REPORT OF THE WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM

(Seoul, Republic of Korea, 16 to 23 August 1993)

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INTRODUCTION

1.1 The Eighth Meeting of the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP) was held at the Hoam Faculty House, Seoul National University, Seoul, Republic of Korea from 16 to 23 August 1993. The meeting was chaired by the Convener, Dr J.L. Bengtson (USA).

1.2 The Convener opened the meeting and welcomed participants. On behalf of the Working Group, he expressed thanks to both the Government of the Republic of Korea and the Korea Ocean Research and Development Institute for inviting the Working Group to hold its meeting in Seoul.

1.3 Scientists from 13 Member countries, namely, Argentina, Australia, Chile, Germany, Italy, Japan, the Republic of Korea, Norway, Russian Federation, South Africa, Sweden, UK and USA, participated in the meeting. The Working Group noted its disappointment that, due to unavoidable delays, Dr T. Øritsland (Norway) was unable to join the meeting until near the end of the session when most agenda items had been closed.

1.4 The Convener welcomed the increased participation in the WG-CEMP meeting. Indeed, he noted that, following his letter to scientists from four Member countries encouraging wider participation in CEMP (SC-CAMLR-XI, Annex 7, paragraph 3.10), Germany had nominated Dr J. Plötz, from the Alfred-Wegener Institute for Polar and Marine Research, to attend the meeting. However, the Working Group noted with regret the absence from the meeting of scientists from Brazil, France and New Zealand. A further discussion of this issue is provided in paragraphs 3.3 and 3.4.

ADOPTION OF THE AGENDA

2.1 The Provisional Agenda was introduced and discussed. Three additional topics were proposed for consideration under "Other Business", namely, "SO-GLOBEC", "SCAR APIS Program" and "Exploratory Fisheries". With these changes, the revised Agenda was adopted.

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

2.3 The report was prepared by Drs D. Agnew (Secretariat), P. Boveng (USA), J. Croxall (UK), B. Fernholm (Sweden), K. Kerry (Australia) and E. Sabourenkov (Secretariat).

REVIEW OF MEMBERS' ACTIVITIES

3.1 During the 1992/93 season Members continued to be actively involved in the collection of data using CEMP Standard Methods and in other research in support of CEMP. A total of 52 documents were submitted for consideration at the meeting. A summary of Members' activities is given in Tables 1, 2 and 3.

3.2 Scientists present at the meeting provided brief reports on their recent and prospective activities as part of CEMP. A compilation of these reports is attached at Appendix D.

3.3 The Working Group noted that important work of direct relevance to CEMP is being conducted by scientists from Brazil, France, New Zealand and Poland. Unfortunately, these scientists were unable to participate in the meeting or to contribute data.

3.4 The Convener advised the Working Group that, as requested (SC-CAMLR-XI, Annex 7, paragraph 3.10), he had written to 17 scientists in France, Germany, New Zealand and South Africa during the intersessional period apprising them of WG-CEMP's activities and encouraging their participation. Responses received indicated an interest in becoming involved, but noted that funding and scheduling difficulties were hampering this. The Working Group asked the Convener to continue to encourage participation from these and other relevant scientists.

3.5 In order to facilitate correspondence between scientists of various countries working on CEMP-related studies, the Secretariat was requested to compile a list of names and addresses of relevant scientists. This list should be made available to all interested scientists on request to the Secretariat.

3.6 The Working Group recommended that a short newsletter, describing major results and conclusions of its work, similar to the Krill Newsletter currently being circulated to scientists in the SCAR and CCAMLR communities, should be prepared and distributed annually following the completion of the Scientific Committee meeting. This newsletter should be distributed as widely as possible to all scientists involved in CEMP-related studies. An initial distribution list should comprise the current membership of WG-CEMP, WG-Krill (and others on the Krill Newsletter mailing list), the Scientific Committee, the SCAR Subcommittee on Bird Biology and the SCAR Group of Specialists on Seals. A call for further names and addresses should be included in each newsletter.

MONITORING PROCEDURES

Predator Monitoring

Sites and Species

4.1 The Delegations of Chile and the USA submitted a draft management plan for the protection of Cape Shirreff and the San Telmo Islands, South Shetland Islands (SSSI No. 32), as a site included in the CCAMLR Ecosystem Monitoring Program (WG-CEMP-93/5). According to the procedure agreed at the last meeting (SC-CAMLR-XI, Annex 7, paragraph 4.5) it had been reviewed by the subgroup on sites which consisted of Dr P. Penhale (USA) and Dr Kerry. They reported that the proposal was in an acceptable form and that only minor editorial changes were suggested. The Working Group recommended that, subject to these being made, the Scientific Committee should consider the draft management plan. The authors expressed their intention to incorporate the proposed changes and submit a revised management plan to the Scientific Committee.

4.2 No other proposals were received for the protection of CEMP sites or for the inclusion of new species for monitoring.

Development of Monitoring Procedures

4.3 The Convener drew attention to the procedures which the Working Group had agreed at its previous meeting for evaluating proposals for new monitoring methods, modifying existing procedures and the incorporation of new species (SC-CAMLR-XI, Annex 7, paragraphs 4.5 to 4.7). Members are required to submit written proposals, together with supporting documentation, to the Convener in advance of the meeting for consideration by the subgroup on practical aspects of monitoring methods. Such proposals will only be considered at a meeting of WG-CEMP if they are received by the Convener for circulation and review no later than three months prior to the start of the WG-CEMP meeting. The subgroup is responsible for reviewing such proposals and presenting its recommendations to the Working Group for appropriate action.

4.4 No proposals had been received by the due date for consideration at this meeting of WG-CEMP.

Field Research Procedures

4.5 Papers were tabled relating to three topics of relevance to the work of WG-CEMP in undertaking predator monitoring:

(i) relevant to Existing Standard Methods for approved Predator Parameters;

(ii) relevant to the development of Standard Methods for Potential Predator Parameters; and

(iii) relevant to the Potential Impact on Predators of using certain Field Procedures.

Developments Relevant to Existing Standard Methods

Method A4 - Age-specific Recruitment and Survival in Penguins

4.6 Data deriving from detailed demographic research on Adélie penguins at Admiralty Bay, King George Island had been contributed to the exercise examining functional relationships between predators and prey (SC CIRCs 93/13 and 93/18). A standard method already exists for the collection of field data for this parameter but not for the analysis and submission of these data. Based on the methods used to produce the contribution referred to above, Dr W. Trivelpiece (USA) agreed to provide a draft text on these topics for consideration by the methods and statistical subgroups and by the Data Manager before the next meeting of WG-CEMP.

Method B3 - Age-specific Recruitment and Survival in Black-browed Albatross

4.7 The paper on the 17-year study of the population dynamics of black-browed albatrosses at Bird Island, South Georgia (WG-CEMP-93/6) includes details of the methods of data collection and analysis. An outline standard method already exists for this parameter in respect of data collection; however, the details of appropriate techniques for data analysis and presentation of results would be a useful addition to the standard method. Dr Croxall agreed to provide a draft text for consideration by the methods and statistics subgroup and the Data Manager prior to the next meeting of WG-CEMP.

Method C1 - Duration of Foraging Trips by Female Antarctic Fur Seals

4.8 Dr Croxall noted that WG-CEMP-93/10 included data and analyses indicating that the relationship between this parameter and fur seal reproductive performance and environmental variation suggests that measurement of foraging trip duration is a particularly valuable part of the CEMP suite of monitoring parameters.

Method C2 - Pup Growth

4.9 For some time WG-CEMP has been requesting a comparison of the two procedures for obtaining indices of fur seal pup growth (serial individual or cross-sectional population weighings). A relevant comparison, from Bird Island, South Georgia, is provided in WG-CEMP-93/9. In this study, some 100 pups were weighed every 7 to 14 days from birth to weaning and the results (for four years) compared with appropriate data from a 15-year data series on birth mass and three subsequent samples of 100 pups weighed at monthly intervals. Growth rates from cross-sectional data were higher in every year (and significantly so for male pups in all years and for female pups in two years). Variances were slightly lower for cross-sectional data. The differences between methods may reflect repeated handling of the serially-weighed pups but other sources of bias are possible. In studies of fur seal pup growth, the two procedures cannot be used interchangeably.

