing effort in relation to a low level abundance of *C. gunnari*, the main target species of the Kerguelen fishery. The catch in 1988/89 was substantially larger than in 1987/88 (see below) but comparable with 1986/87. Small catches of *N. squamifrons* were taken from Kerguelen-Heard Bank during 1988/89.

172. Comprehensive length frequency data are available from the commercial fisheries. Other available data include indices of abundance from catch and effort data (WG-FSA-89/9) and survey estimates of stock biomass in 1987 and 1988 (WG-FSA-88/22 Rev. 1). Results from VPA analyses of data after 1980 (see SC-CAMLR-VII, paragraph 101, page 131) and Soviet stock assessments of various stock parameters (age, growth and mortality) for the years 1969–1972 and 1980–1986 (WG-FSA-89/16 and 17) are also available.

173. A lack of both length frequency and length-at-age data in the CCAMLR database precluded sensible VPA's, particularly for the period when the stock was most heavily depleted (1971-1978).

174. Fishing mortality affects age classes 5+, with the age of maturity being 9 years. The wide range of values for natural mortality (Duhamel, 1987; WG-FSA-89/17) obtained to date and the uncertainty concerning the longterm trajectory of the stock make it extremely difficult to assess fishing mortality.

175. No information is available concerning trends in recruitment (whether constant or variable) for this species.

176. Both CPUE and catch level data indicate that the stock remains at a low level. Catches in 1986/87 and 1988/89 have been less than the catch limits for these two seasons. CPUE index values of abundance south and southeast of the Island confirm that there has been a decreasing trend in the stock biomass. However, in 1988/89 this downward trend was not evident (WG-FSA-89/9, Figure 7). When taking into account the annual areal distribution of the stock this apparent recovery of the stock is small. It would appear therefore that the enforced restriction of fishing in 1987/88 is unlikely to have any longterm affect on this already heavily exploited stock.

177. Data are required on the following:

- recruitment;

- mesh selectivity to improve management advice based on yield-per-recruit calculations;

- additional surveys of stock biomass should be undertaken in order to improve currently available knowledge of stock abundance. In particular, surveys should be undertaken prior to any future exploitation of unexploited stocks in Division 58.5.1 (see paragraph 171).

178. In order to improve assessments of the stock, including trends in exploitation, it is critically important that the following data be submitted to CCAMLR:

- length frequency and age/length data for the *N. squamifrons* fishery in Division 58.5.1 from 1972 to the present. Such data should be provided for individual years as far as possible.

- catch data prior to the declaration of an EEZ around Kerguelen by France (3 February 1978) should be separated for Division 58.5.1 (as done in WG-FSA-89/16 and 17) and re-submitted.

- consolidate the catch data for Subarea 58.5. In particular care should be taken to ensure consistency between the data submitted to CCAMLR and data available to or held by individual members.

- all length data reported should only be total length to avoid possible confusion in the future.

Management Advice

179. A lack of information on recruitment patterns makes it difficult to provide objective predictions of future trends in the stock. However, given observed exploitation trends and the present status of the stock, protection of the *N. squamifrons* stock in Division 58.5.1 will be facilitated by closure of the directed fishery for this species. Similarly, recovery of this already depleted stock will be facilitated.

180. Since only about 15% of the current total stock biomass is comprised of adults and that fishing on other species in this area will continue, the setting of acceptable by-catch levels appears necessary. As the current quota levels have not been attained, it is recommended that future by-catch levels should be substantially lower than present quotas.

Division 58.5.2 (Heard Island)

181. Since 1979 no fishing has taken place in the area. A joint Soviet/Australian research cruise in 1987 (SC-CAMLR-VI/BG/16) encountered some small stocks of *C. gunnari*, but very low catches of other species were taken. Before any exploitation can take place, much work is necessary to determine the size of the stocks and their identity. There are already some indications that the stocks of *C. gunnari* on outlying banks are separate from those on the main Heard Island Shelf.

182. Additional data on all exploited stocks of Channichthyids in Statistical Area 58 as a whole are still required urgently for assessment purposes. Such data should be submitted to and considered at the next meeting of the Working Group.

GENERAL ADVICE TO COMMISSION

183. In addition to the recommendations made to the Commission based on assessment of individual stocks, a number of other matters were raised by the Commission at its last meeting (CCAMLR-VII, paragraphs 114 to 116). These are covered in this section.

184. The possible catch, biomass and spawning stock biomass trajectories for the *C. gunnari* stocks are dealt with elsewhere in the report. The problem of by-catch of depleted species in the directed fishery for *C. gunnari* is different for the two main areas, Subareas 48.3 and Division 58.5.1.

185. In Subarea 48.3 a rough idea of the extent of the problem can be noted from the reported catches of *N. gibberifrons* and *N. rossii* from the USSR operations in October and November 1988. The catch of *C. gunnari* was 21 359 tonnes and the by-catch of *N. gibberifrons* was 838 tonnes and that of *N. rossii*, 152 tonnes.

186. Ideally, data on a haul by haul basis are needed to assess this problem but were not available. In their absence the simple pro rating of the catch figures above are the only guide the Working Group could give (i.e. if the catch doubled, a reasonable expectation would be for the by-catch also to double).

187. In Division 58.5.1 there appears to be no by-catch problem as the fishery operates on different species in different areas.

188. Two papers (SC-CAMLR-VIII/BG/42 and 47) available to the Working Group dealt with the implications of the operation of a complete ban on fishing for *C. gunnari* or a very low value for fishing mortality followed by a higher level. The papers had focussed on *C. gunnari* in Subarea 48.3. In general terms both papers indicated that there were benefits from a closure of the fishery or the operation of a low fishing mortality. Both papers were based on the assumption that the stock level was around that presented in WG-FSA-89/27. In this situation, a low fishing mortality results in decreased variability in catch and stock levels with little sacrifice in expected yield. A closure of the fishery would substantially decrease the probability that the stock would fall below any specified critical level.

189. No analysis of this type had been done for the *C. gunnari* stock in Division 58.5.1, however, the stock status is addressed in paragraphs 151 to 159.

Notothenia gibberifrons and *Notothenia rossii*

190. Four questions were asked by the Commission concerning these stocks. The Working Group's responses are given below.

> '(a) Is the abundance resulting from F_{max} a satisfactory measure of the GNAI population level for these species or should another measure be used?'

191. In the case of these two species a decline in stock size has been associated with a decline in recruitment. This means that the operation of a high constant fishing mortality is

likely to lead to stock depletion. The calculation of F_{max} is dependent on a particular equilibrium assumption of constant recruitment and hence is violated when recruitment declines. The priority for these stocks should be to facilitate recovery to a level where recruitment improves.

> ‘(b) What factors, other than directed or incidental catching, might be impeding their recovery?’

192. In addition to the decline in recruitment referred to above, juvenile *N. rossii* may be experiencing increased predation from fur seals. Information on this topic is qualitative not quantitative and the Working Group did not feel it could comment further, but recommended that advice be sought from SCAR. The central problem is that recruitment is lower than in earlier years. This low recruitment is associated with low spawning stock sizes and in the absence of other information is the most likely cause.

> ‘(c) What might be the effect, in terms of the total catches of these species, of the changes of fishing gear suggested for the *C. gunnari* fishery in SC-CAMLR-VII, paragraph 3.17?’

193. The use of a semi pelagic or midwater trawl for *C. gunnari* would reduce the by-catch of these two species. However, this would be at the expense of targeting on the younger age groups of *C. gunnari*. WG-FSA-89/27 suggests that around seven times more fish at age 1 and 1.7 times fish at age 2 were likely to be distributed above the bottom, in the water column. Assuming the mesh size currently in use, the age group 2 especially, may still be taken in midwater trawls.

194. An additional point made was that major shifts in the mode of operation of the fishery would present problems of stock estimates using CPUE based methods as the time series of catch and effort would be limited.

> ‘(d) What will be the likely results of keeping catch levels as high as four times the TAC calculated for F_{max} on the capability of the exploited part of the stock of *N. gibberifrons* to recover in 20 to 30 years?’

195. The stock is likely to be driven to extinction if such catch levels are retained for several years.

Mesh Size Regulations

196. Specific recommendations on mesh size are discussed in the report (paragraphs 29 to 40) and summarised in paragraph 36.

197. The Working Group wished to add that mesh regulations, even if they permitted the escape of young fish, were insufficient to ensure management of the stocks for sustainable yield. They would only be successful when operated with other management measures involving the control of fishing effort. It was noted that for certain stocks elsewhere in the world, high mortality of fish passing through nets had been observed.

Area/Season Closures to Protect Young Fish and Spawning Grounds/Aggregations

198. The current closed season is from 1 April to 20 November. SC-CAMLR-VIII/BG/16 examined the reproductive behaviour of *C. gunnari* and other Antarctic fish and suggested that the closed season should be extended to operate from 1 March to the end of the Commission meeting.

199. The Working Group agreed that a closed season was desirable and that the proposed extension was reasonable. However, an operational date which would not end until after the Commission's Meeting and would not tie the measure to the timing of the Commission's meeting, is required.

200. The Working Group noted that if mesh regulation were introduced to protect immature fish, the need for a closed season would be reduced.

Area Closures

201. The Working Group had no additional information on which to base particular recommendations to protect spawning grounds and aggregations.

Stock Levels where Recruitment may be Impaired

202. In two stocks, *N. rossii* and *N. gibberifrons* recruitment declines have been detected. In other stocks where declines in recruitment has not been detected a useful working definition would be the lowest spawning stock biomass estimated for the stock. Hence, if the current spawning stock was the lowest observed, the management should aim to ensure that future stock levels do not drop below this level.

General Conservation Policy

203. There are a number of significant uncertainties associated with the assessment of all stocks considered. For this reason, the Working Group considered that TAC's should be set for one year only, that management should ensure that target fishing mortality levels would not involve the reduction of spawning stock to levels where recruitment might be impaired.

204. Certain stocks have been depleted to very low levels and the potential by-catch from fisheries directed at less depleted species could endanger their recovery. In this context, the large level of the krill fishery, around 200 000 tonnes in Subarea 48.3, means that even a very small by-catch of larval or young fish in krill catches could be sufficient to endanger recovery of depleted species. This problem is potentially very serious and data on this aspect are limited, however, some data are published. The Working Group recommended that sampling on board krill vessels should be instituted to assess the level of abundance of fish larvae and young fish in the vicinity of krill concentrations. Methods for such sampling were developed during the BIOMASS program.

205. The Working Group draws the attention of the Scientific Committee to the stocks that it was not able to assess because of the lack of data. It recommends that the Scientific Committee considers ways to encourage the collection and submission of the required data.

206. Biomass surveys are central to many of the assessments carried out by the Working Group. The high sensitivity of the biomass estimates from the USSR survey conducted on the Kerguelen Shelf shows that it is crucial in interpreting survey results to have full details of the conduct of the surveys. The Working Group recommends that full details of the survey design and the haul by haul data should be made available when the results of surveys are submitted.

FUTURE WORK

Data Requirements

207. A summary of requests for data made by the Working Group in this and previous reports is attached as Appendix 9.

208. The provision of a datasheet for recording details of longline fisheries was specifically addressed by the Working Group. The requirement for detailed recording of this fishery, especially directed at *D. eleginoides* was identified in paragraphs 8 to 12.

209. The Secretariat was asked to prepare draft reporting sheets for the longline fishery. The Working Group recommended that reporting of these data be considered of high priority and should be implemented for the current fishing season.

210. Current methods for the analysis of biomass survey data use strata defined as areas of seabed within certain depth ranges and certain statistical areas. The currently used strata were obtained for a purpose slightly different from that of the Fish Stock Working Group. It was suggested that the procedure of defining strata should be reassessed in the light of the Working Group's requirements. These should include CCAMLR finescale reporting areas and 50 m depth contours down to 500 m where possible.

211. In reference to paragraph 3.6 concerning predation of *N. rossii* by Antarctic fur seals, it was suggested that if the feeding habits of *Arctocephalus gazella* were monitored, details of species and ages of fish prey consumed would be of interest to the Working Group. The Working Group recommended that the SCAR Group of Specialists on Seals be requested to provide advice on the most effective ways of obtaining quantitative information to address this problem.

212. The Working Group noted that there were some instances where catch data currently available in the CCAMLR database were inconsistent with those available to or held by individual Members (e.g. paragraph 66(ii)). It was therefore recommended that Members should make every effort to ensure adequate validation of and consistency in data submitted to the Secretariat and to other organisations.

Data Analyses Required and Software to be Developed Prior to the Next Meeting

213. Expansion of the Secretariat's assessment programs to include several VPA tuning methods is required. In particular, the Laurec-Shepherd and the Rivard (WG-FSA-89/22) models are required by the Working Group, and should be available alongside the traditional VPA and SVPA programs.

214. A more complete description of the Secretariat's databases is also required, and should be provided for the Working Group in 1990.

215. Some difficulty was encountered in using the Secretariat's Macintosh Microcomputers since most delegates are more familiar with IBM compatible computers. The Secretariat was requested to provide access to IBM machines at future meetings.

New Trends in Assessment Work

216. Discussion of new trends is assessment methodologies is restricted because of the short time available to delegates at the meeting. Investigation of new methodologies would be best served by discussions centred around working papers submitted to the Working Group.

217. The Working Group currently has no methodologies available for assessing the impact of closed areas and similar management strategies. It is not clear whether the appropriate data are available for the CCAMLR stocks, but such methods are available from, for instance, FAO sources.

Organisation of the Next Meeting

218. Because of the high number of assessments needing to be performed at the meeting there was a shortage of time available to the Working Group. Consequently, extending the next meeting by one day was recommended.

219. The Working Group requested that certain preliminary analyses be made by the Secretariat before the Working Group meeting. For this to be facilitated the Working Group emphasised that the deadline of 30 September for the submission of data must be adhered to.

This will allow the available data and analyses to be presented to the Working Group on the first day of its meeting.

220. The Working Group requested that the Secretariat in consultation with Members should prepare a glossary of terms used by the Working Group in its reports for the benefit of the Commission and other interested parties. This glossary should be included as an appendix in the next report of the Working Group.

APPENDIX 1

AGENDA

Working Group on Fish Stock Assessment
(Hobart, Australia, 25 October to 2 November 1989)

1. Opening of the meeting

2. Adoption of the agenda

3. Review of material for the meeting
   - 3.1 Catch and effort statistics
   - 3.2 Size and age composition data
   - 3.3 Results of the CCAMLR Otoliths/Scales/Bones Exchange Scheme
   - 3.4 Other available biological information
   - 3.5 Mesh selection experiments
   - 3.6 Assessments prepared by Member Countries
   - 3.7 Other relevant documents

4. Organisation of assessment work

5. Questions raised and information needed by the Commission

6. Policy advice

7. Management strategy

8. Advice to the Commission
   - 8.1 Mesh size regulations
   - 8.2 Closed areas/closed seasons
   - 8.3 TACs
   - 8.4 Other approaches to control fishing mortality
   - 8.5 By-catch in directed fisheries
   - 8.6 Uncertainties in the advice and policy alternatives

9. Future work
   9.1 Data requirements
   9.2 Data analyses required and software to be developed prior to the next meeting
   9.3 New trends in assessment work
   9.4 Organisation of the next meeting

10. Any other business

11. Adoption of the report

12. Close of the meeting.

APPENDIX 2

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(Hobart, Australia, 25 October to 2 November 1989)

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APPENDIX 3

LIST OF DOCUMENTS

Working Group on Fish Stock Assessment
(Hobart, Australia, 25 October to 2 November 1989)

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WG-FSA-89/3	List of Documents
WG-FSA-89/4	List of Participants
WG-FSA-89/5	Analyses Carried Out During the 1988 Meeting of the Fish Stock Assessment Working Group Secretariat
WG-FSA-89/6	Report of the Joint UK/Polish Fish Stock Assessment Survey Around South Georgia, February 1989 G. B. Parkes and I. Everson (UK) J. Sosinski, Z. Cielniaszek and J. Szlakowski (Poland)
WG-FSA-89/7	Proposed Maturity Scale for Icefish (Channichthyidae) Z. Cielniaszek (Poland) and G. B. Parkes (UK)
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WG-FSA-89/23	Longline Data Recording Sheet Secretariat

WG-FSA-89/24	Vacant
WG-FSA-89/25	Summary of Length Composition Data Applicable to 1987/88 (Secretariat) (This is a copy of document WG-FSA-88/25)
WG-FSA-89/26	Summary of Length Composition Data Applicable to 1988/89 Secretariat
WG-FSA-89/27	Correction for Under-representation of 1 and 2 Year Old *Champsocephalus gunnari* in Bottom Trawl Surveys J. Beddington and M. Basson (UK)

Other Documents:

SC-CAMLR-VIII/BG/2	Summary of Fisheries Data Secretariat
SC-CAMLR-VIII/BG/16	Reproduction in the Antarctic Icefish *Champsocephalus gunnari* and Its Implication for Fisheries Management in the Atlantic Sector of the Southern Ocean Delegation of Federal Republic of Germany
SC-CAMLR-VIII/BG/18	The State of Exploited Fish Stocks in the Atlantic Sector of the Southern Ocean Delegation of Federal Republic of Germany
SC-CAMLR-VIII/BG/20	Evaluation of the Results of Trawl Selectivity Experiments by Poland and Spain in 1978/79 and 1986/87 W. Slosarczyk (Poland), E. Balguerias (Spain), K. Shust (USSR) and S. Iglesias (Spain)
SC-CAMLR-VIII/BG/26	Preliminary Observations on the Suitability of Semipelagic Trawl Gear in the Fisheries of Icefish (*Champsocephalus gunnari* Lönnberg, 1905) Delegation of Spain (partially translated)
SC-CAMLR-VIII/BG/27	Some Data on the Distribution, Abundance and Biology of the *Patagonotothen brevicauda guntheri* (Norman 1937) at Shag Rocks Delegation of Spain (partially translated)
SC-CAMLR-VIII/BG/35	Status of the Stocks of Antarctic Demersal Fish in the Vicinity of South Georgia Island, January 1989 Delegation of USA

SC-CAMLR-VIII/BG/36	Distribution and Abundance of Larval Fishes Collected in the Western Bransfield Strait Region, 1986-87 Delegation of USA
SC-CAMLR-VIII/BG/42	Effects of Variable Recruitment on the Potential Yield of the *C. gunnari* Stock Around South Georgia Delegation of United Kingdom
SC-CAMLR-VIII/BG/45	Bibliography of Antarctic Fish Delegation of Federal Republic of Germany
SC-CAMLR-VIII/BG/46	CCAMLR Antarctic Fish Otolith/Scales/Bones Exchange System Convener of the Fish Stock Assessment Working Group
SC-CAMLR-VIII/BG/47	Effects of Different Harvesting Strategies on the Stock of Antarctic Icefish *Champsocephalus gunnari* Around South Georgia Delegation of Federal Republic of Germany

MATURITY SCALES

ANTARCTIC ROCK CODS (NOTOTHENIIDAE)*

Code	Maturity Stage	Description
Females: stages in ovarian maturation		
1	Immature	Ovaries small and firm. No eggs visible to naked eye.
2	Maturing virgin	Ovaries about $^1/_4$ length of body cavity, firm and full of eggs that are uniform in size.
3	Developing	Ovaries large and contain eggs of two sizes.
4	Gravid	Ovaries large. Large ova spill out when fish is handles or ovary is cut.
5	Spent	Ovaries flaccid and contain many small eggs with only a few large eggs.
Males: stages in testicular maturation		
1	Immature	Testes very small, translucent and lying close to vertebral column.
2	Developing	Testes small (about 1% body weight), white, and convoluted.
3	Developed	Testes large, white, and convoluted. No milt produced when pressure is applied to testes or testes are cut.
4	Ripe	Testes large and opalescent white. Drops of milt produced when pressure is applied to testes or testes are cut.
5	Spent	Testes dirty white in colour, much smaller and more flaccid than at stage 4.

* EVERSON, I. 1982. Fish. In: El-sayed, Z. (Ed). Biological Investigations of Marine Antarctic Systems and Stocks. Cambridge: BIOMASS. Volume II, p. 79-97. CCAMLR Format Specifications for Reporting Biological Data to the CCAMLR Secretariat.