Standard Methods for Potential Predator Parameters

Foraging Performance

4.10 At its 1991 meeting, WG-CEMP discussed the desirability of assessing the extent to which data on at-sea behaviour (and especially those available through the use of time-depth recorders (TDRs) on penguins and seals) might be developed into appropriate indices for incorporation into CEMP.

4.11 At that stage, the intention was to try to convene a workshop to review data, identify suitable indices and propose standard methods for collecting and processing such data.

4.12 However, at its meeting in 1992, WG-CEMP agreed that further progress should await the results of a workshop on the analysis of data from TDRs being held in Alaska in September 1992 and the completion of work by UK scientists on selection of sampling intervals for TDR studies and on delimitation of foraging bouts and derivation of foraging indices (SC-CAMLR-XI, Annex 7, paragraph 4.18).

4.13 The paper by Dr I. Boyd (UK) (WG-CEMP-93/14) on the influence of the sampling interval on the analysis and interpretation of TDR data shows that the sampling interval affects the detection of dives and statistics of diving behaviour; e.g., an increase in the sampling interval from 5s to 15s resulted in 20% of dives of fur seals being unrecognised, a 38% increase in mean maximum dive depth, and a 29% increase in duration of surface interval. He concluded that critical comparisons should be confined to data collected using similar data intervals.

4.14 The study of foraging bouts and indices referred to in paragraph 4.12 above, which UK scientists will complete in time for circulation at the Scientific Committee meeting in 1993, provides a new method for the delimitation of foraging bouts (intended to supersede the use of log-frequency and probit analysis methods) and compares foraging performance of Antarctic fur seals over five years of studies using a variety of indices.

4.15 A related paper by Dr Y. Mori (Japan) (WG-CEMP-93/17), described the use of TDRs in recording diving bouts (determined by log-frequency analysis) and related characteristics for chinstrap penguins.

4.16 The report of the Alaska Workshop (WG-CEMP-93/18) covered many topics of considerable relevance to WG-CEMP, particularly on dive and bout classification and statistical analysis of TDR data.

4.17 In his summary to this report, the Convener of the Workshop, Dr J.W. Testa, concluded that a set of cohesive analysis protocols would not be sufficient for the variety of data being collected with TDRs and related instruments. Rather, each research project will require unique data analyses that suit the specific research questions, the behaviour of the species under consideration and the required technical approach.

4.18 Noting this, the Working Group reaffirmed that WG-CEMP should try to develop its own set of guidelines and methods for the use of TDRs to provide standardised sets of data which could be used to derive indices of diving and/or foraging performance.

4.19 Variables that might be relevant in a consideration of potential indices include duration of foraging trip, time spent in searching and feeding, number of diving bouts, duration of bouts and dive characteristics such as duration and depth.

4.20 The Working Group agreed to address this topic by arranging an intersessional collation and exchange of information, reviewing this at its next meeting and then deciding on whether or not it would be appropriate to seek to hold a workshop on this topic, perhaps in 1995. The Working Group recommended that the Scientific Committee should consider providing funds to support such a workshop.

4.21 To proceed with this initiative the Working Group agreed:

(i) that attention should initially be restricted to Adélie, chinstrap, gentoo and macaroni penguins, Antarctic fur seals and crabeater seals; and

(ii) that during the next intersessional period scientists who have TDR data from any of these species should be asked by the Secretariat, in consultation with the Convener of WG-CEMP, to send to Dr Boveng as soon as possible summaries of the nature and content of such data (with particular attention to the availability of data on the variables listed in paragraph 4.19), together with copies of published and unpublished reports and papers on these data and notification of relevant work in progress.

Dr Boveng agreed to collate the information for review by the Working Group at its next meeting.

Potential Impact of Field Procedures on Predators

4.22 Dr Kerry presented WG-CEMP-93/19, which provided information on the effects of flipper bands, implanted electronic tags, gastric lavage and external instrument attachments on Adélie penguins at the Béchervaise Island CEMP monitoring site. The attachment of satellite tracking devices during the incubation period and on several consecutive trips during chick rearing increased foraging trip duration and reduced breeding success. Attachment for a single foraging trip post-hatching caused no significant increase in foraging trip duration. No reduction in fledging rates of chicks from nests of stomach-lavaged birds was detected over two breeding seasons. The return rate for birds banded as breeding adults was 63% in each of two successive years for the same population. There was no evidence of either tag or band loss over one season for birds carrying both marking systems.

4.23 Dr Trivelpiece presented the draft report (WG-CEMP-93/20) of a "Workshop on Researcher-Seabird Interactions" which was held from 14 to 18 July 1993 in Minnesota, USA. The 28 participants addressed six major areas of concern:

(i) banding and marking techniques;
(ii) diet sampling and stomach lavage;
(iii) instrument attachment, external technologies;
(iv) instrument implantation, internal technologies;
(v) physiological studies; and
(vi) general disturbance.

4.24 Key points arising from the meeting are summarised below:

(i) flipper bands, even if properly applied by trained operators, may affect the swimming and hence foraging performance of the penguin and cause mortality, particularly of fledglings;

(ii) band loss is known to occur but is difficult to estimate. The use of implanted electronic tags in banded birds is now providing the possibility to determine this and, if used alone, providing a method of identification which should not affect performance. However, new research is needed to develop alternative ways of identifying which birds are carrying the tags;

(iii) diet sampling through stomach lavage is considered a safe procedure if conducted by skilled and experienced operators. Further, current studies have found no measurable effects on penguin chick growth and mortality providing lavaging is performed once per season and on only one member of an adult pair (see also WG-CEMP-93/19); and

(iv) the effects of instrument packages attached to the birds' feathers by tape or glues are minimised by streamlining and placing them low on the back. Packages do affect the performance of birds, at least initially.

4.25 The Working Group noted the importance and timeliness of the Workshop and thanked the US for hosting the meeting. Since the report contained much that impinged directly on monitoring methods and the likelihood of biasing the data, the Working Group asked the *ad hoc* subgroup on monitoring methods to further evaluate the final report, expected to be available by 1 December 1993, and to recommend what modifications might be made to the CEMP Standard Methods.

4.26 The Working Group strongly encouraged Members to take note of the report as a basis for assessing the impact of their own field research practices on the species being monitored. Further, where a number of research programs by different operators (national groups) are being undertaken in a region, they should consider developing a control site at which to measure the impact of their research.

4.27 The Working Group noted that implanted electronic tags were now being used by a number of Members but there were no national registration schemes or experience requirements for operators, as in present bird banding schemes. It was suggested that such schemes were urgently required and noted that SCAR was being asked to address this requirement. It was recommended that Members maintain a national register, similar to that of a banding register, of tags used and should ensure field staff are properly trained in implanting techniques. As a minimum requirement, a record should be kept of date, place, species, tag brand, the location on the bird where the tag is inserted, tag number and band number of all birds tagged.

Prey Monitoring

Krill

4.28 Mr D. Miller (South Africa) (Convener of WG-Krill) recalled that methods for monitoring krill in support of CEMP predator monitoring had been developed by WG-Krill's Subgroup on Survey Design (SC-CAMLR-X, Annex 7, paragraphs 4.55 to 4.68). He noted that no changes to these methods were required at present.

Other Species

4.29 Lic. R. Casaux (Argentina) presented a paper (WG-CEMP-93/26) which showed the diet composition of piscivorous blue-eyed shags at Duthoit Point, Nelson Island, South Shetland Islands, based on an analysis of 50 regurgitated casts (also referred to as pellets) collected in February 1991. The fish component of the diet was comprised of *Harpagifer antarcticus*, *Notothenia neglecta*, *Nototheniops nudifrons* and *Trematomus newnesi*.

4.30 In speaking to a companion paper (WG-CEMP-93/25), Lic. Casaux indicated there was very good agreement between the fish species identified from otoliths in the shags' regurgitated casts and those species regularly sampled with trammel nets in the same area. He noted also that juveniles of the commercially-fished species of *Notothenia rossii* and *Notothenia gibberifrons* had declined sharply over the period from 1983 to 1990, whereas *N. neglecta*, which has similar ecology but was not subjected to fishing, remained stable. *N. rossii* and *N. gibberifrons* were not found in the casts of the blue-eyed shag.

4.31 These observations led Lic. Casaux to suggest that observations on the diet of the blue-eyed shag might be used to monitor the abundance of littoral fish populations in the South Shetland Islands.

4.32 Dr Croxall noted the considerable potential of the method suggested by Lic. Casaux. Some previous studies, similar to those reported in WG-CEMP-93/26, had identified significant discrepancies between the fish eaten by shags and the otoliths recovered in pellets (e.g., Johnstone *et al.*, 1990, *Bird Study* 37: 5-11). Before the use of pellets could be adopted in a CCAMLR Standard Method, it was likely that evidence, from appropriate validation studies, would be required to demonstrate that similar problems do not occur with blue-eyed shags in the Antarctic.

4.33 The proposal in paragraph 4.31 raised two important issues. The first related to the actual use of the blue-eyed shag to monitor the relative abundance of juvenile fish. The Working Group agreed that, in the first instance, WG-FSA should be asked to review this proposal and then refer the matter back to WG-CEMP.

4.34 The second issue related to the present focus of WG-CEMP and the species selected for monitoring. The Convener recalled that, at its first meeting, the then *ad hoc* Working Group had decided to focus its attention on the krill-based ecosystem and to monitor variables of only a few species which were considered the most likely to provide statistically robust evidence of change. The Working Group acknowledged that there were many other important areas for work in support of the objectives of the Convention as embodied in Article II.

4.35 The Working Group agreed that expanding the scope of WG-CEMP to include species and sites other than those identified as part of the krill-based system would be a step of some magnitude and one that would require careful consideration. It was agreed therefore that consideration of this matter should be deferred until the next meeting, where it would receive detailed attention under a separate agenda item.

Environmental Monitoring

Land-based Observations

4.36 No proposals for changes to Methods F1, F3 and F4 had been received.

Remote Sensing

4.37 The Data Manager presented a report (WG-CEMP-93/15) on calculations of indices of sea-ice data that had been requested by the Working Group at its last meeting (SC-CAMLR-XI, Annex 7, paragraph 4.28). The Working Group welcomed this report, noting that the Secretariat had done an excellent job in moving forward with these analyses. Because the entire data files were too long to print in their entirety only an example was given for index a(i), latitude of the ice edge each week by 5° longitude intervals. For index F2/3, which is defined in the paper as the distance to the ice edge from selected CEMP sites, data for 1989/90 were reported. It is anticipated that once the database has been developed, data could be supplied to Members either as ASCII files for requested dates and areas, or in a form suitable for use in available GIS programs.

4.38 The Working Group agreed that these indices seemed to be a cost-efficient way of standardising the sea-ice data necessary for its work. It therefore recommended that the Secretariat be asked to continue according to the original plans of putting recent (1990/91 and 1991/92) and earlier (back to mid-1980s) data into the database during the forthcoming year.

4.39 In the deliberations of the Working Group some weaknesses in these indices were pointed out. For instance, the US Joint Ice Center (JIC) data are, in some cases, inadequate for the detection of open water masses and/or polynias and this may hamper efforts to detect areas of importance for foraging of predators. Although it was agreed that the JIC data could provide a broad indication of sea-ice distribution it may be desirable to supplement this information with more detailed sea-ice data. Where possible, individual researchers were encouraged to obtain detailed sea-ice images of relevance to particular study areas to help to interpret the coarser data available from JIC (e.g., as shown in WG-CEMP-93/28).

REVIEW OF MONITORING RESULTS

Predator Data

Status of Data Submissions

5.1 The Data Manager noted that data from each standard method for which there is currently a submission form were received within two weeks of the deadline, facilitating the task of calculating and updating predator indices for consideration by WG-CEMP. The Working Group expressed its concern, however, that data were received from only three Members and that, with the exception of the Bird Island black-browed albatross data (paragraphs 5.17 and 5.18), no historical data were received in response to requests made at the last meeting of WG-CEMP (SC-CAMLR-XI, Annex 7, paragraph 5.8). It was again stressed that timely and reliable assessments of predators and their interactions with prey and the environment cannot be achieved without the continual provision of information from several years' research from a broad suite of monitoring sites and species.

5.2 The Working Group recommended that the Scientific Committee strongly encourage Members to make available their predator data for relevant standard methods. These data are critically important to the success of CEMP, and Members were once again urged to submit these data to the CCAMLR Data Centre as a matter of priority.

Report on Indices and Trends

5.3 Indices computed from the CEMP database, including the submissions made this year, were presented in WG-CEMP-93/16. This summary updated the results reported last year in WG-CEMP-92/8 and 12, and in addition presented graphical summaries that were requested last year. Members that submitted data were requested to verify the values reported in WG-CEMP-93/16, so as to guard against errors that may have occurred during transcription from the data forms. Furthermore, Members were again reminded that the analytical methods for computing the indices are given in Appendix 6 of the *CEMP Standard Methods* manual and that software for computing the indices is available for testing and verification from the Secretariat.

5.4 The indices were reviewed by the Working Group, particularly with respect to whether any of the values were incongruous with the typical ranges for these parameters or with the data that were submitted. Because several discrepancies were noted between data submitted and the corresponding index values, it was agreed that, in the future, authors of data should meet with the Data Manager prior to the WG-CEMP plenary to resolve such discrepancies. The Data Manager noted a few minor modifications to the computational procedures that have become necessary as new data are added to the database; these are described below under headings for the respective methods.

5.5 For several of the methods considered below, some particularly noteworthy or conspicuous patterns are discussed. Further consideration of patterns and the magnitude and significance of changes in the indices is given in paragraphs 6.42 to 6.47.

Standard Methods for Penguins

Method A1 - Mean Weight on Arrival

5.6 Data were submitted for the 1992/93 season from Bird Island and Béchervaise Island.

Method A2 - Duration of Incubation Shift

5.7 Thus far, data on this parameter have been received only for Béchervaise Island.

Method A3 - Breeding Population Size

5.8 Data for this parameter had been received for the 1992/93 season from the sites at Anvers Island, Signy Island, Bird Island and Béchervaise Island.

Method A4 - Age-specific Recruitment and Survival

5.9 Standard protocols for submission of data and calculation of indices for this method have not yet been developed by WG-CEMP, though several Members are collecting data by the agreed field methods. It was anticipated that proposals for the analytical portion of the method will be submitted for consideration at WG-CEMP's next meeting (paragraphs 4.6 and 4.7).

Method A5 - Duration of Foraging Trip

5.10 Data for this parameter had been received for the 1992/93 season from sites at Anvers Island and Seal Island. The Data Manager noted that both indices for this method (brood- and creche-stage trip durations) had been computed in two slightly different ways (WG-CEMP-93/16). The first was unchanged from last year's method (*CEMP Standard Methods*, Appendix 6) and resulted in a large number of cases in which the index values could not be computed because the reported foraging trip durations were not measured during the specified time intervals following peak hatching or peak creching. The second method, therefore, was based on longer time intervals to ensure that indices would result from a greater proportion of the reported foraging trip durations. Members who had submitted these data were encouraged to consider whether this change is sensible with respect to the breeding biology of the penguin species involved and to report back to WG-CEMP at its next meeting.