ICEFISH (Channichthyidae)

Based on observations of three species: *Champsocephalus gunnari*, *Chaenocephalus aceratus* and *Pseudochaenichthys georgianus.*

Table 1. Males

Maturity stage	Description
1. Immature	Testis small, translucent, whitish, long, thin strips lying close to the vertebral column.
2. Developing or resting	Testis white, flat, easily visible to the naked eye, about 0.25 x length of the body cavity.
3. Developed	Testis large, white; no milt produced under external pressure.
4. Ripe	Testis large, opalescent white; drops of milt produced under external pressure.
5. Spent	Testis shrunk and flabby, dirty white in colour.

Table 2. Females

Maturity stage	Description
1. Immature	Ovaries small, firm, short and ovoid; no eggs visible to the naked eye.
2. Developing or resting	Ovaries more extended, firm, colour milky to yellowy-orange. Small eggs may be visible, giving ovaries a grainy appearance.
3. Developed	Ovaries large, starting to swell the body cavity, colour varies according to species: *C. gunnari* - greyish; *C. aceratus* - yellow; *P. georgianus* - orange. Full of large opaque eggs held in connective tissue.
4. Gravid	Ovary large, filling the body cavity; large ova spill out of ovary when cut open.
5. Spent	Ovary shrunk, flaccid and generally empty, possibly with a few large eggs.

SOME COMMENTS ON THE ESTIMATION OF NATURAL MORTALITY FOR *C. GUNNARI, N. SQUAMIFRONS* AND *P.B. GUNTHERI* BASED ON SOVIET DATA

(P. Sparre, FAO, Rome)

ESTIMATION OF NATURAL MORTALITY

Natural mortality rates may be estimated by several alternative methods.

2. Some methods use age composition data representing the virgin stock, i.e. data from before fishing started. These methods assume the fish stock to be in an equilibrium state, i.e. that all parameters have remained constant for a period of time not less than the life span of the species in question. This assumption is not likely to be met in reality. The recruitment, especially, is known to fluctuate considerably between years. This problem, however, can be circumvented by using the average age composition for a range of years.

3. As the age composition should be representative for the population in the sea, each age composition should be weighted by the number caught per unit of effort before summation.

4. The methods using age compositions sampled from the virgin stock either assume Natural Mortality, M, to remain constant from age group to age group or to be variable. Only one method estimating variable M is considered:

Baranov's method: (Baranov, 1914)

$$M\ (=Z) = \ln\ (N_{a+1}/N_a)$$

N_a = average number caught per unit of effort belonging to age group a.

Heincke’s method (1913) provides an estimate of the average M value:

$$M\ (=Z) = \ln \frac{N_a + N_{a+1} + N_{a+2} + \ldots}{N_{a+1} + N_{a+2} + \ldots}$$

where a is an age group fully recruited to the fishery.

The remaining methods assume M to remain constant from age group to age group.

The Beverton and Holt (1956) method based on age data:

$$M\ (=Z) = \frac{1}{\bar{t} - t^{\nabla}}$$

where t^{∇} is an age under full exploitation, and $\bar{t}$ is the average age of fish of age t^{∇} and older.

Robson and Chapman (1961) showed that:

$$M\ (=Z) = \ln \left(1 + \frac{1}{\bar{t} - t^{\nabla}}\right)$$

is a more efficient estimator than that of Beverton and Holt.

The Beverton and Holt (1956) method based on length data:

$$M\ (=Z) = K\ \frac{L_{\infty} - \bar{L}}{\bar{L} - L^{\nabla}}$$

where L^{∇} and K are von Bertalanffy growth parameters, L^{∇} is a length under full exploitation and $\bar{L}$ is the mean length of fish of length L^{∇} and longer.

The Alverson-Carnee method:

$$M\ (=Z) = \frac{3K}{e^{TK} - 1}$$

where K is the von Bertalanffy parameter and T is the age when $N_t \supseteq w_t$ takes it’s maximum value. N_t is the number of survivors at age t and w_t is the corresponding body weight.

A seventh method is the age based catch curve analysis which is based on the regression analysis:

$$\ln (N_x) = A - M{:}X \quad , \quad x = a, a + 1, ...$$

where a is an age group under full exploitation and A is a parameter (the intercept) which is not used. This method, however, is not used in the present paper. The age based catch curve has a length based equivalent.

5. Two methods are based on more general ecological/physiological considerations. They do not use size composition data as input and are therefore indirect methods. The preceeding methods based on size composition data will all provide an estimate of M, the precision of which depends on the quality of the input data and the degree to which the underlying assumptions are met. The two following approaches involve a number of assumptions which are highly questionable for individual fish species, as they are based on assumptions pertaining to a 'hypothetical average fish species'. These two (second class) methods are:

Pauly's method: (Pauly, 1980)

$$\ln (M) = -0.0152 - 0.279 \ln (L_\infty) + 0.6543 \ln (K) + 0.463 \ln (T)$$

where L_∞ and K are von Bertalanffy parameters and T is the temperature of the ambient water. For polar fish species Pauly replaced T by the so-called 'Effective physiological temperature', T_e which he defined by a graph giving the relationship between T and T_e. Selected values read from the graph are:

T	-2	-1	0	1	2	3	4°C
T_e	24	17	11	8	6	4.5	3.5°C

The Rikhter and Efanov (1976) method:

$$M = \frac{1.521}{T_m^{0.72}} - 0.155$$

where T_m is the age when 50% of the population is mature.

6. The Pauly method or the Rikhter and Efanov method should be used only when no age composition data representing the virgin stock are available, as they are considered less precise.

7. If estimates of longevity are available (e.g. from age/length keys) estimates of M may be converted into longevity and compared to the alternative estimate. If we define the longevity of a species as the age at which only 1% of a cohort has survived in the case of no fishing, the longevity, T_e, becomes:

$$T_e = -\frac{\ln(0.01)}{M} = \frac{4.605}{M}$$

NATURAL MORTALITY OF *CHAMPSOCEPHALUS GUNNARI* IN
SOUTH GEORGIA WATERS

8. Frolkina and Dorovskikh (WG-FSA-89/20) gave the following input data representing the virgin stock:

Age group	1	2	3	4	5	6	7	8
Mean age	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5
N_a	20	258	509	272	227	119	49	15
$M = \ln \frac{N_a}{N_{a+1}}$	-	-	.62	.19	.64	.89	1.19	

9. The data represents the period from 1965 to 1969. It is not known how the data of the individual years were obtained (e.g. which age/length keys were used) and how they were pooled (e.g. are they the straight sum or were they weighted by CPUE before summed?).

10. It appears from the table that the mortality rate varies from age group to age group (up to a factor of six) so the assumption of a constant parameter system appears to be violated. One can only speculate on the reasons for increasing trend from age 5 and onwards. Plausible explanations are:

(a) the fish migrate out of the fishing grounds or escape from the trawl when they grow larger;

(b) the fish die from spawning stress or old age progressively from age 5 and onwards; and

(c) ages have been underestimated due to difficulties in otolith readings.

11. Disregarding the variability between age groups the following estimates of M were obtained:

Heincke's method;

$$M = \ln \frac{509 + 271 + 227 + 119 + 49 + 15}{271 + 227 + 119 + 49 + 15} = 0.56/\text{yr}$$

The two first age groups were excluded as they are obviously not fully recruited to the fishery. Excluding also age group 3 gives an M of 0.51 per year.

The Beverton and Holt method based on age data:

$$\bar{t} = \frac{3.5x509+4.5x271+5.5x227+6.5x119+7.5x49+8.5x15}{509+271+227+119+49+15}$$

$$= 4.63 \text{ year}$$

$t^{\nabla} = 3$ year

$$Z = \frac{1}{4.67 - 3} = 0.60 \text{ per year}$$

Robson and Chapman's method gives:

$$Z = \ln \left(1 + \frac{1}{\bar{t} - t^{\nabla}} \right) = 0.47 \text{ per year}$$

The Alverson-Carnee method gives:

$$M = \frac{3K}{e^{TK} - 1} = 0.34$$

with K = 0.12
and T = 6 years

where the value of T is based on the table:

age	N_a	Body Weight $w_a g$	$N_a\ W_a$ kg
3.5	509	77.6	39
4.5	272	163.1	44
5.5	227	228	52
T			
6.5	119	416	50
7.5	49	572	28
8.5	15	740	11

where w_a and $N_a\ W_a$ are weights in grammes and Kgs respectively, and the body weights and K are those given in the paper by Frolkina and Dorovskikh.

12. Based on length frequency data (which were not given in their paper) Frolkina and Dorovskikh calculated M from Beverton and Holt's length based formula and found the value to be 0.51 per year.

13. Taking into account that M is expected to lie in the range between 1.5K and 2.5K (Beverton and Holt, 1959) or 0.18 – 0.30 all the above values appear on the high side. Pauly's formula gives 0.19/year (with $T_e = 6$) and Rikhter-Efanov gives 0.53/year with T_m = 3 years.

14. Thus, only Pauly's formula gives a result which is in the expected range. It would therefore be of great interest to the Working Group if the basic data (length frequencies and age/length keys for each year) were made available to allow for a full discussion.

15. The table below lists the results of the six alternative methods applied together with the corresponding longevity.

	M	longevity $= \frac{4.605}{M}$
Heincke	0.56	8.2
Beverton & Holt, age	0.60	7.7
Robson & Chapman	0.47	9.8
Alverson & Carnee	0.34	13.5
Pauly	0.19	24.2
Rikhter-Efanov	0.53	8.7
Mean value	0.45	10.2

It is recommended that both the Heincke's estimate of 0.56, and the lowest value, namely 0.19 derived from Pauly's formula, be tested in further analyses.

NATURAL MORTALITY OF *N. SQUAMIFRONS* IN THE INDIAN OCEAN SECTOR

16. This species is believed to be long lived (a life span of more than ten years). Thus, a time series of at least five years is required to produce a data set not biased by fluctuations in recruitment.

17. Zaitsev presents results based on data from 1978 to 1979 for Ob and Lena Banks and for Kerguelen Islands 1969 to 1972 in a working paper (WG-FSA-89/17). This paper does not present any input data but merely lists the results. Thus it is not possible to discuss the results of this paper. It would be of great interest to the Working Group to see the basic data behind Zaitsev's results.

18. Based on the Rikhter-Efanov method and the Pauly method Zaitsev presents results for M in the range from 0.10 to 0.31. A value of M = 0.2 seems reasonable for this species. This implies that after twenty three years 1% of the stock would survive in the case of no fishery.

NATURAL MORTALITY OF *PATAGONOTOTHEN BREVICAUDA GUNTHERI* FROM SHAG ROCKS

19. Shlibanov presents age composition data for the second half of 1978 in working paper (WG-FSA-89/18). As the time period considered is short, the data are not useful for estimation of mortality rates based on age composition methods.

20. This leaves us with only the Pauly method and the Rikhter and Efanov methods. Using Pauly's formula with $L_\infty = 23.31$, $K = 0.33$ and $T_e = 6$ gives $M = 0.45$ per year. Rikhter and Efanov's method gives $M = 0.48$ with $T_m = 3.2$ years (WG-FSA-89/17).

21. Using $T_m = 2.5$ as suggested by Shlibanov gives $M = 0.63$. A value of 0.5 seems reasonable for this species. This implies that after nine years 1% of the stock would survive in the case of no fishery.

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APPENDIX 6

PROBLEMS IN TUNING THE VPA FOR ASSESSMENT OF *C. GUNNARI* STOCKS IN SUBAREA 48.3 USING DATA FROM A UK/POLISH TRAWL SURVEY

(Submitted by the USSR Delegation)

The major patterns of change in biomass (see WG-FSA-89/27 and WG-FSA-89/22 Rev. 1) are consistent over the fishing seasons (see WG-FSA-89/27, Figure 2). The formation of points on the diagram linking biomass and CPUE is identical in both cases. In the terminal year there is only one difference in the biomass values which is defined by various abundance estimates for age group 2 only.

2. In the calculation of abundance and fishing mortality for age group 2, the following problems arise:

(i) abundance and biomass data from the UK/Polish trawl survey in January–February 1989 were underestimated due to an approximate 25% decrease in the area covered. This in turn reflected a 25% drop in abundance for all age groups over the 1988/89 season;

(ii) abundance and biomass estimates from the trawl survey contain an uncertainty of 49.9% in the variation rate. This bias is augmented by the bias obtained when defining age composition and age/length keys from only 184 specimens; and

(iii) although the abundance estimate for *C. gunnari* given in WG-FSA-89/27 was made on 1 July 1988, this value needs to be defined for 1 June 1988. In the same way the estimated number of specimens subject to natural mortality declined between 1 July and 1 November 1988.

3. Points (i) and (ii) prove that the calculations used in WG-FSA-89/27 produce estimates approximately 50% less than actual values and that the uncertainty surrounding the variation rate (ii) calls into doubt their possible practical application.

APPENDIX 7

PROBLEMS IN THE USE OF USSR CATCH AND EFFORT DATA FOR VPA TUNING

(Submitted by the UK Delegation)

Serious concerns were expressed by a number of Members of the Working Group with the use of the gross catch and effort data for the assessment of *C. gunnari*, which may render the results of WG-FSA-89/22 Rev. 1 unreliable. They are inter alia:

(i) the size and type of vessel differred over the period. The standardisation of effort had been performed on the basis of total catch for a season. It is not possible to judge whether such a calibration is reasonable;

(ii) as the geographical variations in the catch and effort data were unavailable it is not possible to judge whether the pooling that was done distorts the changes in catch and effort;

(iii) the time series of catch and effort used spanned the period of both the regulated and unregulated fishery. This could bias the time series in the later years as fleets orientated themselves to the high density areas (see paragraph 88); and

(iv) changes in efficiency of the fleets are possible as bottom trawls were substituted with midwater trawls. The calibration of vessels of different capacities would mask any such effect.

APPENDIX 8

BIOMASS ESTIMATES FROM THE USSR SURVEY OF KERGUELEN SHELF (DIVISION 58.5.1) IN 1988

A trawl survey was conducted in 1988 over the Kerguelen Shelf by two vessels from the USSR (WG-FSA-88/22 Rev. 1). Preliminary analysis of the results at last year's meeting suggested that a very strong cohort was about to enter the fishery. However, the Working Group noted that the CPUE from the 1989 season (WG-FSA-89/9) was in fact slightly lower than that from the preceding strong cohorts of 1979 and 1982 at corresponding ages.

2. Examination of the haul locations from the survey showed inhomogeneity in the sampling intensity, with the greatest intensity occurring in the areas of high densities for *C. gunnari*. This will lead to a substantial overestimate of the stock unless the survey analysis can be properly stratified. The preliminary analysis of these data were stratified on the basis of depth range only. This led to an estimate of biomass for *C. gunnari* on the Kergulen Shelf of 429 thousand tonnes, as shown in Table 8.1.

3. The nature of the problem with the realised survey design can be seen by comparing the station chart (Figure 8.1) with the fish density profiles synthesized from various sources by Duhamel (1987), shown in Figure 8.2. It can be seen that the sector to the northeast is a major concentration area for *C. gunnari* and that this area has had by far the largest number of hauls. The commercial fishing grounds, which have the highest fish concentrations, occur between latitudes 48°10'S and 49°S, and longitudes 70°50'E to 71°E. This small region of 1 136 km^2 comprises about 2% of the total 100 – 200m depth stratum. However, nine out of 97 hauls in the stratum were taken in this region. In terms of swept area, these hauls represented 10.4% of the sampling effort. Thus sampling within this stratum is not at random with respect to the distribution of fish.

4. That is not the only problem which leads to the need for further stratification. The Southern shelf used to contain the high concentrations of *N. rossii*, rather than concentrations of *C. gunnari*. The Western shelf area is difficult to trawl because of rough ground, and it may also be less productive than the other sectors of the Kerguelen Shelf.

5. The Working Group concluded that the estimates should be calculated on a depth stratified basis over the five sectors bounded by the lines shown on Figure 8.1. Even finer

geographical stratification could be required in the northeast sector, to take into account the density distributions in Figure 8.2. However, with the equipment available during the meeting stratification on such a fine scale was not possible.

6. The results given in Table 8.1 show that re-stratification of the estimate has led to a substantial revision of the biomass estimate for *C. gunnari* from 429 thousand tonnes down to 244.1 thousand tonnes. The estimates for the major species are given in Table 8.2.

Table 8.1: Biomass (tonnes) of *C. gunnari* Kerguelen Shelf stock during the 1988 survey.

Depth Range (m)	WG-FSA-89/22 Rev. 1	WG-FSA-89/27
100 – 200	299 814	107 700
200 – 300	96 348	86 400
300 – 500	32 800	40 000
Total	428 962	234 100

Table 8.2: Total biomass and biomass by species obtained during the 1988 survey on the Kerguelen Shelf (restratified).

	Fish biomass (tonnes)
Total	277 300
C. gunnari	234 100
N. rossii	13 800
N. squamifrons	2 200*
D. eleginoides	27 200

* probably underestimated in relation to migration

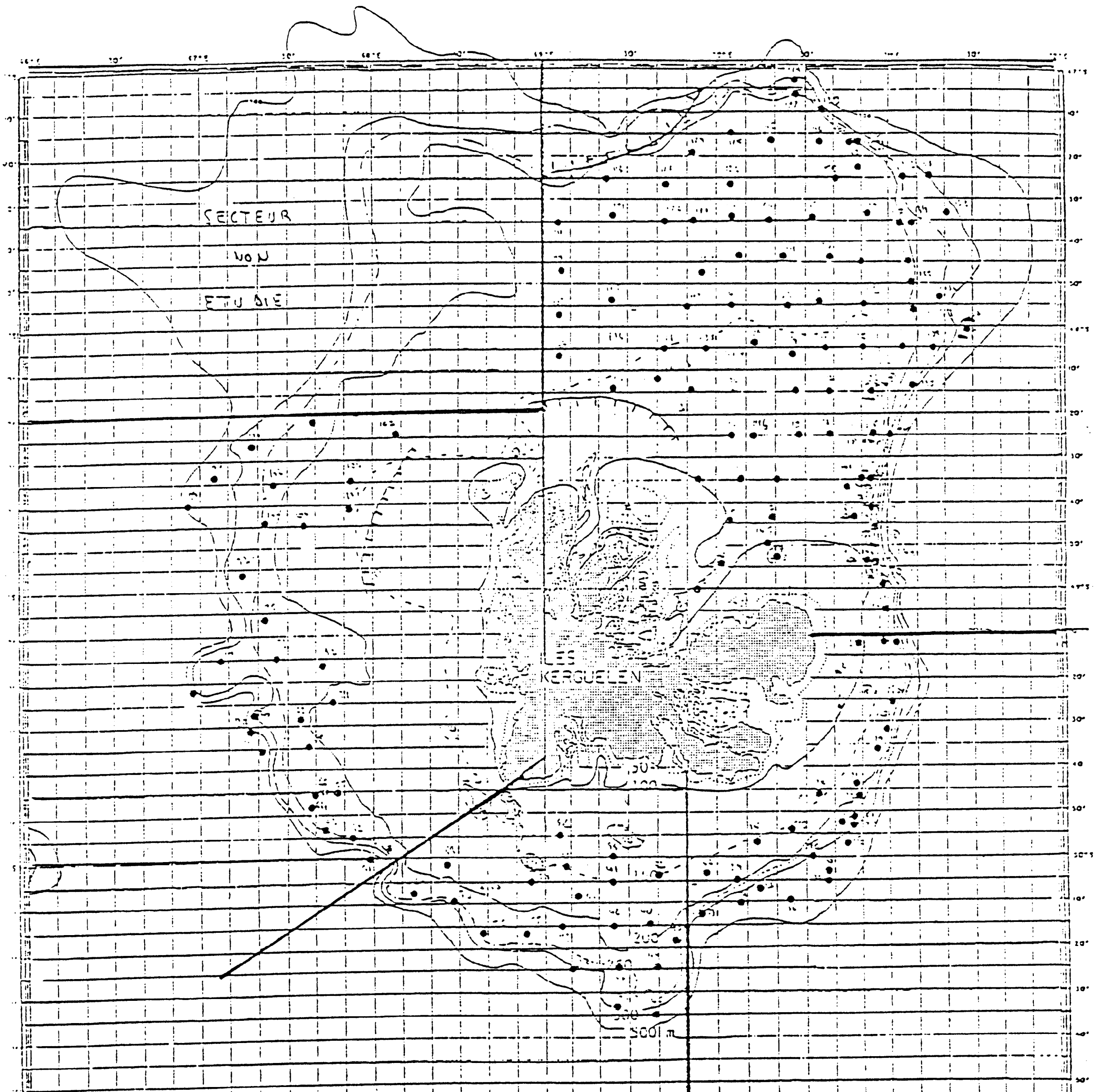

Figure 8.1

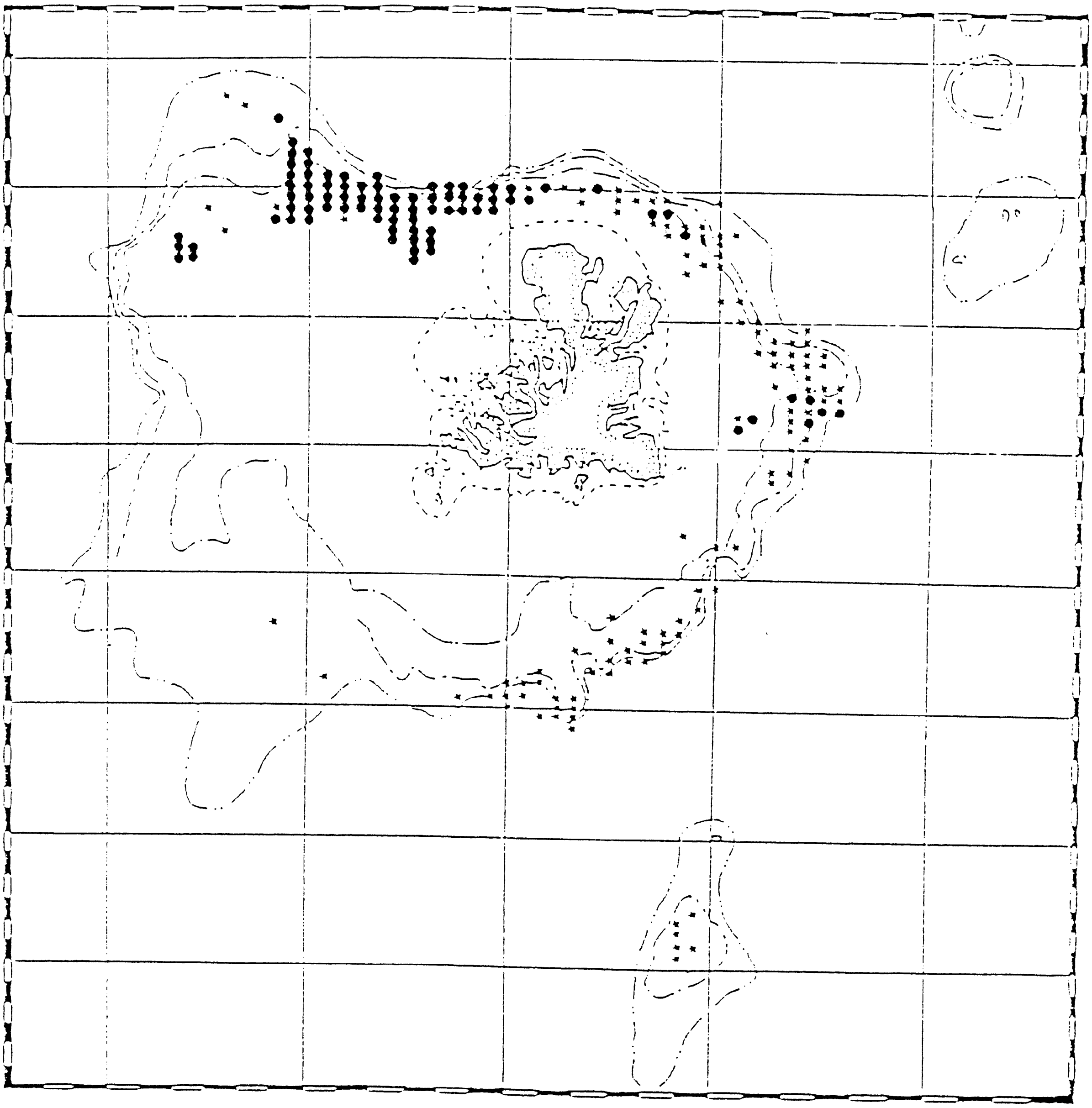

Figure 8.2

APPENDIX 9

DATA REQUIREMENTS

1. Catch and effort for longline fisheries on *D. eleginoides* in Subarea 48.3. (See this report, paragraph 10).

2. New length composition data from commercial fishery to improve assessment. (Generally).

3. USSR scientists asked to provide 1990 Meeting with data for a year by year analysis of growth and natural mortality in *C. gunnari* in Subarea 48.3. (See this report, paragraphs 46 and 47).

4. Biological information (length composition, age/length keys) should be collected from the incidental catch of *N. rossii* in Subarea 48.3. (See this report, paragraph 83; also SC-CAMLR-VII, Annex 6, paragraphs 11 and 22; SC-CAMLR-VI, Annex 5, paragraph 12; SC-CAMLR-V, Annex 4, paragraphs 22, 45 and 48; SC-CAMLR-IV, Annex 4, paragraph 26).

5. Information on length and age of *N. squamifrons* in Subarea 48.3 for past and current commercial catches as well as biomass estimates from research vessel surveys is urgently needed. (See this report, paragraph 113; also SC-CAMLR-V, Annex 4, paragraph 79).

6. Length and age data from the catches since the mid 1980's of *C. gunnari* and *C. gunnari* and *N. gibberifrons* in Subarea 48.2 are needed. An estimate of current stock biomass from a research vessel survey is also highly desirable. (See this report, paragraph 133; also SC-CAMLR-VII, Annex 6, paragraphs 61 and 64; SC-CAMLR-VI, Annex 5, paragraph 91).

7. Age and length data from recent and current catches of *N. gibberifrons* in Subarea 48.1 is needed. A biomass estimate from a research vessel survey is also needed. (See this report, paragraph 139).

8. Fine scale reporting of catches of *P. antarcticum* in Subarea 58.4 is required. (See this report, paragraph 144).

9. Catches of *C. wilsoni* are being reported as *C. gunnari* from Subarea 58.4 - more care needed in reporting species. (See this report, paragraph 45; also SC-CAMLR-V, Annex 4, paragraph 79).

10. Data from recent trawl surveys undertaken by the USSR have been used in analyses presented to the Working Group. It is recommended that the basic survey data and details of survey design be made available to the 1990 Meeting of the Working Group. (See this report, paragraph 148).

11. Historical catch data for *N. squamifrons* in Division 58.4.4 should be submitted. (See this report, paragraph 150; also SC-CAMLR-VII, Annex 6, paragraphs 80 and 81; SC-CAMLR-V, Annex 4, paragraph 79).

12. Age/length keys and length frequency data are required from catches of *C. gunnari* in Division 58.5.1 prior to 1980. (See this report, paragraph 158; also SC-CAMLR-IV Annex 4, paragraph 51).

13. The following data is required for *N. squamifrons* in Division 58.5.1 (see this report, paragraph 178):

    (a) length-frequency and age/length data for *N. squamifrons* taken from Division 58.5.1 are required from 1972 to the present;

    (b) catch data prior to 1978 should be separated from Division 58.5.1;

    (c) data held by Members should be checked for consistency with that held in CCAMLR data base; and

    (d) length data should be requested as total length.

14. Data on all exploited stocks of *Channichthyids* in Statistical Area 58 are required. (See this report, paragraph 182; also SC-CAMLR-VII, Annex 6, paragraph 73).

APPENDIX 10

1989 ASSESSMENTS SUMMARIES

1989 ASSESSMENT SUMMARY FOR *CHAENOCEPHALUS ACERATUS* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Biomass[f] (tonnes)	Mean F
1977			293		na
1978			2 066		na
1979			464		na
1980			1 084		na
1981			1 272		na
1982			6 767		na
1983			0		na
1984			161		na
1985			1 042	11 542[a]	na
1986			504		na
1987			339	8 621[b]	na
1988			313	6 209[b]	na
1989	1 100[d]	[e]	1	5 770[c]	na
1990	0				

[a] from FRG research vessel survey

[b] from joint US/Polish research vessel surveys

[c] from joint UK/Polish research vessel survey

[d] applying $F_{0.1}$ = 0.15 (females) and 0.18 (males) to the mean of (b) (8 000 tonnes) (1988/89), (c) (6 000 tonnes) (1989/90)

[e] catches prohibited under Conservation Measure 11/VII

[f] using 'swept area' method

The Fishery:

Catches are usually relatively small and variable. This species is mostly taken incidentally by fisheries directed at other species.

Conservation Measures in Force:

General Conservation Measures for Subarea 48.3 apply.

This includes Conservation Measure 11/VII (fishing on *C. gunnari* and by-catch prohibited from 4 November 1988 to 20 November 1989).

Data and Assessments:

Length composition data mainly from research vessel catches are available for most years. Biomass estimates from a number of surveys are available, in particular, since 1984/85. No VPA calculations have been attempted.

Fishing Mortality:

No reliable information.

Recruitment:

No reliable information.

State of the Stock:

The biomass still seems well below the level prior to exploitation and in the first years of fishing.

Management Advice:

Given the rather even distribution of the species over the area and its co-occurrence with other species (e.g. *N. gibberifrons, P. georgianus*) it is unlikely that this catch could be taken without a substantial by-catch of these species. In view of these problems, its likely detrimental effects on other species with a low stock size and the apparent stock-recruitment relationship in *C. aceratus*, the Working Group recommended that no directed catches of these species be taken and by-catches be reduced to a minimum to allow the recovery of this stock.

Data Requirements:

Catch records from all fishing nations. Length and age compositions from commercial catches from most of the years.

1989 ASSESSMENT SUMMARY FOR *CHAMPSOCEPHALUS GUNNARI* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Biomass (tonnes)	Mean F
1971	-	-	10 701		
1972	-	-	551		
1973	-	-	1 830		
1974	-	-	254		
1975	-	-	746		
1976	-	-	12 290		
1977	-	-	93 400		
1978	-	-	7 557		
1979	-	-	641		
1980	-	-	7 592		
1981	-	-	29 384		
1982	-	-	46 311		
1983	-	-	128 194		
1984	-	-	79 997		
1985	-	-	14 148		
1986	-	-	11 107		
1987	-	-	71 151		
1988	31 500	35 000	34 620		
1989	10 194[(a)]	[(b)]	21 359		
1990	[(c)]				

(a) at $F_{0.1} = 0.313$

(b) directed fishing on *C. gunnari* was prohibited from 4 November 1988 in accordance with CCAMLR Conservation Measure 11/VII. A TAC was not appropriate.

(c) see below, Management Advice.

The Fishery:

High variability in recruitment makes the stock abundance vary greatly. During years of high abundance (1977, 1983/84, 1987) there is an important directed fishery.

During the Seventh Meeting of the Commission, 24 October to 4 November 1988, the catch of *C. gunnari* reported under Conservation Measure 9/VI reached 10 121 tonnes with two periods still unreported. Following the Scientific Committee’s advice of a TAC at $F_{0.1}$ of 10 194 tonnes, Conservation Measure 11/VII was adopted prohibiting fishing of this species after 4 November 1988 (CCAMLR-VII, paragraphs 92 to 97).

Conservation Measures in Force:

(1) Fishing, other than for scientific purposes, prohibited in waters within 12 n miles around South Georgia (Conservation Measure 1/III).

(2) Minimum mesh size of 80 millimetres for trawls used in directed fishing for *C. gunnari* (for protection of young fish) (Conservation Measure 2/III).

(3) System for reporting catches on the basis of 10-day period (Conservation Measure 9/VI).

(4) Prohibition of a directed fishery on *C. gunnari* from 4 November 1988 to 20 November 1989 (Conservation Measure 11/VII).

Data and Assessments:

Age and length data are available for the 1988/89 season. Estimates of biomass are available from research surveys (joint UK/Polish and USA). Soviet catch and effort data from STATLANT forms for 1988/89 are available.

Two VPA assessments were considered, one tuned to the UK/Polish survey estimate of biomass, the other tuned to effort data (see WG-FSA-89/27 and WG-FSA-89/22 Rev. 1).

Fishing Mortality:

The two assessments described give radically different absolute levels of fishing mortality. In the last years the mortality on age group 2 has been high.

Recruitment:

Although the two working papers give rather similar levels of abundance, the pattern of recruitment is substantially different. WG-FSA-89/27 indicates that recent recruitment is small compared to the average over previous years, while WG-FSA-89/22 Rev. 1 indicates that there is a substantial year class born in 1987, which is the highest in the last 7 years.

State of the Stock:

There is a large difference between the estimates of total abundance in the final year (1988/89) from the two analyses. The abundance of the stock still mainly depends on young fish, 1 to 3 year olds.

Management Advice:

The TAC's at different target F levels that have been derived from the two assessments are given in Table 2. They differ substantially.

Table 2: TAC levels (tonnes) for *C. gunnari*, Subarea 48.3, calculated from assessments presented in WG-FSA-89/27 and WG-FSA-89/12 Rev. 1 (M = 0.35).

	Assessment presented in WG-FSA-89/27	Assessment presented in WG-FSA-89/22 Rev. 1
$F_{0.1} = 0.313$	6 545	22 235
$F_{max} = 0.645$	11 961	40 273

In essence, if the trawl survey and the analysis based on it is correct, a TAC based on the CPUE tuned VPA will lead to a substantial depletion of the stock.

If the analysis based on the CPUE tuned VPA is correct and a TAC is set on the basis of the trawl survey results, the stock will increase substantially.

Analysis of mesh selectivity experiments now indicate that a mesh size of 110 mm would afford substantial protection to juvenile fish and permit the growth of any strong year class that might appear. If the Commission decides to adopt this, then a new TAC based on a different $F_{0.1}$ value would need to be calculated (see paragraph 89).

Data Requirements:

Because of the major discrepancy between the two analyses presented, a further survey is clearly desirable. Estimates of the strength of recruiting year classes are urgently required, which might best be obtained by a survey with both bottom and midwater trawls.

1989 ASSESSMENT SUMMARY FOR *PSEUDOCHAENICHTHYS GEORGIANUS* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Biomass[f] (tonnes)	Mean F
1977			1 608		na
1978			13 015		na
1979			1 104		na
1980			665		na
1981			1 661		na
1982			956		na
1983			0		na
1984			888		na
1985			1 097	8 134[a]	na
1986			156		na
1987			120	5 520[b]	na
1988			401	9 461[b]	na
1989	1 800[d]	[e]	1	8 278[c]	na
1990	0				

(a) from FRG research vessel survey

(b) from joint US/Polish research vessel surveys

(c) from joint UK/Polish research vessel survey

(d) using $F_{0.1}$ = 0.3 on the mean of (a - c) (8 000 tonnes)

(e) catches prohibited under Conservation Measure 11/VII

(f) estimates using 'swept area' method

The Fishery:

Large catches have been taken in only one season (1977/78). Otherwise this species is mostly taken as by-catch.

Conservation Measures in Force:

General Conservation Measures for Subarea 48.3 apply.

Data and Assessments:

Estimates of biomass are available from a number of surveys. Length frequency data mostly from research vessel catches are available since 1975/76 and some age length keys from the first years of fishing. Age determinations have been made by microincrements (daily rings) and other methods. No VPA calculations have been attempted.

Fishing Mortality:

No reliable information, but presumably small in recent years.

Recruitment:

There are suggestions from year-to-year changes in length frequency that recruitment varies considerably.

State of the Stock:

Although reported catches have been fairly light since 1977/78, stock biomass is still much less than before the fishery started in 1976/77.

Management Advice:

Catches of this species can only be taken with a substantial by-catch of other species. In view of this problem and its likely detrimental effects on other species with a low stock size (e.g. *N. gibberifrons*, *C. aceratus*) the Working Group recommended that no directed catch of these species be taken and by-catches to be reduced to a minimum to allow recovery of these stocks.

Data Requirements:

Catch reports from all fishing countries. Length frequency compositions and age/length keys from the commercial fishery for most years.

1989 ASSESSMENT SUMMARY FOR *NOTOTHENIA GIBBERIFRONS* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Biomass (tonnes) [a]	Mean F [a]
1976			4 999		
1977			3 357		
1978			11 758		
1979			2 540		
1980			8 143		
1981			7 971		
1982			2 605		
1983			0		
1984			3 304		
1985			2 081		
1986			1 678		
1987			2 844		
1988			5 222		
1989		[b]	838		
1990	[c]				

[a] from VPA with M = 0.125

[b] total ban on fishing *N. gibberifrons* (Conservation Measure 11/VII)

[c] $F_{0.1}$ = 0.094, M = 0.125

The Fishery:

Moderate catches have been taken in most years with a peak of 11 000 tonnes in 1978. Catch in 1988/89 was mainly by-catch in the *C. gunnari* fishery.

Conservation Measures in Force:

General Conservation Measures for Subarea 48.3 apply.

This includes Conservation Measure 11/VII prohibiting commercial by-catches of *N. gibberifrons* in Subarea 48.3.

Data and Assessments:

Catch at age data was updated to 1987/88, but no commercial data was available for 1988/89 catches. The VPA was run up to 1987/88 and calibrated to the biomass estimates from trawl surveys. Half the catch in 1987/88 was added to the estimate to approximate the biomass at the beginning of the 1987/88 season.

Fishing Mortality:

Fishing mortality is high and has increased on younger age groups in the population. Terminal F was estimated at 0.9 on fully recruited age groups in 1987/88.

Recruitment:

From the VPA results, recruitment appears to have declined from 1976 to 1986, as stock size has decreased. Projections based on mean recruitment levels may overestimate the size of new recruiting age classes.

State of the Stock:

Biomass estimates from trawl surveys in recent years suggest that this stock has declined from about 14 000 tonnes in the period 1984 to 1986 to about 8 000 tonnes from 1987 to 1989. The stock appears to be at only 20% of the level of the mid 1970’s (40 000 tonnes).

Management Advice:

Because of the current low stock size and the evidence for a stock recruitment relationship, the Working Group was unable to recommend a TAC at the level of $F_{0.1}$. Catches should be kept to a minimum to increase stock size. The Working Group recommended that there should be no directed fishery for *N. gibberifrons* and by-catch should be restricted to not more than 300 tonnes.

Data Requirements:

Length and age data are required from commercial catches.

1989 ASSESSMENT SUMMARY FOR *NOTOTHENIA ROSSII*
IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Spawner Biomass (tonnes)	Biomass[e] (tonnes)	Mean F
1970			399 704			
1971			101 558			
1972			2 738			
1973			0			
1974			0			
1975			0			
1976			10 753		35 682[a]	
1977			7 945			
1978			2 192		9 325[a]	
1979			2 137			
1980			24 897			
1981			1 651			
1982			1 100			
1983			866			
1984			3 022			
1985			1 891		12 781[a]	
1986		[f]	70			
1987		[f]	216		11 471[b] 1 634[c]	
1988		[f]	197		1 699[c]	
1989		[f]	152		2 439[d]	

(a) from FRG research vessel survey

(b) from Spanish research vessel survey

(c) from US/Polish research vessel survey

(d) from UK/Polish research vessel survey

(e) estimates using 'swept area' method

(f) directed fishing prohibited under Conservation Measure 3/IV

The Fishery:

A very large directed fishery took place in the 1969/70 and 1970/71 seasons and smaller directed fisheries in 1975/76 and 1979/80. Otherwise catches have been taken as by-catch in fisheries based largely on other species.

Conservation Measures in Force:

General Conservation Measures apply. In addition,

(1) Directed fishing on *N. rossii* in 48.3 is prohibited. By-catches of *N. rossii* in fisheries directed to other species shall be kept to the level allowing the optimum recruitment to the stock (Conservation Measure 3/IV).

(2) Directed fishing on *C. gunnari* is prohibited in Subarea 48.3 from 4 November 1988 to 20 November 1989 and during this time *N. rossii* shall not be taken except for scientific purposes (Conservation Measure 11/VII).

Data and Assessments:

Length and age data are available for most seasons, and biomass estimates have been made from a number of research surveys, in particular since 1984/85. Problems with interpretation make the age data unsuitable from 1985 onwards, but VPA have been run up to that data.

Fishing Mortality:

Fishing mortality has been very high from age 4 onwards in the seasons of directed fishing. The younger fish are largely in the fjords and unaccessible to fishing.

Recruitment:

Recruitment is now very much lower than it must have been in the 1960s. The decrease seems to have taken place in abrupt steps, and though this has occurred during a period when the stock was in decline, the relation between stock abundance and recruitment does not appear to be simple.

State of the Stock:

Stock abundance is now very low and will not improve appreciably until recruitment increases.

Management Advice:

No significant catches can be taken until recruitment increases and the stock begins to recover. Any fishing on the depleted stock will delay the recovery and reduce the probability of better recruitment. Conservation measures should remain in force.