5.11 The extreme variability in durations of foraging trips by Adélie penguins at Palmer Station that the Working Group noted at its last meeting (SC-CAMLR-XI, Annex 7, paragraph 5.11) was discussed again. Because the standard deviation of the index was frequently larger than the mean, Members questioned the utility of the index for this species and site. Previously, some Members had suggested that the variability may have resulted from patchiness in prey availability. However, Drs Trivelpiece and Kerry indicated that the variability may result from a strategy in which Adélie penguins employ both short and long foraging trips. If so, a modification to the standard method may be appropriate for this species. Drs Trivelpiece and Kerry were encouraged to evaluate their data to determine the feasibility of distinguishing between these two foraging trip types and to report to the Working Group at its next meeting.

Method A6 - Breeding Success

5.12 Data for this parameter had been received for the 1992/93 season from sites at Anvers Island, Seal Island, Signy Island, Bird Island and Béchervaise Island. The Data Manager noted that in order to produce an index from data submitted under Procedure A of this method, data from Method A3 must also be provided.

Method A7 - Chick Weight at Fledging

5.13 Data for this parameter had been received for the 1992/93 season from the sites at Anvers Island, Seal Island and Bird Island. Dr Croxall noted that, at least for gentoo penguins at Bird

Island, a year with high breeding success can also be characterised by relatively light fledglings (i.e., an inverse relationship), suggesting that both indices are necessary for correct interpretation of conditions in any particular year.

Method A8 - Chick Diet

5.14 Data for this parameter had been received for the 1992/93 season from the sites at Anvers Island and Bird Island. Five indices were produced from this method, in contrast to the two produced last year. Members submitting data found it somewhat difficult to check for discrepancies owing to the arcsin transform used in this method. The Data Manager was requested to provide, in future updates, separate tables for the raw data and the computed indices for this method.

5.15 It was noted that when Adélie penguins at Béchervaise Island (WG-CEMP-93/19) in the Prydz Bay ISR undertake short duration foraging trips (paragraph 5.11), they return with shelf-organisms, e.g. amphipods and *Euphausia crystallorophias*, but after longer foraging trips they return with *Euphausia superba*. These results may confound the analysis of this parameter and consideration may need to be given to regional differences in the calculation of indices of chick diet.

Method A9 - Breeding Chronology

5.16 Data for this parameter had been received for the 1992/93 season for the sites at Anvers Island and Seal Island. It was noted that the indices derived from this method are primarily used for establishing the time periods over which indices are computed for the other methods, rather than for monitoring purposes.

Standard Methods for Flying Seabirds

Methods B1 and B2 - Breeding Population Size and Breeding Success of Black-browed Albatross

5.17 Data for these parameters had been received for the 1992/93 season from the site at Bird Island. Dr Croxall noted that WG-CEMP-93/6 included full historical data for these parameters from the years 1977 to 1991 inclusive, thereby completing the provision of all available historical data for these two parameters at this site.

Method B3 - Age-specific Annual Survival and Recruitment of Black-browed Albatross

5.18 Results from a 17-year study of the population dynamics of black-browed albatrosses at Bird Island, South Georgia are contained in WG-CEMP-93/6. This constitutes formal submission of estimates of annual mean adult survival (for both sexes) and recruitment rates.

Standard Methods for Fur Seals

Method C1 - Duration of Foraging Trips by Females

5.19 Data for this parameter had been received for the 1992/93 season from the sites at Seal Island and Bird Island.

Method C2 - Pup Growth Rate

5.20 Data for this parameter had been received for the 1992/93 season from the sites at Seal Island and Bird Island. Data for 1988 to 1993 indicate that pup growth rates at Bird Island have been consistently lower than those at Seal Island. Dr Croxall noted that pup growth rates had decreased consistently from 1986 to 1992 at Bird Island (WG-CEMP-93/9), perhaps suggesting a density-dependent response; this would be consistent with the faster growth at Seal Island, a younger and less dense colony. However, fur seal density remains high at Bird Island and the 1993 pup growth rates were amongst the highest measured there, so this may be too simple an explanation.

Prey Data

5.21 In introducing this item the Convener recalled that WG-CEMP had requested the following data to enable it to undertake its annual assessments and to formulate advice based upon an integrated perspective of predator, prey and environmental data (SC-CAMLR-XI, Annex 7, paragraph 5.19):

(i) summaries of fine-scale catch data and an analysis of the distribution of catches relative to predator colonies;

(ii) the most recent estimates of krill biomass (or relative biomass) in each ISR and other subareas or meso-scale survey areas as estimates become available; and

(iii) results of specific fine-scale surveys near CEMP sites or surveys to determine aspects of distribution movements or behaviour, as they become available.

5.22 Mr Miller, the Convener of WG-Krill, reviewed the highlights of the WG-Krill report as they pertained to this item. The details of his summary are included in the relevant paragraphs below.

5.23 The Data Manager summarised the fine-scale catch data in Statistical Area 48 as reported to CCAMLR for 1991/92 (WG-Krill-93/9). It was noted that there had been a significant decrease in the total krill catch in Statistical Area 48 during the 1992/93 season. At the time of the meeting, 81 394 tonnes had been reported for the 1992/93 season as compared to 302 961 tonnes for 1991/92.

5.24 The reasons for the reduction in catch levels were discussed. In part they reflected the reduction in number of fishing vessels used by Russia, Ukraine, etc. However, the catch by Japanese vessels had also decreased, because of a decrease in fishing effort.

Fine-scale Catch Data

5.25 Mr T. Ichii (Japan) introduced WG-Krill-93/25 which summarised data from the Japanese krill fishery for the 1991/92 season. The main fishing ground was persistently north of Livingston Island. Another interesting result was that the CPUE had decreased during the latter part of the season. It was also noted that similar analyses of trawling positions, CPUE, and length frequency distributions from the Japanese krill fishery had been submitted in each of the past six years. The author was encouraged to prepare a summary of these data to investigate the potential patterns or trends in these data and to table such analyses at the next CEMP meeting.

5.26 The Working Group commended the author for having prepared such an extremely valuable paper, which provided a rich source of information pertaining to the Group's work. It was agreed that it would be very helpful if similar data for the fishery from other nations, especially Russia and Ukraine, could also be provided, especially for those areas in close proximity to CEMP sites including those in Division 58.4.2.

5.27 The need to obtain prey data at various scales for CEMP studies was noted. Larger scales will assist studies of environmental effects and smaller scales provide insight to predator/prey interactions near CEMP sites. It was concluded that such questions of scaling would be appropriate issues for discussions during a joint meeting of WG-CEMP and WG-Krill.

5.28 A preliminary estimate of CPUE trends for the Chilean krill fishery (WG-CEMP-93/21) was reviewed. This analysis suggested that good and bad years for the fishery seem to be discernible. Mr Miller, however, cautioned that several aspects unrelated to krill biomass (e.g., seasonal distribution, fishing locations) could affect the CPUE estimates.

5.29 In reviewing the status of the krill stock around Elephant Island (WG-Krill-93/8) it was noted that some correspondence between data from research cruises and fisheries is apparent. This observation triggered a discussion on whether the fisheries target a specific part of the total krill population. It was pointed out that the driving forces for the fishermen are krill quality, optimisation of catch in time, etc. Sought-after krill quality may also differ between nations and years (SC-CAMLR-XI, Annex 4, Figure 1).

5.30 The Working Group noted that it had now developed a series of annual indices of predator parameters with which to monitor predator performance. In the context of integrating information from predators, prey and environmental conditions, it felt that increased attention needed to be focused on refining a series of prey indices.

5.31 The Working Group agreed that in addition to prey data from fishery-independent surveys, fine-scale data from the fishery, such as catch locations, CPUE and krill length frequencies would be valuable. The Working Group believed that, although these data were not being used for estimation of biomass, if indices could be defined which described these data on an annual basis from the vicinity of CEMP sites, such indices would provide valuable input into the syntheses of data from the predators, prey and environment (e.g., SC-CAMLR-XI, Annex 7, Table 4).

5.32 It was acknowledged that the above fishery-based indices would represent relative krill availability (local or aggregation density) to the fishery, but would not provide areal indices of krill biomass without additional information on patch distribution such as is provided by searching time (SC-CAMLR-XII/4, paragraph 5.29).