Data Requirements:

The current doubts about age determination should be resolved. More needs to be understood about possible factors affecting recruitment. It would also be desirable to establish methods of monitoring the younger, pre-recruit fish. Albeit commercial catches are small, information on length frequency composition, age/length keys etc. should be submitted to CCAMLR.

1989 ASSESSMENT SUMMARY FOR *PATAGONOTOTHEN BREVICAUDA GUNTHERI* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Biomass (tonnes)	Mean F
1979			15 011		
1980			7 381		
1981			36 758		
1982			31 351		
1983			5 029		
1984			10 586		
1985			11 923		
1986			16 002		
1987			8 810	81 000[a]	
1988			13 424		
1989	[b]	13 000[c]	13 016		
1990					

[a] from Spanish survey

[b] no TAC recommended

[c] based on recent years catches

The Fishery:

Total catch in 1988/89 was 13 016 tonnes taken by a Soviet directed fishery in the Shag Rocks area. Age compositions of catches were mainly age groups 2 to 4 as in previous years.

Conservation Measures in Force:

(1) The catch of *P.b. guntheri* in Subarea 48.3 was limited to 13 000 tonnes in the 1988/89 season (Conservation Measure 12/VII).

(2) The catch reporting system applies (Conservation Measure 9/VI).

Data and Assessments:

Catch at age data was available up to 1988/89 and was used in the VPA. Some CPUE data was available from the Soviet fleet and one estimate of biomass from a trawl survey was available for 1986/87 (81 000 tonnes). Assessments were made using two values of natural mortality, 0.48 and 0.63.

Fishing Mortality:

Fishing is directed at age classes 2 to 4 and appears to be only at moderate levels in recent years.

Recruitment:

The biomass estimated for 1989/90 from projections of the VPA results is very sensitive to the assumed value of recruitment. Use of near values may give over-optimistic results. A large proportion of the fishable biomass is made up of new recruits, e.g. for M = 0.63, ages 1 and 2 make up 50% of the projected biomass in 1989/90.

State of the Stock:

The current status of this stock is unknown. Uncertainty in the value of natural mortality and the lack of any time series showing discernable trends prevent an accurate assessment of the stock size at present.

Management Advice:

In the absence of reliable estimates of natural mortality to evaluate the alternative analyses and in the absence of information of current stock size, catch levels should not be based on VPA results using $F_{0.1}$ calculations and assumptions on recruitment.

Data Requirements:

Length and catch at age data should continue to be collected from commercial catches. Survey estimates of abundance over a time series are required for stock assessment. Natural mortality should be determined from unexploited populations if possible.

1989 ASSESSMENT SUMMARY FOR *NOTOTHENIA SQUAMIFRONS* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Biomass[d] (tonnes)	Mean F
1972			35		
1973			765		
1974			0		
1975			1 900		
1976			500		
1977			2 937		
1978			2 327[a]		
1979			280[a]		
1980			272		
1981			544		
1982			812		
1983			0		
1984			0		
1985			1 289		
1986			41		
1987			190	13 950[b]	
1988			1 553	409[b]	
1989			927	131[c]	

[a] from subarea unknown, probably South Georgia

[b] from US/Polish research vessel survey

[c] from UK/Polish research vessel survey

[d] estimates using ‘swept area’ method

The Fishery:

Catches have been reported since 1971/72. Annual catches usually varied between several hundred and 2 to 3 000 tonnes.

Conservation Measures in Force:

General Conservation Measures for Subarea 48.3 apply.

Data and Assessments:

Fishing Mortality:

No reliable information.

Recruitment:

No reliable information.

State of the Stock:

No reliable information.

Management Advice:

As the status of the stock is unknown the Working Group was unable to recommend a TAC.

Data Requirements:

Length and age compositions from the commercial catches.

1989 ASSESSMENT SUMMARY FOR *DISSOSTICHUS ELEGINOIDES* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Biomass[d] (tonnes)	Mean F
1976				13 497[a]	
1977			441		
1978			1 920	7 322[a]	
1979			194		
1980			255		
1981			239		
1982			324		
1983			116		
1984			109		
1985			285	8 159[a]	
1986			564		
1987			1 199	1 208[b]	
1988			1 809	674[b]	
1989			4 138	326[c]	

[a] from FRG research vessel surveys including Shag Rocks

[b] from joint US/Polish research vessel surveys excluding Shag Rocks

[c] from joint UK/Polish research vessel survey excluding Shag Rocks

[d] estimates using 'swept area' method

The Fishery:

Catch history is available since 1976/77. Annual catches until 1985/86 were mostly several hundred tonnes. Since 1985/86 catches gradually increased to 4 138 tonnes in 1988/89.

Up to 1987/88 the fishery was entirely trawl-based. Most of the catches of the 1988/89 season were taken by longlines.

Conservation Measures in Force:

Mesh size regulations.

Data and Assessments:

Length compositions from research vessel catches in 1975/76, 1977/78 and 1984/85. Biomass estimates for 1975/76, 1977/78, 1984/85, 1986/87 – 1988/89.

Fishing Mortality:

No information.

Recruitment:

No information.

State of the Stock:

The Working Group was unable to assess the current state of the stock.

Management Advice:

In the absence of information on stock size the Working Group was only able to calculate the yield for different levels of unexploited stock size based on natural mortality estimates of 0.06.

Biomass	Sustainable Yield
8 000 tonnes	240 tonnes
40 000 tonnes	1 200 tonnes

As the figure of 40 000 tonnes is some five times the stock estimate obtained by the FRG survey in 1984/85, this could be considered as a reasonable upper limit until further data become available.

Data Requirements:

Length and age compositions from the commercial fishery (past and current). Biomass estimates from research vessel surveys.

1989 ASSESSMENT SUMMARY FOR *NOTOTHENIA SQUAMIFRONS* IN DIVISION 58.4.4 (OB AND LENA BANKS)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Biomass (tonnes)	Mean F
1980			4 340	na	na
1981			2 926	na	na
1982			785	na	na
1983			95	na	na
1984			203	na	na
1985			27	na	na
1986			61	na	na
1987			930	na	na
1988			5 302	na	na
1989			3 660		

The Fishery:

Catches are variable (Table 6) and appear to reflect diversion of effort from the Kerguelen finfish fishery (see Tables 5 and 8) or the Antarctic krill fishery in the southern Indian Ocean. At present it is not possible to determine the proportionate composition of the total catch as being from either Ob or Lena. It appears that the stocks of *N. squamifrons* on these two seamounts should be considered separately.

Conservation Measures in Force:

80 mm mesh size restrictions for directed fishing on *N. squamifrons* (Conservation Measure 2/III).

All other Conservation Measures are applicable in this division as outlined in Division 58.5.2.

Data and Assessments:

Length frequencies, age compositions and age length keys have been submitted by the USSR separately for Ob and Lena Banks.

The USSR Member's Activities Report gives biomass estimates for Ob and Lena Banks of 21.25 ± 11.44 thousand tonnes and 12.76 ± 4.34 thousand tonnes respectively. The Working Group recommends that the new survey data be made available for consideration and further analysis by the Working Group for Fish Stock Assessment in 1990.

Recruitment:

There was no information from which to assess current recruitment.

State of the Stock:

The lack of catch data separated for each bank has precluded assessment.

Management Advice:

The Working Group drew attention to the observation that catches have increased over the last two seasons.

In the absence of an assessment, the Working Group was unable to give specific management advice. It recommends the submission of the recent survey data and historical catch data separately for each bank.

Data Requirements:

1989 ASSESSMENT SUMMARY FOR *CHAMPSOCEPHALUS GUNNARI* IN DIVISION 58.5.1 (KERGUELEN SHELF AND SKIF BANK)

Split-Year Ending	TAC	Skif Bank Actual Landings (tonnes)	Skif Bank Cohort (Yr)	Skif Bank Mean F	Kerguelen Shelf Actual Landings (tonnes) [c]	Kerguelen Shelf Cohort (Yr)	Kerguelen Shelf Spawner Biomass (tonnes)	Kerguelen Shelf Mean F
1971					10 231			
1972					53 857			
1973					6 512			
1974					7 392			
1975					47 784			
1976					10 424			
1977					10 450			
1978					72 893	1976		
1979					0			
1980		1			1 630	1976		
1981		992	1978		130	1979		
1982		1 024	1978		15 059	1979		
1983		4			25 848	1979		
1984		904	1981		6 223	1979		
1985	x	223	1981		8 030	1982		
1986	x	0			17 137	1982		
1987	16 000[a]	2 625	1984		0			
1988	12 500[b]	2			157	1985		
1989					23 628	1985		

(a) refers period 1 October 1986 to 31 December 1987 for Division 58.5.1

(b) refers to period 1 January 1988 to 31 December 1988 for Division 58.5.1

(c) landings prior to 1989 are for the whole of Subarea 58.5

The Fishery:

There are two separate stocks in Division 58.5.1 (Kerguelen Shelf and Skif Bank). Catches are variable and reflect fairly closely a three year cycle in recruitment. Over the last decade fishing has occurred on only one cohort at a time with large catches taken as the fish reach 3 years of age. This occurred in 1983, 1986 and again in 1989.

No fishing occurred on the Skif Bank stock in the 1989 season and so no reassessment was undertaken.

Conservation Measures in Force:

(1) Minimum mesh size of 80 mm for trawls used during directed fishing on *C. gunnari* (Arrêté N°: 20 of 2-08-85 taken in application of Conservation Measure 2/III).

(2) Minimum size limit of 25 cm (Arrêté N°: 20 of 2-08-85).

(3) TAC's set from 1985 onwards under the joint French-Soviet agreement.

(4) Conservation Measures as for *N. rossii* in Division 58.5.1.

Data and Assessments:

Comprehensive length and age data for both Skif and Kerguelen Shelf since 1980.

CPUE data since 1981.

Survey estimates of biomass for Kerguelen Shelf* stocks in 1987 and 1988 (WG-FSA-88/22 Rev. 1) was partially reanalysed, but because of non randomness in sampling distribution, it was decided not to use the abundance estimate (see Appendix 1).

Fishing Mortality:

The cohort analysis from the 1988 Meeting was updated as far as possible (see Appendix 2).

Recruitment:

Based on the CPUE data (Figure 1), the strength of the incoming cohort seems to be comparable in strength with the two preceding strong cohorts, although it may be slightly weaker.

* fish at age 1 in pelagic phase therefore bottom trawl survey not useful.

State of the Stock:

In light of the unsatsifactory biomass estimates there is little recourse but to assume, on the basis of the CPUE data, that the current cohort in the fishery is of comparable strength to the preceding strong cohorts of 1979 and 1982. Thus the biomass of the 1985 cohort during 1988/89 could have been in the range of 23 000 to 45 000 tonnes. Therefore the catch of 23 000 tonnes in the 1989 season may have had a severe impact on the current cohort.

Management Advice:

In previous assessments it was pointed out that reduction in fishing effort would increase the number of cohorts available to the fishery. The structure of the present stocks and the current minimum size limit in force do not allow continuous exploitation of either Kerguelen Shelf or Skif Bank. A pattern of ‘pulsed’ fishing effort appears to give an appropriate exploitation policy provided that exploitation of a strong cohort is not allowed to start until the fish have grown to the size at sexual maturity.

Given that substantial depletion of the current strong cohort could have occurred in 1989, it would be prudent for any fishing in 1990 to be in the range of previous catches from the preceding cohorts at 4 years of age, i.e. 0 to 6 000 tonnes. A survey is required to assess the strength of the 1988 cohort.

Data Requirements:

New and properly designed survey .

Careful reanalysis of 1988 survey.

Stratified as suggested in Appendix 1.

Studies of post spawning mortality.

1989 ASSESSMENT SUMMARY FOR *DISSOSTICHUS ELEGINOIDES* IN SUBAREA 58.5.1 (KERGUELEN SHELF AND SKIF BANK)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes) [(a)]	Biomass (tonnes)	Mean F
1978			2		
1979			0		
1980			138		
1981			40		
1982			121		
1983			128		
1984			145		
1985			6 677		
1986			459		
1987			3 144		
1988			554		
1989			1 630	27 200	

[(a)] landings prior to 1989 are for the whole of Subarea 58.5

The Fishery:

The fishery is confined to a concentration in a relatively small area on the west coast in water 300 to 600 m deep. Large catches began in 1985 when this area was discovered. In 1986 and 1988 effort in this fishery was low because of concentration on *C. gunnari*. In years of significant fishery, the catch has declined from 6 677 tonnes to 1 630 tonnes per year and CPUE has declined from 2.50 t/h to 1.64 t/h.

Conservation Measures in Force:

None.

Data and Assessments:

Biomass estimate 1988/89 (from Soviet/French survey):

for total area	27 200 tonnes
for western zone	19 000 tonnes

CPUE:	1984/85	1985/86	1986/87	1987/88	1988/89	
	2.50	1.41	1.79	0.78	1.64	(t/hour)

Fishing Mortality:

No estimates available.

Recruitment:

No data.

State of the Stock:

As CPUE has declined by approximately 30% in three years, and this is a long-lived species with probably low productivity (as in the case with most other nototheniids), this rate of fishing may be too high.

Management Advice:

Assessment urgently required.

Data Requirements:

Age/length keys.
Length.

1989 ASSESSMENT SUMMARY FOR *NOTOTHENIA ROSSII* IN DIVISION 58.5.1 (KERGUELEN)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes) (b)	Biomass (tonnes)	Mean F
1971			63 636		
1972			104 588		
1973			20 361		
1974			20 906		
1975			10 248		
1976			6 061		
1977			97		
1978			46 155		
1979			0		
1980			1 742		
1981			7 924		
1982			9 812		
1983			1 829		
1984			744		
1985		0(a)	1 707		
1986		0(a)	801		
1987		0(a)	482		
1988		0(a)	21		
1989		0(a)	245		

(a) avoidance of direct fisheries (CCAMLR Resolution 3/IV) and by-catch only allowed (Franco-Soviet Fishery Contract)

(b) landings prior to 1979 are for the whole of Subarea 58.5

The Fishery:

There was a steady decline in catches from high level at the start of the fishery in 1970/71 to a low of 97 tonnes in 1976/77, with an isolated high catch in 1978, just before the declaration of an EEZ. After a closure of the area from July 1978 to October 1979, the fishery recommenced at a moderate level, and then declined to low catches. Only the adult part (age 5+ years) of the stock has been exploited. Since 1985 directed fishing has been prohibited and by-catches have declined steadily.

Conservation Measures in Force:

(1) Fishing other than for scientific purposes is prohibited in waters within 12 n miles around Kerguelen. (Arrêté N°: 18, 16.05.80).

(2) Minimum mesh size of 120 mm for trawls used in directed fishing (Arrêté N°: 20, 2-08-85 taken in application of Conservation Measure 2/III).

(3) Directed fishing on stock of *N. rossii* in Statistical Subarea 58.5 has been prohibited since 1985. (In application of Resolution 3/IV).

(4) Maximum allowed by-catch of 500 tonnes in 1987 and 1988 (i.e. total landings in these years are by-catch).

(5) All the fishing grounds in Division 58.5.1 are closed yearly in May and June, Sector 4 (west of 69°30'E and south of 49°30'S) is closed in April and Sector 1 (east of 69°30'E and south of 50°S) is closed from 15 September to 1 November (Arrêté N°: 32 of 22-10-84).

(6) There is a system for the weekly reporting of catches. Catch statistics and data are reported daily on a trawl-by-trawl basis (logbooks provided by the French authorities).

(7) A system of inspection and observation was established in 1980.

(8) Only a limited number of trawlers is allowed on the fishing grounds (number revised each year).

Data and Assessments:

No new data are available since the 1988 Scientific Committee Meeting in relation to the prohibition of a directed fishery on the adult stock. A provisional biomass estimate was available from the USSR survey.

Fishing Mortality:

Recruitment:

A program to study pre-recruits in coastal waters to assess the stock and detect any changes in the abundance of the juvenile portion of the stock has been established recently (1982). Regular experimental fishing with trammel nets would allow detection of variations in abundance of this part of the stock (based on catches of age classes 2 and 3 fishes). A gradual increase in abundance with an average growth rate of 36.3% has been observed from 1984 to 1988 (WG-FSA-89/9). Considering the deferred impact to the adult part of the stock an expected increase in recruitment would be detectable in four years for the shelf stock.

State of the Stock:

Management Advice:

Conservation measures (no directed fishery) will be continued into the beginning of 1990 for the adult stocks. Trends in the abundance of the juvenile part of the stock need to be continually monitored. An evaluation survey will need to be conducted prior to any new exploitation.

Data Requirements:

1989 ASSESSMENT SUMMARY FOR *NOTOTHENIA SQUAMIFRONS* IN DIVISION 58.5.1 (KERGUELEN)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes) [b]	Biomass (tonnes)	Mean F
1971			24 545[a]	na	
1972			52 912[a]	na	
1973			2 368[a]	na	
1974			19 977[a]	na	
1975			10 198[a]	na	
1976			12 200[a]	na	
1977			308[a]	na	
1978			31 582[a]	na	
1979			1 307[a]	na	
1980			11 308		
1981			6 239		
1982			4 038		
1983			1 832		
1984			3 792		
1985			7 394		
1986			2 464		
1987		[c]5 000	1 641		
1988		[c]2 000	41[d]		
1989		[c]2 000+	1 825		

[a] includes catches from Division 58.4.4 and possibly Subarea 58.6

[b] landings prior to 1989 are for the whole of Subarea 58.5

[c] TAC set by fishing season and **not** by split-year

[d] see (5) under Conservation Measures in Force

The Fishery:

Prior to the declaration of an EEZ around Kerguelen by France (3 February 1978), it is not possible to separate catches taken in Subarea 58.5 from those in Subarea 58.4. Since 1980 there has been a steady decline in catches with an indication of a small increase in 1984 and 1985. This probably resulted from a redirection of fishing effort in relation to a low level abundance of *C. gunnari*, the main target species of the Kerguelen fishery. The catch in 1988/89 was substantially larger than in 1987/88 (see below) but comparable with 1986/87.

Conservation Measures in Force:

(1) Prohibition of fishing on *N. squamifrons* (and to other species) between 15 September to 1 November for protection of spawning stock (area south of 50°S and east of 69°30’E) (Arrêté N°: 32 of 22/10/1984).

(2) Minimum mesh size of 80 millimetres for trawls used in directed fishing for *N. squamifrons* (for protection of young fish) (Arrêté N°: 20 of 2/08/1985 in application of Conservation Measure 2/III).

(3) Catch limits have been set since 1987 under the joint French/Soviet agreement (SC-CAMLR-VII, paragraph 83, page 120).

(4) Conservation Measures as for *N. rossii* in Division 58.5.1.

(5) During 1987/88 no directed fishing on *N. squamifrons* was undertaken between December 1987 and September 1988.

Data and Assessments:

Comprehensive length frequency distribution data are available from the commercial fisheries. Other available data include indices of abundance from catch and effort data (WG-FSA-89/9) and survey estimates of stock biomass in 1987 and 1988 (WG-FSA-88/22 Rev. 1). Results from VPA analyses of data post 1980 (see SC-CAMLR-VII, Annex 5, paragraph 101) and Soviet assessments of various stock parameters (e.g. growth/mortality) for the years 1969 to 1972 and 1980 to 1986 (WG-FSA-89/16 and 17) are also available.

A lack of both length frequency and length at age data in the CCAMLR database precludes sensible VPA’s, particularly during the period when the stock was most heavily exploited (1971 to 1978).

Fishing Mortality:

Fishing mortality affects age classes 5+ with the age of maturity being 9 years. The wide range of values for natural mortality (Duhamel, 1987; WG-FSA-89/17) obtained to date and uncertainty concerning the long-term trajectory of the stock make it extremely difficult to assess fishing mortality.

Recruitment:

No information is available concerning trends in recruitment (whether constant or variable) for this species.

State of the Stock:

Both CPUE and catch level data indicate that the stock remains at a lower level. Catches in 1986/87 and 1988/89 have been less than the catch limits for these two seasons (see Table 6). The value of the CPUE index value of abundance south and southeast of the island confirm that there has been a decreasing trend in the stock biomass, however in 1988/89 this downward trend was not evident (WG-FSA-89/9, Figure 7). However, taking into account the annual areal distribution of the stock, this apparent recovery of the stock is small. It would appear therefore that the enforced reduction of fishing in 1987/88 is unlikely to have any longterm effect on this already heavily exploited stock.

Management Advice:

A lack of information on recruitment patterns makes it difficult to provide objective predictions of future trends in the stock. However, given observed exploitation trends and the present status of the stock protection of the *N. squamifrons* stock in Division 58.5.1 will be facilitated by closure of the directed fishery for this species. Similarly, recovery of an already depleted stock will be facilitated.

Since only about 15% of the current total stock biomass is comprised of adults and that fishing on other species in the area will continue, the setting of acceptable by-catch levels appears necessary. As the current quota levels have not been attained, it is recommended that future by-catch levels should be substantially lower than present quotas.

Data Requirements:

Data are required on the following:

- recruitment patterns;

- mesh selectivity to improve management advice based on yield-per-recruit calculations; and

- additional surveys of stock biomass should be undertaken in order to improve currently available knowledge of stock abundance. In particular, surveys should be undertaken prior to any future exploitation of unexploited stocks in Division 58.5.1 (see paragraph 171).

In order to improve assessments of the stock and exploitation trends, it is critically important that the following data be submitted to CCAMLR:

- Length frequency and age length data for the *N. squamifrons* fishery in Division 58.5.1 from 1972 to the present. Such data should, as far as possible, be provided for individual years.

- Catch data prior to the declaration of an EEZ around Kerguelen by France (3 February 1978), should be reported for Division 58.5.1 (as done in WG-FSA-89/10 and 17) and re-submitted.

- consolidated catch data for Subarea 58.5. In particular, care should be taken to ensure consistency between the data submitted to CCAMLR and data available to or held by individual members.

- to avoid possible confusion in the future, all length data should be reported as total length only.

ANNEX 7

REPORT OF THE WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM

(Mar del Plata, Argentina, 23 to 30 August 1989)

REPORT OF THE WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM

(Mar del Plata, Argentina, 23–30 August 1989)

The Fourth Meeting of the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP) was held from 23–30 August in Mar del Plata, Argentina. Three previous meetings have taken place: Seattle in 1985; Hamburg in 1986; Dammarie-les-Lys in 1987. Reports of these meetings can be found in the relevant Reports of the Scientific Committee (SC-CAMLR-IV, V and VI, respectively).

2. The Convener of the WG-CEMP, Dr K. Kerry (Australia) thanked the Government of Argentina for inviting the Working Group to hold this meeting in Mar del Plata and expressed his gratitude to the Comisión de Investigaciones Científicas de la Provincia de Buenos Aires (CIC) for making the arrangements for the meeting. Dr Kerry then welcomed participants to the meeting. A list of participants is attached (Appendix 1).

3. The Convener described the work which had taken place since the last meeting. The following documents were prepared by the Convener and Secretariat and distributed to Members for comment:

- draft formats for reporting data on monitoring seabirds and seals (SC-CAMLR-VII, paragraph 5.10);

- draft formats for recording field data on monitoring seabirds and seals (SC-CAMLR-VII, paragraph 5.30);

- instructions for the preparation of sensitivity analyses (SC-CAMLR-VII, paragraph 5.31); and

- advice on guidelines for the submission, validation, storage, access and analyses of CEMP data.

The results of this work are incorporated in a series of documents presented at this meeting (WG-CEMP-89/12). A paper describing the objectives of CEMP as well as its development and implementation, was prepared by the Secretariat (WG-CEMP-89/5) for Working Group participants as well as other scientists involved in Antarctic research.

4. A provisional agenda and annotations to the provisional agenda for the meeting were circulated to participants in advance of the meeting (WG-CEMP-89/1 and 2). Several suggestions on the restructuring of the agenda were received; the agenda as finally adopted is attached as Appendix 2.

5. A list of the meeting documents is in Appendix 3.

6. The Report was prepared by Drs J. Bengtson (USA), J. Croxall (UK), I. Everson (UK) and E. Sabourenkov (Secretariat).

EVALUATION OF AGREED PREDATOR MONITORING PARAMETERS

Evaluation of Monitoring Sites

7. The lists of monitoring sites within the Integrated Study Regions (SC-CAMLR-VI, Annex 4, Tables 1 and 2) and in network areas were reviewed.

8. Dr Croxall introduced a document (WG-CEMP-89/24) from the SCAR Bird Biology Sub-Committee commenting on CEMP monitoring sites: matters raised therein are dealt with in paragraphs 9 to 15 below.

9. It was agreed to delete the entry for Adelie penguins at Elephant Island because only a few pairs nest there.

10. The suggestion to add Adelie penguins at Esperanza (Hope Bay) as a formal CEMP site was declined on the recommendation of E. Marschoff (Argentina). Since a major construction project (satellite antenna) was about to begin there, it would be inappropriate to add this site to CEMP at the present time. He indicated that research on Adelie penguins at Esperanza, which has been underway since 1985/86, will continue as part of the environmental assessment associated with the construction project. It was noted that both the construction project and the environmental assessment are being conducted jointly by Argentina and the Federal Republic of Germany.

11. For the Prydz Bay region, Magnetic Island in Princess Elizabeth Land was added as a CEMP site for Adelie penguin monitoring because it has been used since 1984 for monitoring some parameters now adopted by the CEMP.

12. References to Adelie penguin and Cape petrel monitoring activities at Pointe Geologie, Adelie Land, were deleted because the monitoring program at this site has stopped as a result of disturbance from construction activities.

13. The status of Budd Coast was changed from a selected to a suggested site for Adelie penguin monitoring.

14. The reference to monitoring of macaroni penguins at Marion and Crozet Islands was deleted because detailed dietary studies have shown that *Euphausia superba* does not form part of these species' diet there.

15. The Rauer Islands (near Davis Station) were added as suggested network monitoring sites for Cape petrels.

16. The suggestion to add monitoring of black-browed albatross at Kerguelen Island to the list was accepted, providing a review of diet data indicates that *E. superba* represents an important prey item for this species in that area. The Working Group agreed that the Convener should write to the Chairman of the SCAR Sub-Committee on Bird Biology to arrange such a review.

17. The changes listed in the preceding paragraphs are recorded in Tables 1 and 2.

18. Table 1 was modified further to include the following key predator species, for which standard methods for routine monitoring have not yet been developed: Cape petrel, Antarctic petrel and crabeater seal.

19. The Working Group reconfirmed that the sites listed in Tables 1 and 2, as amended, are desirable and appropriate for CEMP monitoring activities in the Integrated Study Regions and complementary network areas.

20. Land-based elements of CEMP depend on the long-term acquisition of annual data collected in standardised ways at sites where disturbance of the study species is minimal. Until the sites selected by CEMP for this work are accorded proper protection, there is a high risk of even accidental disturbance being sufficient to seriously affect the quality of the data being collected. This would compromise both the data obtained in any one year and the ability to make unbiased comparison between years.

21. Therefore, the Working Group again calls the attention of the Scientific Committee to the critical need to ensure that monitoring sites receive statutory conservation protection as a matter of priority (see also paragraph 110).

22. Recognising the importance of conducting monitoring studies in undisturbed areas, CEMP investigators are urged to follow research protocols that have been developed with the aim of minimising potential disturbance due to monitoring activities.

Evaluation of Methods

23. The standard methods for monitoring parameters of predatory species were reviewed in the light of Members' experiences in using the instructions, existing data from sensitivity analyses and results of sensitivity analyses conducted in response to the guidelines in WG-CEMP-89/13, (WG-CEMP-89/6, 89/7, 89/21). Argentina provided field data on floppy disk in MS-DOS as suggested in WG-CEMP-89/13. The Working Group agreed that it would be most valuable if these data could be analysed following the guidelines in WG-CEMP-89/13 and the results submitted to the Working Group's next meeting.

24. Based on Members' written comments and the Working Group's discussions, major revision and reorganisation was recommended for most standard methods. The nature of the more important changes is noted below in paragraphs 31 to 49. Because of the urgency of completing this task, it was agreed that a small drafting group (co-convened by Drs Bengtson and Croxall) should meet immediately before the meeting of the Scientific Committee to prepare revised draft methods for circulation to Members at the meeting of the Scientific Committee. The Co-Conveners were asked to consult in advance of this meeting with appropriate colleagues, especially members of the SCAR Group of Specialists on Seals and the Sub-Committee on Bird Biology, in order to clarify matters of detail.

25. It was agreed that each standard method should be presented in the same format. The following headings were suggested:

- species
- parameter
- associated parameters
- aim
- data collection (separate sections for Methods A, B, etc.)
  - mandatory data
  - highly desirable data
  - problems to be considered
  - comments on the method
- data processing and analysis
  - analytical methods
  - interpretation of results
  - problems to be considered
- data reporting
- ancillary studies
- references
- background papers

26. It was suggested that it would be desirable to take into account the presence of predatory species preying on species being monitored. It was agreed that the presence of predators such as skuas, giant petrels, and leopard seals and their estimated impact on predators being monitored should be noted and reported where appropriate.

27. To facilitate comparison of data sets from various sites and years, it was agreed that the five-day sampling periods called for in several of the methods would be standardised. There are 73 five-day periods in each year, with the first of these beginning on 1 January. A schedule of the beginning dates for each of the standard five-day periods will be included in the Handbook of CEMP Standard Methods.

28. The various papers reporting results of sensitivity analyses also provide useful guidance on appropriate sample sizes. Because the variance of different parameters at different sites is unlikely to be identical, investigators should examine their own data to ensure that the recommended sample sizes are adequate at their site. A table (WG-CEMP-89/23) showing relationships between the coefficient of variation (standard error/mean), the statistical power ($1 - \beta$, where β is the probability of accepting a false null hypothesis), and the smallest difference between means to be detected, given a specific α level (where α is the probability of rejecting a true null hypothesis) is provided for general guidance. WG-CEMP-89/7 and especially WG-CEMP-89/6 treat this topic in further detail.

29. As an initial general guide, it was recommended that investigators attempt to design sampling at their sites to detect at least a 10% change in the measured parameter at a 90% confidence level (α and β = 0.1). These decisions reflected recognition of the difficulties of detecting change at the 95% level in biological monitoring data in general (WG-CEMP-89/8, 89/13). Specifying identical values for α and β reflects that, in a conservation context, a failure to detect a change that actually occurred (type II or β error) may be equally, or perhaps more, serious than detecting an apparent, but false, change (type I or α error).

30. It was noted that standard method sheets have not yet been developed for black-browed albatross breeding success and breeding population size, although there has been adequate evaluation of these parameters. Dr Croxall agreed to try to arrange the preparation of draft instructions as soon as possible.

Standard Method A1.1: Adult Penguin Weight on Arrival at Colony

31. Due to the different arrival schedules and sizes of male and female penguins, it is desirable for investigators to be able to determine accurately the sex of penguins being weighed. Measurements of bill dimensions are the most practical way to accomplish this. A discriminant function analysis of bill measurement data from studies such as those conducted by Drs D. Vergani and Z. Stanganelli (Argentina) and Dr W. Trivelpiece (USA) would be helpful in identifying which bill measurements are most useful in determining a bird's sex. Dr Vergani informed the Working Group that he intended to undertake such an analysis and report the results at the next meeting of the Scientific Committee.

32. Although a geographical cline in penguin morphometrics may cause different results for discriminant function analyses of bill measurements among different areas, such analyses can provide a general guideline for the present time. Investigators should be encouraged to conduct the appropriate bill measurements and analyses for birds at their sites.

33. It was agreed that a set of instructions for determining a penguin's sex by bill measurements should be developed and included as an appendix to the Handbook of CEMP Standard Methods. These instructions should include a diagram of the specific locations on the bill where measurements should be taken.

34. The question of whether sampling weights need to be taken during several five-day periods or whether instantaneous samples taken during the time of peak arrival would suffice, was discussed. The nature of inter-relationships between sex, age, arrival data and arrival

weight are uncertain at present and need investigating in future analyses. For now, it is preferable to collect data over several five-day periods. Where birds are sexed, however, it may be sufficient to weigh a larger sample of birds on one or more days. In either case, data on the timing of arrival of the study population (in relation to the first or mean laying date) are highly desirable and a suggested method for monitoring this will be prepared.

Standard Method A2.1: Length of Penguin First Incubation Shift

35. The importance of making a distinction between successful and unsuccessful shift reliefs was emphasised. In addition, the departure and arrival dates for each adult should be determined and recorded separately.

Standard Method A3.1: Annual Trend in Size of Penguin Breeding Population

36. To improve accuracy and to make counting easier, the priority with this parameter should be on breeding groups that are discrete so that the whole group can be counted. For very large colonies, transect counts may be useful to sub-sample the area and the Working Group solicited information on appropriate methods.

37. For areas where there is reliable access to suitable aircraft, the ability to distinguish between breeding and non-breeding birds, and the opportunity to conduct appropriate ground-truth counts, aerial surveys may prove valuable. Members considering such surveys should consult BIOMASS Handbook No. 20 (1982) and are encouraged to develop a draft aerial survey protocol and to submit the proposal to the Working Group for consideration and possible adoption as an addition to this standard method.

38. Because a standard CEMP data collection and reporting format has been adopted, the ISAS Census Card and instructions were deleted from the revised standard method.

Standard Method A4.1: Age-Specific Annual Survival and Recruitment in Penguins

39. The Working Group agreed to change the title of this parameter from ‘Demography’ to ‘Age-Specific Annual Survival and Recruitment’. Because of the complexity and large number of approaches to the analysis of demographic data, it was agreed that standard data

processing, analysis, or reporting protocols would not be developed at this time. Members are requested to inform the Working Group of the recording and analytical protocols currently in use in their programs. These reports will be reviewed by the Working Group and may be used to help develop standard protocols for CEMP at a later date.

Standard Method A5.1: Duration of Penguin Foraging Trips

40. The factors affecting this parameter with penguins are more complex than for the same parameter for fur seals (see paragraph 49). Aspects such as whether there are one or two chicks being fed, whether one or both adults are feeding the chick, and whether attachment of a radio transmitter affects the behaviour of the bird need to be considered. Investigators should note and record the number and fate of chicks as well as the sex and identity of the parents at nests being monitored.

41. Although the general feeling among investigators at present is that models of small transmitters currently being used do not alter substantially penguin behaviour, Members are encouraged to conduct comparative studies of birds with and without instruments. If transmitters have no significant adverse effect on birds' behaviour, it would be desirable to deploy transmitters on both mates at each nest.

Standard Method A6.1: Penguin Breeding Success

42. The results of the sensitivity analyses conducted for this parameter, as well as Members' experiences in the field, indicated a need to revise instructions for this method. The revised data collection protocol for Method A is intended to be clearer, with an emphasis in Method B on identifying the chronology of breeding events within a season.

Standard Method A7.1: Penguin Chick Weight at Fledging

43. The extent and significance of differences in the weights of fledglings sampled in successive five-day periods needs further investigation to determine whether it would be sufficiently accurate to weigh a large sample of chicks on one or more days during the time of peak fledging. In either case, the chronology of fledging in the study population will need to be determined (see paragraphs 34 and 42).

Standard Method A8.1: Penguin Chick Diet

44. E. Marschoff summarised the results of an analysis of Adelie penguin diet (WG-CEMP-89/16), which indicated that a modified protocol is required if one is trying to interpret observed changes in the size-frequency of krill consumed. This standard method was therefore split into two separate parts. The aim of Method A is to characterise the gross composition of prey items in chick diet. Method B will provide a detailed description of prey items taken (e.g. sex, maturity stage and size). Because sensitivity analyses indicated that very large samples would be required to detect anything less than major changes in meal size, measurements of this parameter were accorded a lower priority than previously.

45. The desirability of having a central sorting facility to analyse diet samples (especially for Method B) was discussed. Such a facility might be particularly valuable in standardising analysis of samples taken by various investigators within CEMP. The Working Group recalled that Poland had extended an offer to the Scientific Committee to sort samples of this type (SC-CAMLR-VI, paragraph 16.5). As it becomes clearer to what extent investigators are collecting samples under the Method B protocol, the need and prospect for central processing will be considered further.

Standard Method C1.0: Fur Seal Pup Growth

46. The guidelines for sensitivity analyses indicated the need to test the assumption that pup growth is adequately described by a linear relationship with time. Although data presented to the meeting (WG-CEMP-89/12) and analysed previously (Doidge et al., 1984) support this assumption, Members were encouraged to verify this independently for each of their year's data. A critical comparison of the results of using Methods A and B at the same site would be desirable.

47. Under Method B, simulations of various sampling schedules (i.e. how many pups and frequency of weighing) would help refine existing sampling strategies. Dr Bengtson indicated that US scientists were planning to conduct such simulations.

Standard Method C2.0: Duration of Female Fur Seal Foraging Trips

48. As with many standard methods for penguins, for fur seals it is important to know the chronology of breeding season events. The most desirable chronological reference point for

this parameter is the date of parturition. The value of observations taken without knowing the parturition date for specific females is likely to be lower and requires further assessment to determine whether collection of such data is worth the effort.

49. Further analysis of existing data on foraging trip duration is required in order to develop the most appropriate analytical procedures for providing an overall index of this parameter (see WG-CEMP-89/21).

Data Recording and Analysis

50. The draft forms for recording field data and reporting summary data were reviewed. In many cases, the revisions of data collection methods outlined above required an alteration of the draft data reporting forms.

51. It was agreed that an example of each of the revised forms for reporting summary data would be included in the standard methods booklet (in a small format). These forms would also be available from the Secretariat in a standard format (e.g. A4 size) for the purpose of actually submitting data to the Secretariat.

52. The option of submitting CEMP data either by hard copy on paper or by soft copy on computer diskette or tape should be available. The CCAMLR Data Manager is requested to propose a specific data format for these computer files.

53. Separate reporting sheets or computer files should be used for each parameter of each breeding group of each species. For reporting forms that relate to a single monitoring site the descriptive header data need only be entered at the top of the first page. In this case, however, all succeeding sheets should specify clearly the breeding group, site and year to which the data refer.

54. The Working Group noted the draft forms for recording field data that had been prepared by the Secretariat in response to the request of the Scientific Committee. These provide an approach to the recording of field data which might help field workers in developing their own methods. The Working Group felt that it was not necessary to proceed further with these forms now. Instead, the emphasis should be placed on improving the sheets to report summary data.

Parameter Evaluation

55. Members were requested to undertake sensitivity analyses to permit critical evaluation of the limitations of the present approved parameters (SC-CAMLR-VII, paragraph 5.31). Results of such studies, following approved guidelines (WG-CEMP-89/13[1]) were provided in WG-CEMP-89/6, 89/7 and 89/21. Although these reports were used extensively in revising the standard methods, critical discussion and comparison of the parameters themselves had to be postponed until the next meeting of the Working Group. Members were urged to submit additional evaluations, using the same guidelines, in time for this meeting.

56. No proposals were received for consideration as new standard methods. Table 3 outlines Members' directed research being undertaken to assess the utility of potential predator parameters.

Implications of Existing Predator Monitoring for Information Required for Prey Monitoring

57. The written comments received from Members (WG-CEMP-89/12, SC-CIRC 89/2) were discussed in the context of what prey data were needed for interpreting changes in predator parameters. R. Williams (Australia) had drawn the Working Group's attention to the fact that in some areas where predator breeding sites are at great distance from the margin of the continental shelf, *E. crystallorophias* and *Pleuragramma antarcticum* are more important prey items for predators than *E. superba.*

58. The Scientific Committee at its Seventh Meeting identified as a priority task the development of prey monitoring operations to aid interpretation of predator parameters (SC-CAMLR-VII, paragraph 5.40). The WG-CEMP was therefore asked to identify the characteristics of predators that needed to be taken into account in prey survey design and bring these to the attention of the Working Group on Krill (WG-Krill).

59. The Working Group reviewed each predator parameter discussed in paragraphs 31 to 49 and identified those features which should be taken into account by the WG-Krill when

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1 Please note there is a typographical error in equation [1] in WG-CEMP-89/13. The correct form of the equation is:

$$n \varepsilon 2 (S/\delta)^2 \ \{t_{\alpha,(v)} + t_{2(1-P),[v]}\}^2$$

designing surveys to monitor local distribution and abundance of krill in the Integrated Study Regions. The temporal and spatial scales relevant to monitoring land-based predators using approved standard methods are summarised in Table 4.

60. Table 5 provides detailed information on temporal and spatial scales of predator parameters for different species at sites within the three Integrated Study Regions. Members were requested to provide information specified in this table at the next meeting of the Scientific Committee.

Implications of Existing Predator Monitoring for Information Required from Environmental Monitoring

61. The information required from environmental monitoring as set out in Table 4 of WG-CEMP-89/5, was divided into two categories; environmental conditions that have a direct influence on predators and environmental conditions that have an indirect effect through their impact on the prey.