5.33 In this context, the Working Group requested that WG-Krill consider the following questions:

(i) What fine-scale fisheries data (e.g., catch, effort, demography) are available within 50 and 100 km of the following CEMP sites:

- Cape Shirreff (48.1);

- Seal Island (48.1);
- Signy Island (48.2);
- Laurie Island (48.2);
- Bird Island (48.3); and
- Béchervaise Island (58.4.2)

as well as the three ISRs (Figure 1), throughout the year, but especially during the times of CEMP predator monitoring activities at these sites?

(ii) What fisheries-derived information can be used to calculate the following indices, and what are the most appropriate methods to use for their calculation:

- krill availability to the fishery;
- krill product quality (e.g., gravid, green, white, etc.); and
- krill catch length composition?

(iii) What are the most appropriate ways of deriving indices of krill cohort strength and recruitment from krill length frequency data? To what extent can comparable indices be derived from research vessel, fishery and predator diet data?

This whole topic should be discussed at a joint meeting of WG-Krill and WG-CEMP.

5.34 In common with the criteria used for calculation of CEMP predator monitoring indices, these fishery-derived indices should:

(i) be statistically defined (i.e. the variance, confidence limits, etc. should be provided);

(ii) be expected to change as the parameters from which the indices are derived also change; and

(iii) be presented so that comparisons within seasons and between years can be easily made.

Estimates of Krill Biomass in Integrated Study Regions (ISRs)

5.35 At its 1992 meeting, WG-Krill had responded to WG-CEMP's request for broad-scale biomass estimates for krill in the ISRs by providing estimates of krill biomass from hydroacoustic surveys conducted within portions of the ISRs (SC-CAMLR-XI, Annex 4, paragraph 5.53, Figure 2, Table 4).

It was emphasised that these biomass estimates are only applicable to the area covered by the surveys and should not be extrapolated to cover the total area of the ISRs.

5.36 At the 1993 meeting of WG-Krill, a recalculation of the FIBEX data for Subarea 48.1 resulted in changes in the biomass estimates for Subarea 48.1 (SC-CAMLR-XII/4, paragraph 4.40). It was noted that aside from these changes, the estimates of krill biomass in the ISRs since last year's summary were unchanged. The current biomass estimates for the ISRs are given in Table 4. The areas to which the estimates pertain are shown as shaded zones in Figure 1.

5.37 The Working Group thanked WG-Krill for these estimates and requested these estimates be updated, as possible, to cover the entire area of the ISRs, and to incorporate new data as they become available.

Fine-scale Surveys

5.38 Dr R. Holt (USA) presented WG-CEMP-93/27 which described research undertaken by the US AMLR Program during the 1992/93 field season. He noted this was the fifth year of an ongoing program which carried out *inter alia* hydroacoustic surveys around the Seal Island CEMP site (near Elephant Island). These hydroacoustic surveys were conducted within an approximately 60 x 130 n mile rectangle (and some areas to the southwest) according to the standard method (SC-CAMLR-X, Annex 4, Appendix D, Attachment 4) supplemented with net sampling of zooplankton and CTD/rosette hydrocasts.

5.39 In WG-Krill-93/49, the authors presented a summary of krill biomass estimates near Elephant Island between the years 1981 and 1993. Comparing estimates of recruitment and biomass it was noted that a strong year class of krill one year appears often to be followed by larger biomass estimates the following year. In the following discussion it was pointed out that the availability of data from net hauls for target identification can be used to improve estimates of mean recruitment and its variability (SC-CAMLR-XII/4, paragraph 4.46).

5.40 Members noted that it is important to be clear in using the term "recruitment". For krill, recruitment into the population refers to krill reaching one year of age. Recruitment into the fishery usually pertains to reaching year class 3. Indices for these two kinds of recruitment are obviously of different significance with respect to predators. Recruitment for penguins and seals usually refers to the number of individuals that enter the breeding portion of the population.

5.41 Dr Holt stated that salps were abundant during parts of the 1993 AMLR survey. It was noted that the Chilean fishery had moved from Elephant Island to Livingston Island in March 1993 because of the salp concentrations in the Elephant Island area (WG-CEMP-93/21). Mr Ichii stated that the Japanese fishery routinely moved to an area over the continental slope north of Livingston Island to avoid salps in years when salps were abundant.

5.42 The Working Group discussed the ecological significance of salps to marine mammals and birds. It was noted that even though surface feeders such as albatrosses are known to eat salps occasionally, there is little evidence that seabirds or pinnipeds prey on salps. It was also pointed out that the relationships between krill and salps are poorly understood and needs further study.

5.43 Krill stock composition and distribution patterns in the vicinity of Elephant Island during the austral summers 1991/92 and 1992/93 were described and compared with information from previous years in WG-Krill-93/8. The length frequency distributions and maturity stage composition reflected relatively good year class success from the 1990/91 spawning season but poor success from 1991/92. Year class success from these and other years appears to be associated with female maturity development and spawning during early summer months. The overall abundance, maturity stage composition and reproductive activity of krill appeared to be affected by dense salp concentrations during 1989/90 and 1992/93.

5.44 The Working Group discussed the results and the hypothesis put forward that spawning success is related to time of spawning. The interpretation of the data is still hampered by the largely unknown effects of flux. The Working Group suggested that these data which represent an important time series of fisheries-independent data, continue to be supplemented and subjected to renewed analyses as new data are acquired.

5.45 Mr H.-C. Shin (Republic of Korea) introduced the paper WG-Krill-93/41 which described a krill survey in the western Bransfield Strait region in 1992/93. Juveniles were dominant in most krill samples, and krill were most abundant in the central Bransfield area. The distribution of krill at different life stages suggested that the young krill encountered had their origin in the coastal waters of Gerlache Strait, to the west of Bransfield Strait.

Environmental Data

Sea-ice Patterns

5.46 As described in paragraph 4.38 above, it is expected that an analysis of sea-ice data from approximately 1985 to 1992 will be available at next year's meeting. It was agreed that, at that time, it would be possible to review these data across a series of years, with the intention of developing appropriate indices for incorporating into the synthesis developed in Table 5.

ECOSYSTEM ASSESSMENT

6.1 At their 1990 meetings, the Commission (CCAMLR-IX, paragraph 4.34), Scientific Committee (SC-CAMLR-IX, paragraphs 5.4, 5.39 and 8.6), and WG-CEMP (SC-CAMLR-IX, Annex 6, paragraphs 41 to 43) agreed that WG-CEMP should determine annually the magnitude, direction and significance of trends in each of the predator parameters being monitored; evaluate annually these data by species, sites and regions; consider conclusions in light of relevant information (e.g., prey and environment); and formulate appropriate advice to the Scientific Committee.

6.2 In 1992, WG-CEMP agreed that this annual assessment procedure should include: (i) a review of background information available to the Working Group in submitted papers; and (ii) assessment of predator, prey, environmental and fishery data. For the first item, the Working Group reviewed papers under the general sub-headings of "Predator Studies", "Prey Studies", and "Environmental Studies".

Review of Background Information

Predator Studies

Population and Demography

6.3 In WG-CEMP-93/6, concerning albatross demography at Bird Island, South Georgia, the periodic low breeding success of black-browed albatrosses (for which krill is the main diet component), in most years attributable to low food availability, is contrasted with the much smaller fluctuations in breeding success of grey-headed albatrosses (for which squid is the main diet constituent). In 1988, however, when late snow and ice in the colonies caused widespread reproductive failure, both species were equally affected. Adult survival rates showed significant interannual variation and future work will try to link these to other indices of reproductive performance and to environmental conditions.

6.4 In WG-CEMP-93/8, the fit of the model based on gentoo penguin population parameters to the data on population fluctuations over 15 years at Bird Island, South Georgia, shows that in the four years of large population decrease (three associated with low krill availability), deferred breeding and increased adult mortality were the likely causes of the observed population changes. The years of poor breeding conditions have disproportionate demographic effects and doubling their frequency in the simulation model would result in a persistent significant rate of population decline.