62. It was agreed that environmental features that have a direct influence on predators (e.g. sea ice, local weather) should be the emphasis at land-based monitoring sites. These features are listed in Table 6.

63. Environmental features that have an indirect effect on predators (e.g. water circulation, productivity) should be considered in association with the distribution and abundance of prey. With respect to *Euphausia superba*, the Working Group noted that these features would be taken into account by the WG-Krill.

PROGRESS AND ACHIEVEMENTS OF DIRECTED RESEARCH ON PREDATORS

Species and Parameters Which May Have Potential for Monitoring

64. A summary of directed research programs being undertaken by Members in the 1987/88 and 1988/89 seasons was included in WG-CEMP-89/5. This summary was updated to include programs for the 1989/90 season for those countries represented at the meeting (Table 7). Information from other Members participating in CEMP will be sought before the next meeting of the Scientific Committee.

65. Dr Bengtson informed the Working Group of a research project conducted jointly by the USA and Sweden during the 1988/89 season on satellite telemetry of crabeater seals. Although the technology is still in the developmental stage (the transmitter was capable of sending only location data), it is expected that new instruments will soon allow the transmission of data on seal diving behaviour and activity patterns.

66. Dr Croxall reported on the successful deployment on grey seals in the northern Atlantic of devices for transmitting via satellite data on location, diving behaviour and activity patterns. This system will also have application for seals in the Antarctic. This project is being carried out by the Sea Mammal Research Unit (UK), under a contract through UNEP to the SCAR Group of Specialists on Seals.

Analysis of Interdependence Between Monitored Predators and Prey

67. The Scientific Committee suggested that the WG-CEMP investigate the nature of relationships between the indices derived from predator monitoring and congruent data on prey abundance (SC-CAMLR-VII, 5.22 (iii)). Explicit questions on this topic were addressed to Members (SC-CAMLR-VII, 5.43). No responses were received. This was probably due to the fact that these requests were made before the Working Group had finished specifying precisely what data should be collected for monitoring prey and predators. Now that these requirements have been clarified, Members are urged to respond to the questions in SC-CAMLR-VII, paragraph 5.43 before the next meeting of the Working Group.

Background for Monitoring Studies

68. The summary table from WG-CEMP-89/5 on directed research on methods to interpret changes in monitored predator parameters was updated (Table 8). Further information on the other Members' activities in this area will be sought before the next meeting of the Scientific Committee.

69. Scientists from Chile and the United States are undertaking collaborative research at Seal Island (South Shetland Islands) to link the results of pelagic prey and environmental monitoring with data obtained from land-based monitoring of predators. These efforts are focussed on the foraging areas of Antarctic fur seals, chinstrap and macaroni penguins, and the biological and physical features with which they are associated. A pilot study was conducted in 1987/88, a

full scale program started in 1988/89 and work is planned to continue in 1989/90. A preliminary report of this collaborative study was presented at the meeting (WG-CEMP-89/22).

PREY

Consideration of Relevant Reports

Scientific Committee

70. At its Seventh Meeting the Scientific Committee had noted (SC-CAMLR-VII, paragraph 5.40):

'A priority task within CEMP should be to develop prey monitoring operations to aid interpretation of predator parameters. Bearing in mind earlier discussion, the Scientific Committee recommended the following procedure:

(i) the Working Group for CEMP should identify the characteristics of predators that need to be taken into account in prey survey design;

(ii) simulation studies are likely to be particularly useful in generating advice on survey design, frequency and duration. Work including modelling krill distribution and behaviour is being undertaken within the Krill CPUE Simulation Study. The Working Group for CEMP should consult with the Working Group on Krill to develop this, and other relevant studies, to provide appropriate advice;

(iii) the Working Group on Krill should arrange the production of standard method sheets for the technical aspects of prey surveys.'

These points had been raised in correspondence with the Convener of the WG-Krill by the Convener of the WG-CEMP (WG-CEMP-89/12).

71. The Reports of the Krill CPUE Simulation Workshop and WG-Krill were discussed.

Krill CPUE Simulation Study

72. The Report of the Workshop on the Krill CPUE Simulation Study (SC-CAMLR-VIII/89/3 Rev. 1) which was held from 7 to 13 June 1989 in La Jolla, USA was presented by Dr Everson. He drew attention to components which were of direct relevance to the CEMP.

73. The Workshop had demonstrated that fine-scale data derived from commercial fishing operations could be effectively used for plotting the distribution of fishable concentrations of krill. An example (WG-CEMP-89/10) of such a distribution map, prepared by Dr S. Nicol (Antarctic Division, Australia) is shown in Figure 1.

74. Examination, during the Workshop, of the distribution of fishable krill concentrations revealed two important points:

- they often occur in the same place for some time and that these locations show some year to year consistency; and

- they tend to occur close to the shelf break.

These points were discussed further by the WG-Krill (SC-CAMLR-VIII/4 Rev. 1, paragraphs 43 to 45).

75. The major outcome of the Krill CPUE Workshop was the development of a Composite Index of krill abundance. This combined an index of krill density within fishable concentrations, which had been derived from Japanese catch and effort data, with an index of the number of krill concentrations in an area, derived from USSR catch and effort data.

76. Additional information on the distribution and size of fishable krill concentrations may be obtained by examination of echosounder chart rolls from past and future commercial and research cruises.

Working Group on Krill (WG-Krill)

77. The First Meeting of the WG-Krill was held from 14 to 20 June 1989 in La Jolla, USA. Dr Everson presented the report of the meeting (SC-CAMLR-VII/89/4 Rev. 1).

78. Acoustics and net sampling were seen, by the WG-Krill, as being the best methods currently available for estimating krill distribution and abundance. The Working Group had considered these, and other methods, at length but had not proceeded as far as providing standard methods protocols.

79. The WG-Krill was unable to proceed with providing specifications for prey monitoring surveys as they relate to interpreting predator parameters being monitored because the WG-CEMP had not met subsequent to the Seventh Meeting of the Scientific Committee to define the important characteristics of predators that need to be addressed by such surveys.

80. Recognising that much information on krill distribution was potentially available from fishery data the WG-Krill assigned a high priority to analysis of fine-scale commercial catch and effort data.

81. WG-Krill had noted that historically about 90% of catches have been taken from particular locations in Statistical Area 48. WG-Krill agreed that the current total catch of krill was unlikely to be having much impact on the circumpolar krill population. However, WG-Krill was unable to say whether or not the present level of krill catch was having an adverse impact on local predators.

82. The WG-Krill also suggested that the simulation models used in the Krill CPUE Simulation Study might be adapted for use in identifying important parameters to study predator/prey interactions in the context of CEMP (SC-CAMLR-VIII-89/4 Rev. 1, paragraph 96).

Prey Monitoring

83. The location of commercial krill fishing activity can be readily derived from the fine-scale catch and effort data supplied to the Secretariat. This information is important in assessing the status of krill within the Integrated Study Regions and Subarea 48.2. The Working Group was unable to state what time and space scales would be the most appropriate for the collection of these data and therefore recommended that, for the time being, these data

should continue to be collected on a haul by haul basis and sent to the Secretariat according to the current system.

84. Dr Everson introduced his paper WG-CEMP-89/9 in which he made some analyses of fine-scale catch data for krill on a monthly basis. One of the important outcomes of these analyses was the demonstration that quite intensive krill fishing took place in the Antarctic Peninsula Integrated Study Region within the foraging range of predators at a time when they may be susceptible to the depletion of krill by the fishery (Figure 2, January-February graph).

85. Dr Vergani reported that Argentine scientists attempted to relate krill catches in CCAMLR Subarea 48.2 with fur seal abundance ashore during January to April at the South Orkney Islands (WG-CEMP-89/15). This analysis would be improved by using fine-scale catch data.

86. Although krill is a key prey component for CEMP, it was agreed that it is not the sole prey species to be incorporated into the program. However, at this stage it was felt best to concentrate activity towards krill and incorporate studies on other components such as *Euphausia crystallorophias* and *Pleuragramma antarcticum* in the future. There still remains the need for more information on these species and further research on aspects relevant to CEMP was encouraged.

87. The spatial and temporal scales within which information on prey is required have been specified in paragraphs 58 to 61. It was emphasised that, although prey monitoring would be concentrated within the time and space scales specified, further information was required from the vicinity of the predator foraging areas and also in advance of the critical period. The precise areas and times of interest will differ from site to site and should be set so as to provide general information on the dynamics of krill around a particular site and detailed information from within the critical foraging areas.

88. The Working Group requested the WG-Krill to consider questions of survey design as they would be better able to take account of sampling constraints in designing suitable surveys.

89. During the intersessional period, Dr K. Sherman (USA) had begun to coordinate studies of net sampling efficiency but was now unable to continue. The Working Group thanked Dr Sherman for his efforts in this study over several years. The Working Group agreed that the study should continue and noted that the WG-Krill had considered the topic. The problems of determining the sampling efficiency of nets are likely to be different for each

prey species. Dr R. Holt (USA) agreed to take over the coordination role and liaise with the Convener of the WG-Krill regarding studies on krill.

Implications for Predator Studies

90. The Working Group noted that a substantial proportion of recent krill harvesting had regularly occurred within the foraging ranges of breeding predators being monitored by CCAMLR, and particularly so within the Antarctic Peninsula and South Georgia Integrated Study Regions.

91. Members were therefore asked to give high priority to synthesising existing published and unpublished data on breeding population size, activity-specific energy budgets, diet and foraging range to provide preliminary estimates of the krill requirements of predators in each Integrated Study Region, at least during the predators' breeding seasons.

92. The Working Group also noted the importance of improving these estimates and encouraged Members to continue and/or initiate research programs aimed at improving current data on:

- population size and distribution, both ashore and at sea;
- activity and energy budgets ashore and especially at sea;
- delimitation of foraging ranges, including at different times of year;
- the characteristics of krill aggregations exploited by predators, including the size and reproductive status of krill eaten; and
- the feeding strategies and tactics employed by krill predators.

SPECIFICATION OF ENVIRONMENTAL DATA

93. As noted above in paragraph 61, environmental data was considered in two categories: environmental parameters which have a direct affect on the predators (these were set down in Table 6) and those which affect predators indirectly through their effects on the distribution and abundance of prey. This latter category is now being discussed in detail by the WG-Krill.

94. In 1987, the Scientific Committee agreed that remote sensing using satellites would play an increasing role in the acquisition of key environmental data. In particular, attention was drawn to the application of satellite imagery data on sea-ice distribution and its characteristics as well as to the possibility of production of global-scale maps of phytoplankton concentrations and distribution with data acquired by the Coastal Zone Colour Scanner (CZCS). Individual scientists who participated at the 1987 Meeting of the Working Group made arrangements to submit their data to Dr G. Feldman (NASA, Goddard Space Flight Centre, Washington, DC, USA) for comparison with relevant satellite-derived data sets.

95. In his reply to a letter from the Convener, Dr G. Feldman advised that data derived from the CZCS, amounting to some 70 000 individual images, are now available 'on-line'. In addition the system allows researchers to view the data on regional scales and to generate movie loops to monitor how ocean conditions changes over the time period of interest. The system will also have an ability to assess and display *in situ* observations such as temperature, salinity, nutrients and chlorophyll profiles that were obtained from the National Oceanographic Data Center. Members were invited to investigate the utility and value of these data for their CEMP national programs.

96. The members of the Working Group expressed their thanks to Dr Feldman for his advice on how to access the data.

97. It was noted that many of the environmental parameters identified (SC-CAMLR-VI, Annex 4, Table 6), particularly satellite derived data, will also be important for the interpretation of the predator parameters. The Working Group noted that standard methods for these parameters are likely to be available through such organisations as WMO, IMO, IOC. The Secretariat was therefore requested to compile a list of standard methods used by such international organisations as might be applicable to CEMP.

RELEVANCE OF CEMP TO CCAMLR MANAGEMENT STRATEGIES

98. The Scientific Committee had indicated a desire for advice from its Working Groups on how information from CEMP might be used in the management of fisheries in the Convention Area (SC-CAMLR-VII, paragraph 5.44).

99. More specifically, the Scientific Committee had also noted that as part of analyses investigating the statistical properties of parameters being modelled, their power to detect

differences and trends and their relationships with estimates of krill abundance/availability, it was also logical to consider the adequacy of the data and estimates to meet the requirements of CCAMLR in distinguishing between natural variations in prey abundance and those induced by fishery activity (SC-CAMLR-VII, paragraph 5.22). The Scientific Committee had commented that this would probably require evaluating how information from the Ecosystem Monitoring Program might be used by CCAMLR in the management of fisheries (SC-CAMLR-VII, paragraph 5.23).

100. The Working Group for the Development of Approaches to Conservation of Antarctic Marine Living Resources (WG-DAC) had requested advice from the Scientific Committee on the ability of the CEMP to detect changes in ecological relationships and to recognise the effects of simple dependencies between species, including distinguishing between natural fluctuations and those induced by fisheries (WG-CEMP-89/20).

101. This meeting of the WG-CEMP had already noted the considerable progress made in the definition of the accuracy and precision of estimates of predator parameters being monitored (reference to paragraphs 31 to 49 above). These are essential first steps in proceeding to address the questions posed in paragraphs 99 and 100 above.

102. It was thought helpful to state that the Working Group was giving particular consideration to the adequacy and application of its predator monitoring program in terms of:

(i) detecting changes in indices of the status and/or reproductive performance of seabirds and seals;

(ii) relating these changes to indices of prey abundance and availability (to predators);

(iii) using predator indices, on the basis of relationships between predators and prey developed above, as a measure of food availability (to the predators); and

(iv) distinguishing between changes in food availability that result from commercial harvesting and changes due to natural fluctuations in the biological and physical environment.

103. It was noted that the Working Group does not think that predator indices will provide a useful index of prey stock abundance, but does think they might give a useful index of prey availability to predators.

104. In responding to the request from WG-DAC, specifically addressing application (iv) above, the Working Group noted the complexity of this topic, including the possible need for modelling studies, which meant that advice could not be provided at present and that further work and discussion will be needed.

105. The Working Group noted that Members were already considering these broader questions (e.g. WG-CEMP-89/8). These developments were welcomed and it was agreed that more critical discussion of this topic would be undertaken at the next meeting of the Working Group.

COORDINATION OF RESEARCH IN INTEGRATED STUDY REGIONS

106. The Convener, in his report to the 1988 Meeting of the Scientific Committee, drew attention to the possible need for coordination of research between various groups conducting monitoring studies within the Antarctic Peninsula Study Region. The Convener subsequently drew this matter to the attention of the relevant Members and solicited suggestions on how best to proceed.

107. Based upon the replies from Argentina, Brazil and Chile it was agreed that the overlap between CEMP and other programs at a particular breeding site is a potentially serious problem. There is therefore a need for coordination among countries working in the same region.

108. Mr A. Mazzei (Chile) informed the Working Group that there is an overlap of scientific effort on Ardley Island (S. Shetlands) where scientists of three countries carry out research on the same penguin colonies. Chilean scientists conduct research in accordance with CEMP. The research of the other countries is apparently not related directly to CEMP objectives. It was agreed that the matter of coordination of the research effort on Ardley Island should be brought to the attention of the Scientific Committee.

109. These circumstances illustrate problems that would be resolved by the Commission's development of appropriate conservation and management procedures for its CEMP sites (see also paragraphs 20 and 21).

110. The Working Group noted the benefits of cooperative programs undertaken by Members in support of CEMP. Since the inception of the program there have been numerous productive collaborations between Members in the Integrated Study Regions. These

activities have included a variety of joint monitoring and directed research projects relating to aspects of prey, predators and environmental features.

CCAMLR/IWC SPONSORED WORKSHOP ON THE FEEDING ECOLOGY OF SOUTHERN BALEEN WHALES

111. The Executive Secretary informed the Working Group that the Scientific Committee of the IWC had decided not to proceed with the Workshop at this time because of the present heavy workload associated with the Comprehensive Assessment of Whale Stocks. The Secretary of the IWC has written to inform CCAMLR of this decision and the proposal from the IWC to consider holding the Workshop in 1991.

OTHER BUSINESS

112. The following items were considered under this agenda item:

- CEMP data reporting;
- interactions with the WG-Krill;
- information from the Convener of the BIOMASS Executive on a planned BIOMASS Colloquium;
- promotion of awareness of the CEMP program in the CCAMLR community and outside it; and
- next meeting of WG-CEMP.

CEMP Data Reporting

113. The Working Group considered the advice of the Secretariat and the Convener of the Working Group regarding submission, validation, storage, access and analyses of ecosystem monitoring data (WG-CEMP-89/14). The Group agreed with the following guidelines.

114. The Secretariat will circulate to the CCAMLR Members the appropriate reporting forms. The Data Manager of the CCAMLR Secretariat will specify the necessary protocols for the submission of data on computer compatible media should any Member wish to use this means of data submission.

115. The CCAMLR Data Manager will contact scientists in national laboratories to ascertain the precautions taken as data are collected and processed prior to their submission to CCAMLR and develop standard procedures to be employed by the CCAMLR Data Centre for checking and logical validation of the summarised data.

116. It was noted that the conditions under which fisheries data held by the Secretariat might be released to Members were outlined under SC-CAMLR-VII, paragraph 3.3. Because of the special value of long-term data sets derived from scientific studies, it was agreed that data access provisions pertaining to CEMP data needed to be strengthened in addition to the conditions described in SC-CAMLR-VII, paragraph 3.3.

117. The Working Group recognised two important points: (a) CEMP data submitted to the CCAMLR Data Centre should be freely available for analysis and preparation of papers for use within the CCAMLR Commission, Scientific Committee, and Working Groups; and (b) the originators/owners of the data should retain control over any use of their data outside of CCAMLR.

118. The Working Group expressed its understanding that papers prepared for meetings of the Commission, Scientific Committee, and Working Groups are not public documents that can be cited or used in the preparation of papers to be published outside of CCAMLR. Furthermore, because inclusion of papers in the 'Selected Scientific Papers' series or any other of the Commission's or Scientific Committee's publications constitutes formal publication, permission to publish papers prepared for meetings of the Commission, Scientific Committee and Working Groups must be obtained from the originators/owners of the data and authors of papers.

119. Subject to agreement on CEMP data access protocols (paragraph 118), it was recommended to start the submission of data to the CCAMLR Data Centre on those species and parameters for which standard methods and reporting forms had been approved by the WG-CEMP. Summarised data only will be reported at present. The Working Group emphasised that it was important for national agencies to retain all raw data in a readily accessible format for future reference if necessary.

120. It was agreed that data should be reported retrospectively for those periods in which Members had indicated that they were monitoring approved parameters using standard methods in the Integrated Study Regions or at network sites.

121. The Working Group agreed that, initially at least, 30 September would be a reasonable annual deadline for the submission of data.

Interactions with the Working Group on Krill (WG-Krill)

122. The Working Group noted the close links which had been established with the WG-Krill both through the instructions of the Scientific Committee in the establishment of the WG-Krill (SC-CAMLR-VII, paragraph 2.26) and by individual scientists participating in both groups. As a result, the WG-Krill has now taken over aspects of the monitoring of prey. The WG-CEMP emphasised the importance of continuing close contact between the groups to ensure that the needs of the CEMP program for prey monitoring were being met.

BIOMASS Colloquium

123. Dr Everson informed the Working Group that the BIOMASS Executive was planning a BIOMASS Colloquium to be held in September 1991. In preparation for this Colloquium a series of workshops is planned on various subjects, some of which are of interest to CCAMLR. Members are encouraged to submit proposals for analyses to the conveners of the workshops.

Promotion of the Awareness of the CEMP Program

124. Dr S.N. Dwivedi (India) suggested to the Working Group that awareness of the CEMP is possibly limited to countries whose experts have participated in its elaboration and whose scientists carry out research within CEMP. It was suggested that it would be very useful to promote awareness of the program among other CCAMLR Members and other countries.

125. This promotion may be undertaken by means of wider distribution of CCAMLR publications dealing with the CEMP development and implementation. In particular, the Secretariat had prepared a very useful summary on CEMP (WG-CEMP-89/5) which might be distributed outside the CCAMLR. The same might be done with the CEMP Standard

Methods and other documents. Some scientists might be also invited to give lectures in various countries.

126. Another direction for the activities of the Working Group might be by helping national programs in support of CEMP activities by advising on the status of ecosystem monitoring methodology, technology and equipment.

Next Meeting of WG-CEMP

127. The Working Group reviewed progress made at the meeting and felt that there were a number of issues that would benefit from further consideration during the next year and agreed that an intersessional meeting in 1990 would be desirable.

ADOPTION OF THE REPORT

128. The Report of the meeting was adopted.

CLOSE OF THE MEETING

129. Dr Kerry informed the Working Group that he felt it was time to step aside as Convener. The Working Group noted that Dr Kerry had been Convener for the past six years. During this period the Working Group had been established and had made good progress in developing the Monitoring Program. This had been a difficult task, breaking much new ground and requiring a great degree of cooperation among participating members. The Working Group placed on record its appreciation for the very significant part Dr Kerry had played in getting CEMP started.

130. The Convener thanked all participants and the Secretariat for their cooperation and efforts not only in making this meeting a success but in supporting him, through his period as Convener. He thanked the Argentine Government for hosting this meeting and Enrique Marschoff and Dr Daniel Vergani for making the detailed arrangements for it.

131. The Convener closed the meeting.

Table 1: Sites within the Integrated Study Regions at which monitoring of predators has been or should be initiated now.

	Site	Species	Critical Period
1.	ANTARCTIC PENINSULA REGION		
	Anvers Island (Palmer Archipelago)		
	(south coast)	Adelie penguin	Nov–Jan
	Livingston Island (S. Shetland Is)		
	(north coast)	Chinstrap penguin	Nov–Feb
	(north coast)	Antarctic fur seal	Dec–Mar
	King George Island (S. Shetland Is)		
	(north ? and south coasts)	Adelie penguin	Oct–Jan
	(north and south coasts)	Chinstrap penguin	Nov–Feb
	(north coast)	Antarctic fur seal	Dec–Mar
	Elephant Island (S. Shetland Is)		
	(west coast)	Chinstrap penguin	Nov–Feb
	(west coast)	Macaroni penguin	Dec–Feb
		Cape petrel*	Dec–Feb
	Seal Island (S. Shetland Is)	Chinstrap penguin	Nov–Feb
		Macaroni penguin	Dec–Feb
		Antarctic fur seal	Dec–Mar
		Cape petrel*	Dec–Feb
	Sea Ice areas	Crabeater seal*	Jan–Dec
2.	SOUTH GEORGIA REGION		
	Bird Island	Fur seal	Dec–Mar
		Macaroni penguin	Dec–Feb
		Black-browed albatross*	Oct–Apr
3.	PRYDZ BAY REGION		
	Mac. Robertson Land	Adelie penguin	Oct–Jan
		Antarctic petrel*	Nov–Feb
	Magnetic Island, Princess Elizabeth Land	Adelie penguin	Oct–Jan
		Antarctic petrel*	Nov–Feb
		Cape petrel*	Nov–Feb
	Sea Ice areas	Crabeater seal*	Jan–Dec

* Species for which standard methods have not yet been developed.

Table 2: Sites selected or suggested for monitoring studies to complement the programs in the three main Integrated Study Regions.

Species	Sites
Adelie penguin	NW Ross Sea (Cape Hallett and Cape Adare) Budd Coast* Ongul Islands (near Syowa Station) Shepard Island* Signy Island, South Orkney Islands Laurie Island, South Orkney Islands
Chinstrap penguin	Signy Island, South Orkney Islands South Sandwich Islands* Bouvet Island*
Macaroni penguin	Bouvet Island* Kerguelen Island*
Cape petrel	Signy Island, South Orkney Islands Rauer Islands (near Davis Station) Elephant Island (South Shetland Islands)
Antarctic fur seal	Bouvet Island * Kerguelen Island
Crabeater seal	Weddell Sea* Amundsen and Bellingshausen Seas*
Black-browed albatross**	Kerguelen Island

* Suggested sites
** Subject to diet data

Table 3: Summary of Members' directed programs on assessing the utility of potential predator parameters.

Parameter	Areas[(a)] from which data are available for analysis/ evaluation	Members' Research Activity					
		Undertaken 1987/88		Undertaken 1988/89		Proposed for 1989/90	
		Analysis of existing data	Acquisition of new data	Analysis of existing data	Acquisition of new data	Analysis of existing data	Acquisition of new data
Penguins[(b)]							
- Macaroni incubation shift	4,5,11,14	UK(11)	UK(11)	UK(11)	Brazil (2)	Brazil (2)	Brazil (2)
- Macaroni weight prior to moult	2,15,14,4,5?	Brazil (2) UK(4)	Brazil (2)	Brazil (2)	Brazil (2)	Brazil (2)	Brazil (2)
- At-sea diving behaviour and activity patterns (A,C,M)	2,4,6	UK (3,C)(4,M)	Australia (6,A) USA (2,C,M)	Australia (6,A) USA (2,C,M)	Australia (6,A) UK (4,M) USA (2,C,M)	Australia (6,A) UK (4,M) USA (2,C,M)	Australia (6,A) USA (2,C,M)
- Weight recovery during incubation (A,C,M)	4,6		Australia (6,A)	Australia (6,A)	Australia (6,A)	Australia (6,A)	Australia (6,A)
- Survival (A,C,M)	1,2,6,11	Australia (6,A) Brazil (2)	Australia (6A) Brazil (2) Chile (12) UK (4,M)	Australia (6,A) Brazil (2) Chile (12) UK (4,M)	Australia (6,A) Brazil (2) Chile (12 UK (4,M) USA(2,C;11,A)	Australia (6,A) UK (4,M) USA(2,C;11,A)	Australia (6,A) UK (4,M) USA(2,C;11,A)
- Chick growth rate	2,11		USA(2,C;11,A)	USA(2,C;11,A)	USA(2,C;11,A)	UK (4,M) USA(2,C;11,A)	USA(2,C;11,A)
FLIGHTED SEABIRDS							
Black-browed albatross							
- Breeding population size	4,9?,15	UK (4)	UK (4)	UK (4)	UK (4)		UK (4)
- Breeding success	4,9?,15	UK (4)	UK (4)		UK (4)		UK (4)
- Duration of foraging trips	4						UK (4)
- Activity budget at sea	4				UK (4)		UK (4)
- Prey characteristics/ diet	4						UK (4)
Antarctic/Cape petrel							
- Breeding success	3,6,8,11,2	Chile (11) Brazil (2)	Brazil (2) UK (3)	Chile (11) Brazil (2)	Chile (11) Brazil (2)		UK (3)
- Chick weight at fledging	2,6,8,11	Brazil (2) Chile (11)	Brazil (2) USA (2)	Brazil (2) Chile (11)	Brazil (2) Chile (11)	Brazil (2) USA (2)	Brazil (2)

Table 3 (continued)

Parameter	Areas[(a)] from which data are available for analysis/ evaluation	Members' Research Activity					
		Undertaken 1987/88		Undertaken 1988/89		Proposed for 1989/90	
		Analysis of existing data	Acquisition of new data	Analysis of existing data	Acquisition of new data	Analysis of existing data	Acquisition of new data
Antarctic/Cape petrel (continued)							
- Prey characteristics/ diet	2,6,8,11	Australia (6) Brazil (2)	Australia (6) Brazil (2)	Australia (6) Brazil (2) Chile (11)	Australia (6) Brazil (2) Chile (11)	Brazil (2)	Brazil (2)
Fur seals							
- Reproductive success	4,2	UK (4)	UK (4) USA (2)		UK (4) USA (2)		UK (4) USA (2)
- Prey characteristics/ diet	4,2	UK (4) USA (2)	USA (2)		UK (4) USA (2)	USA (2)	UK (4) USA (2)
- At-sea diving behaviour and activity pattern	2,4	UK (4) USA (2)	USA (2)	USA (2)	UK (4) USA (2)	UK (4) USA (2)	UK (4) USA (2)
- Indices of physiological condition	11	Chile (11)		Chile (11)	Chile (11)		UK (4)
- Fine structure of teeth	4	UK (4) USA (4)			UK (4)	UK (4)	UK (4)
Crabeater seal							
- Reproductive rates	2,3,8,10-12				USA (11)	USA (11,12)	
- Age at sexual maturity	2,3,8,10-12				USA (11)	USA(10,11,12)	
- Cohort strength	2,3,8,10-12			USA(10,11,12)	USA (11)	USA(10,11,12)	
- Indices of physiological condition	11,12				USA (11)	USA (11,12)	
- Instantaneous growth rate	11,12						
- Prey characteristics/ diet	11,12				USA (11)	USA (11)	
- At-sea diving behaviour and activity pattern	11,12	USA (11,12)		USA (11,12)		USA (11,12)	USA (11,12)

Table 3 (continued)

Parameter	Areas[(a)] from which data are available for analysis/ evaluation	Members' Research Activity					
		Undertaken 1987/88		Undertaken 1988/89		Proposed for 1989/90	
		Analysis of existing data	Acquisition of new data	Analysis of existing data	Acquisition of new data	Analysis of existing data	Acquisition of new data
Minke whales							
- Reproductive rate	13,1	Japan (completed)	Japan	Japan	Japan		
- Age of sexual maturity	13,1	(completed)					
- Cohort strength	13,1	(under way)	Japan	Japan	Japan		
- Analyses of existing data:							
- stomach contents	13,1	(almost (completed)	Japan	Japan	Japan		
- blubber thickness	13,1	(completed)	Japan	Japan	Japan		
- density/patchiness	13,1	(under way)	Japan	Japan	Japan		
- school size	13,1	(completed)	Japan	Japan	Japan		
- Feeding activity patterns	13,1	(under way)	Japan	Japan	Japan		

[(a)] Areas:

1. Ross Sea	5. Macquarie Island	9. Crozet Island	13. Mainly from the Indian Ocean (IWC Areas III and IV)
2. South Shetland Is	6. Davis Station	10. Balleny Is	14. Marion Is
3. S. Orkney Is	7. Syowa Station	11. Antarctic Peninsula	15. Kerguelen Is
4. S. Georgia Is	8. Dumont d'Urville Sea	12. Weddell Sea	

[(b)] Penguin species: A - Adelie, C - Chinstrap, M - Macaroni/Royal

Table 4: Approximate spatial scales relevant to monitoring approved predator parameters at land-based sites. These scales should be considered when designing prey surveys in the Integrated Study Regions.

Standard Method		Temporal Scale			Spatial Scale	
		Time of Year Measured	Duration of Observation Period	Parameter Integration Period[1]	Foraging Range/ Area	Depths of Predator Foraging[2]
A1	Arrival weight	Oct – Nov	20 days	May – October	CCAMLR Subarea	20 – 30 m (max 150 m)
A2	Shift length	Nov – Dec	5 – 15 days	First shift 30 + days Second shift 10 days	100 – 500 km 25 – 50 km	20 – 30 m (max 150 m) 20 – 30 m (max 150 m)
A3	Population size	Oct – Nov	1 day periods	Previous 12 months	CCAMLR Subarea	20 – 30 m (max 150 m)
A4	Demography	Oct – Mar	6 months	1 + years	CCAMLR Subarea (adults) CCAMLR Area (juveniles)	20 – 30 m (max 150 m)
A5	Foraging trips	Jan – Feb	Samples throughout field season	1 – 3 days*	25 – 50 km	20 – 30 m (max 150 m)
A6	Breeding success	Nov – Mar	Counts throughout field season	Nov – March	25 – 150 km	20 – 30 m (max 150 m)
A7	Fledging weight	Jan – Mar	20 days	Jan – March (chick rearing period)	25 – 50 km	20 – 30 m (max 150 m)
A8	Chick diet	Dec – Feb	Samples throughout field season	1 – 3 days	25 – 50 km	20 – 30 m (max 150 m)
C1	Pup growth	Dec – Mar	Samples throughout field season	Dec – Mar	50 – 100 km	Mean 30 m, max 150 m
C2	Foraging trips	Dec – Mar	Samples throughout field season	2 – 5 days*	50 – 100 km	Mean 30 m, max 150 m

[1] Timespan over which parameter potentially integrates prey abundance/availability

[2] Diurnal changes in the vertical diving depths of penguins and fur seals should be taken into account when designing prey surveys

Table 5: Summary of temporal and spatial scales relevant to monitoring of land-based predators, using approved standard methods in each of the Integrated Study Regions.

Parameter[1]	Integrated Study Region	Species	Time of Year of Measurement[2]	Duration of Measurement[3]	Integration Period[4]	Foraging Range/Area[5]	Foraging Depth Mean	Foraging Depth Max	Comments
	Prydz Bay	Adelie							
	Antarctic Peninsula	Adelie							
		Chinstrap							
		Macaroni							
		Fur seal							
	South Georgia	Macaroni							
		Fur seal							

1 Use separate sheet for each parameter
2 Calendar date of start and finish
3 In days, months etc
4 Timespan over which parameter potentially integrates prey abundance/availability
5 Range in km; area in terms of CCAMLR Area, Subarea etc while measuring parameter

Table 6: Environmental parameters which may have a direct effect on the predator parameters being monitored.

Feature	Parameter	Period
Sea ice cover viewed from the colony	Ice type and cover	2-3 weeks before arrival, until finish weighing of birds
Sea ice within Integrated Study Region	Ice type and cover	2-3 weeks before arrival, until finish weighing of birds
Local weather	Synoptic observations on temperature, precipitation, pressure Wind speed and direction	2-3 weeks before arrival to end of season
Snow cover in colony	Depth and extent	Throughout field season

Table 7: Summary of Members' CEMP activities on monitoring approved predator parameters.

Method Sheet Number	Parameter	Species: A-Adelie penguin M-Macaroni penguin C-Chinstrap penguin F-Fur seal				Country	Site name/ Integrated Study Region/ Network Site	Site Location	Year Started
		A	M	C	F				
A1.1	Weight on arrival at breeding colonies	X				Australia	Magnetic Is Davis Station/ Prydz Bay	68°33'S 77°54'E	1983/84
		X				Argentina	King George Is Stranger Point S. Shetland Is	62°14'S 58°30'W	1987/88
		X				Argentina	Laurie Is Mossman Peninsula S. Orkney Is	60°45'S 44°44'W	1987/88
			X	X		Brazil	Elephant Is S. Shetland Is Ant. Peninsula	61°04'S 55°21'W	1990/91
			X			UK	Bird Is/ South Georgia	52°00'S 38°02'W	1988/89
A2.1	Length of the first incubation shift	X				Australia	Magnetic Is Davis Station/ Prydz Bay	68°33'S 77°54'E	1983/84
		X				Argentina	King George Is Stranger Point S. Shetland Is	62°14'S 58°30'W	1987/88
			X	X		Brazil	Elephant Is S. Shetland Is Ant. Peninsula	61°04'S 55°21'W	1990/91
A3.1	Annual trends in breeding population size	X				Australia	Magnetic Is Davis Station/ Prydz Bay	68°33'S 77°54'E	1983/84
		X				Argentina	King George Is Stranger Point S. Shetland Is	62°14'S 58°30'W	1987/88
			X	X		Brazil	Elephant Is S. Shetland Is/ Ant. Peninsula	61°04'S 55°21'W	1986
		X		X		Chile	Ardley Is S. Shetland Is/ Ant. Peninsula	62°11'8"S 58°55'W	1982
		X				Japan	Syowa Station/ Network site	69°00'S 39°30'E	1970
			X			UK	Bird Is/ South Georgia	52°00'S 38°02'W	1975/76
			X		X	UK	Signy Is/ Network site	60°43'S 45°38'W	1978/79
			X	X		USA	Seal Is S. Shetland Is/ Ant. Peninsula	60°59.5'S 55°24.5'W	1987/88
		X				USA	Anvers Is. Palmer Station/ Ant. Peninsula	64°06'S 64°03'W	1987/88

Table 7 (continued)

Method Sheet Number	Parameter	Species: A-Adelie penguin M-Macaroni penguin C-Chinstrap penguin F-Fur seal				Country	Site name/ Integrated Study Region/ Network Site	Site Location	Year Started
		A	M	C	F				
A4.1	Demography			X		Chile	Ardley Is S. Shetland Is/ Ant. Peninsula	62°11’8”S 58°55’W	1982
			X	X		Brazil	Elephant Is S. Shetland Is/ Ant. Peninsula	61°04’S 55°21’W	1986
			X	X		USA	Seal Is S. Shetland Is/ Ant. Peninsula	60°59.5’S 55°24.5’W	1987/88
		X				USA	Anvers Is Palmer Station Ant. Peninsula	64°06’S 64°03’W	1987/88
A5.1	Duration of foraging trips	X				Australia	Magnetic Is Davis Station/ Prydz Bay	68°33’S 77°54’E	1983/84
				X		USA	Seal Is S. Shetland Is/ Ant. Peninsula	60°59.5’S 55°24.5’W	1987/88
A6.1	Breeding success success	X				Australia	Magnetic Is Davis Station/	68°33’S 77°54’E	1983/84
		X				Argentina	King George Is Stranger Point S. Shetland Is	62°14’S 58°30’W	1987/88
			X	X		Brazil	Elephant Is S. Shetland Is/ Ant. Peninsula	61°04’S 55°21’W	1986
				X		Chile	Ardley Is S. Shetland Is/ Ant. Peninsula	62°11’8”S 58°55’W	1982
			X			UK	Bird Is/ South Georgia	52°00'S 38°02'W	1975/76
		X		X		UK	Signy Is/ Network site	60°43'S 45°38'W	1978/79
			X	X		USA	Seal Is S. Shetland Is/ Ant. Peninsula	60°59.5’S 55°24.5’W	1987/88
		X				USA	Anvers Is Palmer Station/ Ant. Peninsula	64°06’S 64°03’W	1987/88
A7.1	Fledging weight	X				Australia	Magnetic Is Davis Station/ Prydz Bay	68°33'S 77°54'E	1983/84
		X				Argentina	King George Is Stranger Point S. Shetland Is	62°14’S 58°30’W	1987/88

Table 7 (continued)

Method Sheet Number	Parameter	Species: A-Adelie penguin M-Macaroni penguin C-Chinstrap penguin F-Fur seal				Country	Site name/ Integrated Study Region/ Network Site	Site Location	Year Started
		A	M	C	F				
A7.1	(continued)	X				Argentina	Laurie Is Mossman Peninsula S. Orkney Is	60°45’S 44°44’W	1987/88
			X	X		Brazil	Elephant Is S. Shetland Is/ Ant. Peninsula	61°04’S 55°21'W	1986
			X			UK	Bird Is/ South Georgia	52°00'S 38°02'W	1988/89
				X		USA	Seal Is S. Shetland Is/ Ant. Peninsula	60°59.5’S 55°24.5’W	1987/88
		X				USA	Anvers Is Palmer Station/ Ant. Peninsula	64°06’S 64°03’W	1987/88
A8.1	Diet	X				Australia	Magnetic Is Davis Station/ Prydz Bay	68°33’S 77°54’E	1983/84
		X				Argentina	King George Is Stranger Point S. Shetland Is	62°14’S 58°30’W	1987/88
		X				Argentina	Laurie Is Mossman Peninsula S. Orkney Is	60°45’S 44°44’W	1987/88
			X	X		Brazil	Elephant Is S. Shetland Is/ Ant. Peninsula	61°04’S 55°21’W	1986
				X		Chile	Ardley Is S. Shetland Is Ant. Peninsula	62°11’8”S 58°55’W	1982
			X			UK	Bird Is/ South Georgia	52°00'S 38°02'W	1985/86
				X		USA	Seal Is S. Shetland Is/ Ant. Peninsula	60°59.5’S 55°24.5”W	1987/88
		X				USA	Anvers Is Palmer Station/ Ant. Peninsula	64°06’S 64°03’W	1987/88
C1.0	Pup Growth				X	Chile	Cape Shirreff/ Ant. Peninsula	62°28’S 60°47”W	1984/85
					X	UK	Bird Is/ South Georgia	52°00'S 38°02'W	1972/73 1977/78
					X	USA	Seal Is S. Shetland Is Ant. Peninsula	60°59.5’S 55°24.5’W	1987/88

Table 7 (continued)

Method Sheet Number	Parameter	Species: A-Adelie penguin M-Macaroni penguin C-Chinstrap penguin F-Fur seal				Country	Site name/ Integrated Study Region/ Network Site	Site Location	Year Started
		A	M	C	F				
C2.0	Cow foraging/ attendance cycles				X	Chile	Cape Shirreff/ Ant. Peninsula	62°27’S 60°47’W	1987/88
					X	UK	Bird Is/ South Georgia	52°00'S 38°02'W	1978/79
					X	USA	Seal Is S. Shetland Is Ant. Peninsula	60°59.5’S 55°24.5W	1987/88

Table 8: Summary of Members' directed research on predator parameters required to provide essential background information needed to interpret changes in monitored predator parameters.