6.5 In addition to its methodological implications, WG-CEMP-93/9 summarises data on Antarctic fur seal pup growth (collected according to CCAMLR Standard Methods) and intersexual differences therein, at Bird Island, South Georgia between 1973 and 1992. The paper shows that pup growth rates are highly correlated with weaning mass. For 11 yearsÕ data there are strong inverse correlations between growth rate and foraging trip duration. However, using data on individuals within seasons, the relationship was only apparent in one in three years.

6.6 WG-CEMP-93/10 reports the results of an investigation of relationships between age, breeding experience and environmental variation (the last being indexed mainly by foraging trip duration) for Antarctic fur seals over 10 years at Bird Island, South Georgia. Many of the results relate to differing performance of primiparae and multiparae and differences between animals breeding first at ages three and four years. For CCAMLR, however, an important conclusion is that the use of data on foraging trip duration consistently improved models of likelihood of pupping and weaning success. After years characterised by longer foraging trips, females arrived to breed later, fewer females pupped and they gave birth to lighter pups. In years of longer foraging trips, females had reduced weaning success.

6.7 Using a sample of 724 upper canine teeth from male Antarctic fur seals dying of natural causes at Bird Island, South Georgia from 1973 to 1989, WG-CEMP-93/11 reported investigation of interannual variations in annual tooth growth (which, in a smaller sample is shown to correlate significantly with body growth). For fur seal cohorts from 1967 to 1988, there was no trend in cohort strength but poor years for growth were closely related to those of poor reproductive performance for females and interannual variation in growth was significantly correlated with the Southern Oscillation Index of climatic variation. Data derivable from tooth sections can thus offer significant insights into predator-environment interactions over time spans much longer than those currently accessible through existing conventional monitoring studies.

6.8 WG-CEMP-93/23 presents results of a preliminary survey of breeding chronology and breeding success of chinstrap and gentoo penguins at Barton Peninsula, King George Island, in the 1992/93 season. Ninety-six chinstrap and 121 gentoo nests were monitored from shortly after egg laying. Chinstrap and gentoo penguins reared 1.45 and 1.32 chicks per breeding pair to the creche stage respectively. The growth of chicks was measured from the beginning of January to the beginning of February. The chinstrap chicks grew from 0.61 to 3.43 kg and gentoos from 0.56 to 4.59 kg.

6.9 Dr D. Torres (Chile) presented summary results of four complete censuses of Antarctic fur seals (between 1966 and 1992) at San Telmo Islands and Cape Shirreff, Livingston Island (WG-CEMP-93/24). These results may help to clarify interpretations of fur seal abundance and population growth at these sites (SC-CAMLR-XI, Annex 7, paragraph 6.7), because the 1966 and

1973 counts, which were from the two sites combined, have previously been ascribed to Cape Shirreff alone.

Predator-Prey Interactions

6.10 Most of the few systematic studies of correlations between at-sea observations of seabirds and seals and data from acoustic surveys for krill collected simultaneously report low correlation coefficients, except for major swarms and concentrations. Results of a fine-scale (seabird records taken at one minute intervals; acoustic resets at 1 n mile intervals) survey by USA and UK scientists around northwest South Georgia in 1986 are reported in WG-CEMP-93/12 and 13. After accounting for variation due to birds and seals commuting to and from breeding colonies (principally at Bird Island) a range of high correlations at different scales and locations, usually different for different species, is reported. As expected, large krill swarms have a disproportionate effect on predator distribution.

6.11 The diving behaviour of chinstrap penguins was observed concurrently with a hydroacoustic assessment of the vertical distribution and abundance of krill in the vicinity of Seal Island during early 1992 (WG-Krill-93/47). Krill showed a distinct diel migration pattern, being dispersed in the upper portion of the water column at night and more concentrated and deeper during the day. On average, chinstrap penguins dived to the shallow limit of the distribution of krill. The maximum depth of penguin dives did not exceed the maximum depth of the distribution of krill.

6.12 The Working Group noted that, although the penguin and krill data were temporally concurrent, there was no information on spatial concurrence. Differences between the areas surveyed hydroacoustically and those actually used by the penguins for feeding may affect the interpretation of results.

At-sea Behaviour of Birds and Seals

6.13 The foraging range of Adélie penguins during autumn and early winter was studied by satellite tracking four birds from the Béchervaise Island CEMP site (WG-CEMP-93/28). Dr Kerry reported birds remained inside the sea-ice zone in close proximity to the edge of the continental shelf (1 000 m isobath) and moved progressively westwards. These studies suggested that Adélie penguins forage during the post moult (autumn) period in the same region as do breeding birds during the breeding season. They are able to remain in the region despite the formation of pack-ice and its extension to the north. Satellite images of the sea-ice showed the presence of a wide lead in the vicinity of the continental shelf break and its maintenance between at least April to July.

6.14 Food habits of the southern baleen whales were reviewed to examine prey composition and inter-specific relationships (WG-Krill-93/16). The paper provided historic information on prey composition and prey size of baleen whales in the Southern Ocean. The Working Group noted that this provided valuable data for two of CCAMLR's three ISRs, namely South Georgia and Prydz Bay, but not for the Antarctic Peninsula Region, which had been part of an IWC whale sanctuary until 1955.

6.15 Although no clear evidence suggesting inter-specific competition for food between whales was found, the author hypothesised that minke whale groups, while feeding, may disperse krill aggregations to such an extent that the feeding success of blue whales is lowered.

6.16 The Working Group noted, however, that little, if any evidence is available in support of this hypothesis. It was further commented that, by analogy, krill trawlers could interfere with krill predators in that, during fishing operations, trawlers may disperse krill concentrations on which the predators feed.

6.17 Dr K.-H. Kock (Germany) drew the attention of the Working Group to a 1993 IWC resolution to study possible causes which impede the recovery of the stocks of Southern Ocean blue whales.

Prey Studies

Krill Populations and Demography

6.18 The biology and size composition of krill from the Indian Ocean sector was the subject of a study described in WG-Krill-93/45. Krill from the area had the following biological characteristics: lifespan five to six years, growth rate from 0.126 to 0.133 mm/day during the first year, decreasing to 0.028 to 0.041 mm/day during the fifth year. It was suggested that krill stocks from the Sodruzhestva and Kosmonavtov Seas are relatively separate from those in other areas.

6.19 Fine-scale catch data for krill in Statistical Area 48 and estimates of krill biomass in ISRs are reviewed and discussed in paragraphs 5.23 to 5.45.

Krill Interactions with Environment

6.20 Regional and circumpolar distribution of krill and environmental changes during the Austral summer were compared in WG-Krill-93/29. An environmental index, $\overline{Q}_{200}$, which utilises the integrated value of water temperature from the surface to 200 m in depth was used. The areas of high krill concentrations coincided with the areas of low $\overline{Q}_{200}$ values; mainly falling in the range of 0°C to -1.5°C, corresponding to a thick layer of winter water, especially within the slope and shelf waters south of the Antarctic Divergence Zone.

6.21 It was noted that WG-Krill-93/29 concluded with the suggestion that use of the $\overline{Q}_{200}$ index may supplement hydroacoustic surveys of stock biomass of *E. superba*. Members indicated their interest in receiving further information on the relationship between the environmental gradient index and key features of the biology and distribution of krill. In addition, it was noted that, before this index could be used to supplement acoustic surveys of krill biomass, studies to calibrate the relationships between these two approaches would be essential.

6.22 The relationship between size of krill and extent of sea-ice in the water around the South Shetland Islands was reported using commercial krill data from 1979 to 1992 in WG-Krill-93/26. The mean size of krill near the coastal zone appeared to be small in a summer season immediately following the occurrence of strong ice cover.

6.23 The relationship between an index of phytoplankton abundance and the maturity of krill around the South Shetland Islands was investigated using five years of commercial krill data in WG-Krill-93/27. Interannual fluctuations of maturity in krill populations seemed to be determined by food availability and the size composition of phytoplankton.

6.24 Effects of biological and physical factors on the distribution of krill in the South Shetland Islands during the 1990/91 austral summer were investigated in WG-Krill-93/38. Krill showed an offshore-onshore heterogeneity in abundance and maturity.

Environment Studies

6.25 Hydrographic flux in Statistical Area 58 was investigated in WG-Krill-93/22. Surface geostrophic velocity and volume transport were calculated from four longitudinal transects using data collected aboard the Japanese RV *Kaiyo Maru* and other vessels. In presenting this paper, Dr M. Naganobu (Japan) noted that geostrophic flow calculations suggest that there may be an easterly flow from the surface or sub-surface to near-bottom in the Southern Indian Ocean in proximity to the shelf break. Satellite imagery has shown that there is a wide lead similar to that shown for May 1993 north of Mawson (WG-CEMP-93/28) parallel to the shelf break to the north of Syowa Station which may be explained partially by the current. This, too, may be important for penguins' foraging during the winter (paragraphs 4.22 and 4.39).

6.26 WG-Krill-93/33 investigated the usefulness of satellite ocean colour remote sensing in the Southern Ocean. A comparison of Coastal Zone Colour Scanner (CZCS) chlorophyll images and ship-measured chlorophyll concentrations in the area around Enderby Land was presented in the paper.

6.27 Spatial and temporal distributions of phytoplankton in the waters around the South Shetland Islands were presented using the Nimbus-7 CZCS data during January to March 1981, in WG-Krill-93/39. Concentrations of phytoplankton pigment were low during the middle of January with blooms beginning during February.

6.28 High concentrations of chlorophyll *a* were observed in the coastal area north of Livingston Island during the 1991 research cruise of the Japanese RV *Kaiyo Maru* (WG-Krill-93/23).

Assessment of Predator, Prey, Environmental and Fishery Data

6.29 The assessment of submitted data on predator parameters could not be undertaken prior to 1992 because of insufficient data and calculated indices (SC-CAMLR-XI, Annex 7, paragraph 6.27).

6.30 At its 1992 meeting, however, WG-CEMP felt that sufficient data were available to commence this process. As a first approach towards the goal set out in paragraph 6.1 above, WG-CEMP in 1992 reviewed all available:

(i) data submitted in respect of predator parameters monitored according to approved methods;

(ii) data for these parameters but which had not been collected according to the CEMP Standard Methods;

(iii) data in tabled papers for predator parameters collected annually in standard fashion but for which standard methods had not been submitted to WG-CEMP;

(iv) other predator data available in tabled or other papers or through participantsÕ personal knowledge; and

(v) data on krill CPUE and catches (obtained from STATLANT B submissions and fine-scale data in the CCAMLR database); and data on krill biomass (from papers tabled at WG-Krill and WG-CEMP). Environmental data were provided by participants submitting predator data.

6.31 It should be noted that, because of inconsistencies between data submitted in 1992 and those in the CCAMLR database and the consequent need to carry out checks and validations, it had been impossible to calculate from the submitted data all the required information on magnitude and significance of interannual differences. Therefore, in 1992, the assessment of predator parameters had depended chiefly on subjective evaluation, by the contributors of the data, of the relative magnitude and direction of differences and trends.

6.32 This whole process in 1992 was a very valuable exercise, producing results of considerable utility, and was warmly welcomed by the Scientific Committee and Commission (SC-CAMLR-XI, paragraph 5.19; CCAMLR-XI, paragraph 4.21).

6.33 At its 1993 meeting, the Working Group agreed that it would be undesirable in future to continue to conduct assessments in this fashion. In particular, there was a concern that subjective assessments combining verified and unverified data which may or may not comply with CEMP Standard Methods, could be potentially confusing to scientists and others not familiar with such data or with the deliberations of WG-CEMP.

6.34 Unfortunately, despite the desire expressed in paragraph 6.33, at the 1993 meeting sufficient inconsistencies between the CCAMLR database and submitted data still remained and the amount of newly-submitted data had diminished so that it was judged impracticable to improve the assessment procedure over that undertaken last year.

6.35 In future, however, WG-CEMP agreed that, beginning at its 1994 meeting:

(i) the formal annual assessment of predator data would be confined to data on parameters collected annually and submitted by the due date according to the approved standard methods;

(ii) data on other predator parameters (i.e., those not subject to CEMP Standard Methods) collected annually by standard procedures and tabled at WG-CEMP for examination would also be considered for similar annual assessment. These data and assessments would be clearly indicated as distinct from those in (i), above; and

(iii) other predator data, whether for approved parameters or not, or whether collected annually or not, would receive separate consideration.

6.36 In order to move as quickly as possible to objective assessment, it was essential to resolve inconsistencies between database and submitted data. Members were asked to give this urgent consideration, in consultation with the Data Manager.

6.37 Once this was done the table summarising formal assessments of predator data (i.e., Table 5) could be replaced by one recording the calculated year-to-year changes together with the statistical significance of these differences. It might also be desirable to report the actual annual values of parameters in these tables but this may have implications for the use of these data outside CCAMLR. Members were urged to consider this situation from the point of view of rules governing access to, use of, and publication of CCAMLR data (CCAMLR, 1992[1]).

6.38 Appropriate treatment of krill and environment data should be a priority item for discussions at the meeting of WG-Krill and WG-CEMP next year.

6.39 Because it was not possible to improve the assessment procedure at the present meeting (paragraph 6.34), the Working Group updated in Table 5 its subjective summary of the nature, magnitude and direction of change of the data recorded for predator parameters. Some update to environment data was also included. Krill catch, biomass and CPUE data were not updated because WG-CEMP felt there was insufficient expertise within the Working Group to undertake this in a fully reliable fashion.

6.40 Furthermore, it was decided to delete all entries for krill biomass, catch and CPUE in Table 5 because it was felt preferable to complete the assessment only after WG-Krill had considered the best potential indices for assessment and discussed these topics with WG-CEMP at the next joint meeting (paragraphs 5.30 to 5.33).

6.41 The provision of appropriate data on prey for inclusion in summaries such as provided by Table 5 should therefore be a priority topic for consideration at the next joint meeting of WG-CEMP and WG-Krill. Specifically, responses to questions such as those in paragraph 5.33 would substantially help WG-CEMP in this regard.

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1 CCAMLR. 1992. *Basic Documents*. Sixth Edition. CCAMLR, Hobart, Australia: 114 pp.

6.42 The update to the predator and environment data included changes to the previous assessment (marked by asterisks in Table 5) as well as the new summaries for 1993.

6.43 The summaries for Subarea 48.1 (Tables 5.1 to 5.5) indicated that 1993 (1992/93 predator breeding season) was a fairly typical year, with not much change from 1992. For example, at Seal Island (Table 5.5), the only parameters that changed substantially were foraging trip durations of Antarctic fur seals and chinstrap penguins and these changed in opposite directions. At Admiralty Bay (Table 5.3) and at Anvers Island (Table 5.1), 1993 was an average-to-good year for Adélie penguin breeding and population sizes were generally stable.

6.44 In Subarea 48.2 (Table 5.6), 1993 was a good year from the standpoint of reproductive performance of Adélie, chinstrap and gentoo penguins at Signy Island. Breeding population size was stable for Adélie penguins and indicated recoveries for chinstrap and gentoo penguins from reduced levels in 1991 and 1992, respectively.

6.45 In Subarea 48.3 (Tables 5.7 and 5.8), breeding performance in 1993 was good for all species (exceptional for gentoo penguins), although fur seal foraging trip durations were inexplicably longer than in 1992 (paragraph 6.43). Breeding population sizes were either stable or showing recovery after substantial reductions in 1991.

6.46 At Béchervaise Island in Division 58.4.2 (Table 5.9) there was very little change in the parameters for Adélie penguins, despite greater than usual snow cover during the pre-laying period.

6.47 The Working Group noted that, despite the subjective nature of this second annual assessment, the general finding - that conditions during the 1993 breeding season for predators were normal to good - was likely to be quite robust, recognising that five years' data, including those for the uniformly poor season in 1991, are now available.