Research Topic	Countries Proposing Directed Research	
	Programs Currently Underway	Programs Proposed to Commence (season of initiation)
PENGUINS		
- Foraging areas	Chile Japan (1988/89) USA	Australia (1989/90)
- Energy requirements		
- Seasonal movements		
- Relationships between monitored parameters and physical environment (e.g. distribution and structure of sea ice and frontal systems)	Chile UK (Frontal systems) USA	Australia (1989/90) UK (1992/93)
FUR SEALS		
- Local abundance/population structure	Argentina, Chile, UK, USA	Brazil
- Energy requirements	UK	
- Foraging areas	Chile, USA	UK (1992/93)
- Relationships between monitored parameters and physical environment (e.g. distribution and structure of sea ice and frontal systems)	Chile (partial), USA	
CRABEATER SEALS		
- Foraging areas	USA	
- Energy requirements		
- Stock discreteness/seasonal movements	USA	
- Relationships between monitored parameters and physical environment (e.g. distribution and structure of sea ice and frontal systems)	USA	
MINKE WHALES		
- Survey abundance (IWC/IDCR[a])	Japan	
- Relationships between monitored parameters and physical environment (e.g. distribution and structure of sea ice and frontal systems)	Japan	

[a] International Whaling Commission/International Decade of Cetacean Research

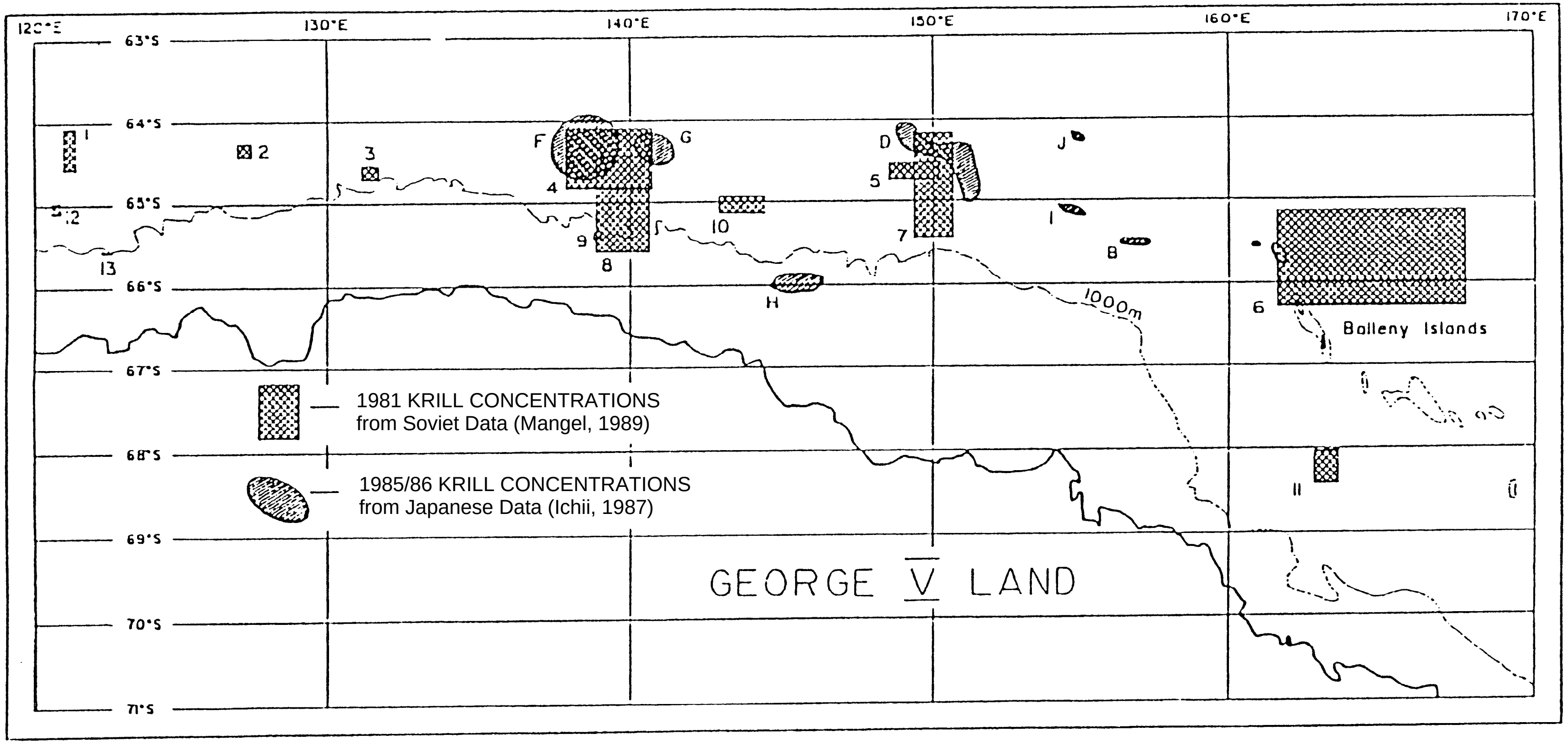

Figure 1: Distributions of krill concentrations based on USSR and Japanese fisheries data (WG-CEMP-89/10).

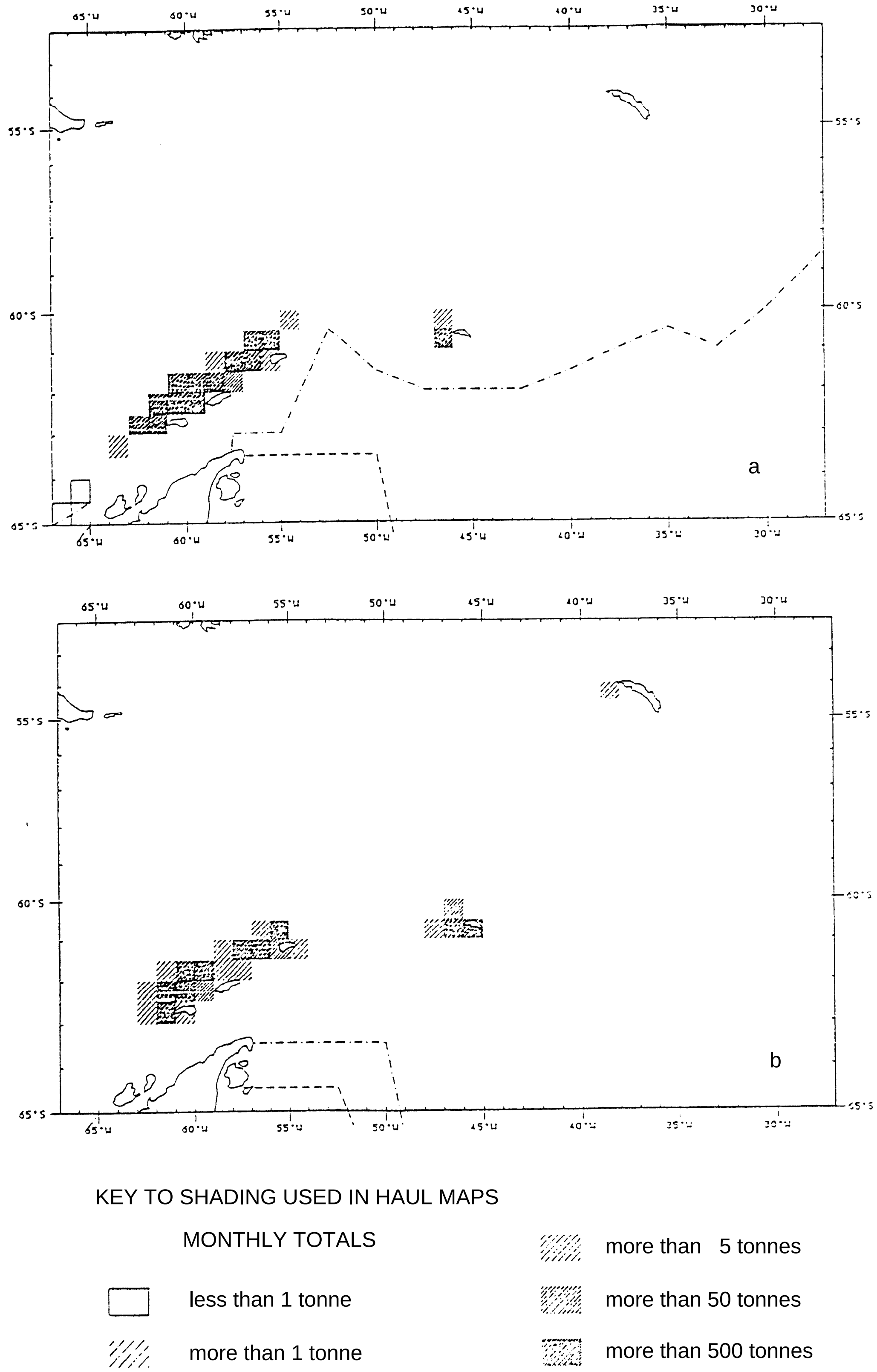

Figure 2: Distribution of commercial catches of krill in the South-West Atlantic in (a) January and (b) February 1988 (WG-CEMP-89/9).

APPENDIX 1

LIST OF PARTICPANTS

Working Group for the
CCAMLR Ecosystem Monitoring Program (WG-CEMP)
(Mar del Plata, Argentina, 23-30 August 1989)

J. BENGTSON	National Marine Mammal Laboratory National Marine Fisheries Service 7600 Sand Point Way NE Seattle, WA 98115 USA
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SECRETARIAT:

D. POWELL (Executive Secretary) E. SABOURENKOV (Science Officer) G. NAYLOR (Secretary)	CCAMLR 25 Old Wharf Hobart, Tasmania Australia

APPENDIX 2

AGENDA

Working Group for the
CCAMLR Ecosystem Monitoring Program (WG-CEMP)
(Mar del Plata, Argentina, 23 –30 August 1989)

1. Opening of the meeting

2. Adoption of agenda

3. Evaluation of agreed predator monitoring parameters
   (i) Evaluation of sites, 5.29 (i)*
   (ii) Evaluation of methods, 5.29 (iii and iv)
   (iii) Data recording and analyses, 5.30 (i-iii)
   (iv) Parameter evaluation, 5.31
   (v) Implications of existing predator monitoring for information required for prey monitoring
   (vi) Implications of existing predator monitoring for information required from environmental monitoring

4. Progress and achievements of directed research on predators
   (i) Species and parameters which may have potential for monitoring as indicated in SC-CAMLR-VI, Annex 4, Table 4
   (ii) - Analysis of interdependence between sampling method and results of monitoring and changes of krill abundance
   - Evaluation of availability of data and information supplied under requests set out in paragraph 5.43 (i-iv)
   (iii) Directed research which provide background for monitoring studies, (SC-CAMLR-VI, Annex 4, Table 8).

* Numbers after each agenda item refer to the paragraphs in the 1988 Report of the Scientific Committee (SC-CAMLR-VII)

5. Prey monitoring
   - (i) Methods of estimating prey parameters
   - (ii) Spatial and temporal scales on which the prey parameters need to be monitored
   - (iii) Survey design

6. Specification of environmental data
   - (i) Data as set out in SC-CAMLR-VI, Annex 4, Table 6
   - (ii) Imagery data, 5.38
   - (iii) Standard method sheets, 5.36

7. Relevance of CEMP to CCAMLR management strategies, 5.44

8. General
   - (i) Coordination of research in Integrated Study Regions, 5.41
   - (ii) Review of relevant sections of reports of other intersessional meetings:
     - Krill CPUE Simulation Study
     - Working Group on Krill
     - CCAMLR/IWC Sponsored Workshop on the Feeding Ecology of Southern Baleen Whales

9. Other business

10. Adoption of the report

11. Closing of the meeting.

APPENDIX 3

LIST OF DOCUMENTS

Working Group for the
CCAMLR Ecosystem Monitoring Program (WG-CEMP)
(Mar del Plata, Argentina, 23-30 August 1989)

Meeting Documents:

WG-CEMP-89/1	Provisional Agenda
WG-CEMP-89/2	Annotated Provisional Agenda
WG-CEMP-89/3	List of Participants
WG-CEMP-89/4	List of Documents
WG-CEMP-89/4 Rev. 1	List of Documents (Revised 23 August 1989)
WG-CEMP-89/5	Development of the CCAMLR Ecosystem Monitoring Program 1982–1989 (Secretariat)
WG-CEMP-89/6	On the Power to Detect Changes Using the Standard Methods for Monitoring Parameters of Predatory Species (Boveng and Bengtson, USA)
WG-CEMP-89/7	Sensitivity Analysis for Predatory Parameters. CCAMLR Ecosystem Program in response to SC-CAMLR-VII, Paragraph 5.22 (i) and (ii) (Whitehead, Australia)
WG-CEMP-89/8	Use of Indices of Predator Status and Performance in CCAMLR Fishery Management Strategies (Croxall, UK)

WG-CEMP-89/9	Krill fishing: An Analysis of Fine-Scale Data Reported to CCAMLR (Everson and Mitchell, UK)
WG-CEMP-89/10	Map of Distribution of Krill Concentrations Off George V Land (Nicol, Australia)
WG-CEMP-89/11	Sensitivity Analyses for Monitoring Parameters of Predatory Species (Sander, Brazil)
WG-CEMP-89/12	Member's Responses to Various Topics Addressed by the Convener and the Secretariat During the Preparation of the WG-CEMP Meeting
WG-CEMP-89/13	Instructions for the Preparation of Sensitivity Analyses (Secretariat and the Convener of the Working Group on CEMP)
WG-CEMP-89/14	Advice Regarding Submission, Validation, Storage, Access and Analysis of Ecosystem Monitoring Data (Secretariat and the Convener of the Working Group on CEMP)
WG-CEMP-89/15	Activities of Argentina into the Ecosystem Monitoring Program - CEMP (Stanganelli, Vergani, Aguire and Coria, Argentina)
WG-CEMP-89/16	The Use of Penguin Stomachal Contents for the Simultaneous Study of Prey and Predator Parameters (Marschoff and González, Argentina)
WG-CEMP-89/17	Discrimination Between Larval and Juvenile Specimens of *Euphausia superba* from Gut Contents (Marschoff and Ravaglia, Argentina)
WG-CEMP-89/18	An Experimental Approach to the Analysis of Zooplankton Escape Reactions and Patchiness (Marschoff, Díaz and Schloss, Argentina)

WG-CEMP-89/19 Replaced by document SC-CAMLR-VIII/4 Rev. 1

WG-CEMP-89/20 Letter from the Convener of WG-DAC to the Chairman, Scientific Committee

WG-CEMP-89/21 Methods for Detecting Annual Changes in Fur Seal Foraging Trip Duration
(Boveng and Bengtson, USA)

WG-CEMP-89/22 Foraging Areas for Fur Seals and Penguins in the Vicinity of Seal Island, Antarctica
(Bengtson and Eberhardt, USA and Chile)

WG-CEMP-89/23 Reference tables for the CEMP Sensitivity Analysis
(Croxall, UK)

WG-CEMP-89/24 Comments on CEMP Monitoring Sites
(Scientific Committee on Antarctic Research Working Group on Biology, Bird Biology Subcommittee, 22 and 28 August 1988, Hobart, Australia)

Reference Documents:

DOIDGE, D.W., J.P. CROXALL and C. RICKETTS. 1984. Growth rate of Antarctic fur seal *Arctocephalus gazella* pups at South Georgia. J. Zool. Lond. 203: 87-93.

WALTERS, C.J. and J.S. COLLIE. 1988. Is research of environmental factors useful to fisheries management? Can. J. Fish. Aquat. Sci. 45: 1848-1854.

SC-CAMLR-VIII/3 Rev. 1. Report of the Workshop on the Krill CPUE Simulation Study, Southwest Fisheries Centre, La Jolla, USA, 7–13 June 1989.

SC-CAMLR-VIII/4 Rev. 1. Report of the First Meeting of the Working Group on Krill, Southwest Fisheries Centre, La Jolla, California, 14–20 June 1989.

SC-CAMLR-VII/5. CCAMLR Ecosystem Monitoring Program. Monitoring Prey. I. Everson (UK).

ANNEX 8

SCIENTIFIC COMMITTEE BUDGET FOR 1990
AND FORECAST BUDGET FOR 1991

SCIENTIFIC COMMITTEE BUDGET FOR 1990
AND FORECAST BUDGET FOR 1991

The Scientific Committee is proposing to undertake three major activities involving expenditure by the Commission in the coming year. The total expenditure for 1990 is A$106 500. The expenditure forecast for 1990 in last year's budget was A$83 700.

JOINT CCAMLR/IWC WORKSHOP ON THE FEEDING ECOLOGY OF SOUTHERN BALEEN WHALES

2. The Workshop has been postponed until 1991. However, it is the recommendation of both the IWC and the Scientific Committee that the Workshop should proceed. A figure of A$22 000 has been included in the forecast for 1991.

MEETING OF THE WORKING GROUP ON KRILL (WG-KRILL)

3. This WG-Krill was set up at the Sixth Meeting of CCAMLR and had its inaugural meeting during the 1988/89 intersessional period. The Scientific Committee has agreed that the WG-Krill should meet to further develop its tasks during the 1989/90 intersessional period. This meeting will be held in Europe, the specific venue and timing have not yet been decided.

The estimated costs are:

	1990	1991
Translation of report	13 500	
Publication and postage of report	2 400	
Administration	2 000	
	A$17 900	A$19 000

MEETING OF THE FISH STOCK ASSESSMENT WORKING GROUP (WG-FSA)

4. A meeting of this Working Group will be necessary in the coming year to assess the status of finfish stocks in the Convention Area. The meeting will be held at the CCAMLR Headquarters.

The estimated costs are:

	1990	1991
Translation of report	20 000	
Publication of report	1 000	
Computing	1 000	
Administration	1 000	
	A$23 000	A$24 400

MEETING OF THE WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM (WG-CEMP)

5. A meeting of this Working Group is necessary during the 1990 intersessional period to consider a number of substantive topics particularly addressing protocols for predator and prey monitoring, experimental design, data analysis techniques and program coordination. Close coordination between the proposed WG-Krill and this WG-CEMP meeting is advised so that expertise available at the WG-Krill may be utilised by the WG-CEMP as regards prey monitoring. The meeting will be held in Europe on a date to be decided but closely following the krill meeting. During 1989 the WG-CEMP developed and published ‘Standard Methods Sheets for Monitoring Predators’. These will be updated in 1990 to take account of refinements and additional information.

The estimated costs are:

	1990	1991
Translation of report	13 500	
Publication and postage of report	2 400	
Administrative costs	2 000	
Reprint Standard Methods Sheets	3 000	
	A$20 900	A$22 200

TRAVEL FOR SCIENTIFIC COMMITTEE PROGRAM

6. During the next year the Scientific Committee recommends that Secretariat staff and the Convener of the WG-FSA undertake the following activities in order to give necessary support to the program:

Convener, WG-FSA:

- attend meeting with the Data Manager and the Chairman to plan for the meeting of the WG-FSA.

Data Manager:

- attend the working group meetings,

- attend a meeting with the Convener and the Chairman to plan for the meeting of the WG-FSA, visit data centres involved with data similar to that to be collected in the CEMP and discuss analytical techniques relevant to the CEMP data base.

Science Officer:

- attend and provide support for the meeting of WG-CEMP.

Secretary:

It is recommended that a CCAMLR secretary attend the meetings of WG-Krill and the WG-CEMP to facilitate the preparation of the working papers and reports for consideration and adoption by the Working Groups at the time of their meetings. This is extremely important if the report of the WG-Krill meeting is to be available for consideration by the WG-CEMP. The WG-CEMP meeting is expected to be held immediately following the meeting of WG-Krill.

The estimated costs are:

1990	1991
A$37 700	A$31 100

CONTINGENCY

The Contingency is calculated as 7% of all items.

	1990	1991
The estimates are:	A$7 000	A$8 300
Sub Total	A$106 500	A$127 000
Less Drawings from the Norwegian Contribution Special Fund	20 500	2 000
	A$86 000	A$125 000

SUMMARY SCIENTIFIC COMMITTEE BUDGET

	1990 A$	1991 A$
Joint CCAMLR/IWC	0	22 000
Working Group on Krill	17 900	19 000
Working Group on Fish Stock Assessment	23 000	24 400
Ecosystem Monitoring Program	20 900	22 200
Travel for Scientific Committee Program	37 700	31 100
Contingency	7 000	8 300
Sub-Total	106 500	127 000
Less Drawings from the Norwegian Contribution Special Fund	20 500	2 000
Total from Commission Budget	A$86 000	A$125 000