Potential Impacts of Localised Krill Catches

Distributions of Krill Catch and Predators

6.48 In recent years it has become increasingly apparent that there is a consistent pattern of temporal and spatial overlap between krill harvesting and feeding by land-based predators in Subareas 48.1 and 48.2 during the predators' breeding seasons (SC-CAMLR-XI, paragraphs 5.24 to 5.31). This situation led to recognition that further work is needed to investigate more precisely this overlap and to assess more accurately the magnitude of potential competition between predators and fishery (SC-CAMLR-XI, paragraph 5.50). Further, WG-CEMP and WG-Krill were encouraged by the Scientific Committee to prepare for such work as a matter of priority, particularly with respect to Subarea 48.1.

6.49 In this regard, WG-CEMP considered two papers presenting updated information about the fine-scale distribution of krill catches in relation to predator colonies. The first, WG-Krill-93/10, updated the analysis presented in WG-Krill-92/19 and indicated that the percentage of the 1992 krill catch within the critical period-distance for breeding seal and seabird predators in Subarea 48.1 (70%) remained similar to, but at the low end of the range of values from previous years. It was noted that the recent percentages tend to be somewhat lower probably because the fishery has been extended into the months of April to June. This difference notwithstanding, the general pattern of the fishery in Subarea 48.1 (concentrations north of Elephant and Livingston Islands) has remained stable. The fine-scale catch data for Subarea 48.2 were incomplete.

6.50 Mr Ichii introduced the second paper, WG-Krill-93/7, which used estimates of prey consumption rates and information on seabird distribution to estimate the spatial and temporal distribution of krill consumption by chinstrap and gentoo penguins breeding on the South Shetland Islands. That distribution was then compared with “finer-scale” catch data (10 x 10 n mile) in an attempt to evaluate the impact on these penguin populations of the Japanese krill catch which, over the past several years, has generally accounted for approximately 80% of the total catch in Subarea 48.1.

6.51 The authors of WG-Krill-93/7 concluded that the present fishery is unlikely to have an adverse impact on the penguin populations for the following reasons:

(i) the spatial overlap between the foraging areas of the majority of local penguin populations and the areas from which the main catch of krill by the fishery is taken is low; and

(ii) the current catch by the krill fishery is low compared with the local krill biomass.

6.52 WG-CEMP welcomed this work as a significant step toward assessing the magnitude of potential competition between predators and the fishery. It further noted the utility of the finer-scale data for this type of exercise. There was, however, considerable discussion of whether the authors' conclusion about the likelihood of adverse impact was in fact supported by the analysis. This discussion included the following points:

(i) the results appear sensitive to the accuracy of the estimates of penguin population size and to knowledge of where penguins from Low Island forage. Use of more recent data on seabird abundance and distribution in that area (Woehler, 1993[2]) might lead to better results but data on foraging areas of Low Island penguins are unlikely to be available in the near future;

(ii) the analysis assumed a constant per-capita rate of krill consumption by penguins during the months of December to March. Therefore, the potentially equally critical post-breeding period, when prey consumption increases markedly due to foraging by adults preparing to moult and by fledglings, was not considered. Very little is presently known about how far from the colonies these groups of penguins forage;

(iii) the analysis assumed that prey consumption by penguins was spread evenly over the area considered; the actual distributions of prey consumption may have been different but there are few data with which to model this; and

(iv) the analysis does not account for such factors as krill flux through the area, the fine-scale foraging patterns of the predators in relation to the distribution and density of krill, and potential effects caused by the fishery on krill availability to penguins (e.g., trawling activity disrupting krill aggregations).

6.53 The first three points above, (as well as the analysis in WG-Krill-93/25), emphasise the need to obtain refined information on predator distribution and foraging locations, allowing a more closely comparable analysis of detailed predator data with the finer-scale fishery data. Progress in this area would be greatly enhanced by undertaking CEMP activities at more sites along the north coasts of the South Shetland Islands near the main fishing grounds north of Livingston Island (e.g., Cape Shirreff).

6.54 It was recognised that some of these points, particularly the fourth, may be especially challenging to address by research in the near future. The Working Group agreed, however, that undertaking research on these topics is essential if progress is to be made in understanding the factors affecting krill availability to predators, and that Members should be encouraged to proceed with such research as a matter of priority.

6.55 The Working Group emphasised that understanding the nature of potential competition between krill predators and the krill fishery is far more complicated than a comparison of the biomass of krill present in a particular zone with the biomass of krill eaten by predators would show.

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2 Woehler, E.J. (Compiler). 1993. *The Distribution and Abundance of Antarctic and Sub-Antarctic Penguins.* Scientific Committee on Antarctic Research (SCAR), Cambridge: 76 pp.

Indeed, there are at least four topics which need to be considered in evaluating potential predator/fishery competition:

(i) spatial overlaps, accounting for the locations of predator foraging areas and commercial fishing grounds;

(ii) temporal overlaps, accounting for the timing and seasonal changes of predators' localised foraging activities and the scheduling of fleet operations;

(iii) behavioural interactions, pertaining to the types and characteristics of krill aggregations needed by predators for efficient foraging (e.g., size and density of krill patches) and the effects of trawling activities on krill aggregation patterns; and

(iv) prey biomass and predator energetic needs, accounting for the actual levels of krill biomass present in and moving through particular localised areas, and the amount of krill biomass needed to meet the energetic needs of predators and their offspring.

6.56 It was noted that several of the papers considered at the present and past meetings had contributed to these topics. For example, papers by the Secretariat had addressed the spatial and temporal scales of the fishery within 50 and 100 km of predator colonies (WG-CEMP-91/9, WG-Krill-92/19 and 10). Similarly, the analysis of the spatial and temporal distributions of prey consumption by predators (WG-Krill-93/7) represents a valuable advancement at this stage.

Consequences of Potential Precautionary Measures

6.57 In 1991 a dialogue was initiated to explore the consequences of various types of conservation measures associated with a precautionary approach to management (SC-CAMLR-XI, Annex 4, paragraphs 5.1 to 5.35). It was agreed that this dialogue had been very useful, and there was a feeling that it should be continued (SC-CAMLR-XI, paragraphs 5.39 and 5.40).

6.58 To facilitate this dialogue, the Scientific Committee requested that the Secretariat conduct a simulation study to explore more fully the potential consequences of different extents and locations of closed areas (SC-CAMLR-XI, paragraph 5.41). The Data Manager completed such a simulation model and presented the results in WG-Krill-93/14.

6.59 In WG-Krill-93/14, the behaviour of the krill fishery in a portion of Subarea 48.1 was modelled using input parameters derived from Chilean CPUE and fishing distribution data, under several alternative management strategies. These strategies included unrestricted fishing, closing waters within 50 km of the South Shetland Islands, closing an area within 100 km of either Livingston or Elephant Island, and closing areas within 100 km of both Livingston and Elephant Islands.

6.60 Under unrestricted fishing, the model predicted a catch level and distribution of catches similar to that seen in the present fishery. Under a closure of the waters within 50 km of the South Shetland Islands, the catch dropped by 24%. Closing the Livingston Island area resulted in a 39% increase and closing the Elephant Island area resulted in a 15% decrease in catches from the unrestricted level, while closing both areas simultaneously resulted in a 71% decrease in catches. A further discussion of the simulation's results can be found in the 1993 Report of WG-Krill (SC-CAMLR-XII/4, paragraphs 5.34, 5.35 and 5.37).

6.61 WG-CEMP welcomed this paper and commended the Secretariat and Data Manager for producing the analysis in a timely and well-presented manner.

6.62 The Working Group noted the advantage at this stage of the simplicity of the model and that it reproduced, in at least a general way, the magnitude and distribution of the catch. There was considerable discussion about how the model could be made more realistic, though it was agreed that only a few of the suggestions would be feasible to incorporate in the near future.

6.63 The Working Group recommended that the Secretariat be asked to refine the model on the following basis:

(i) as feasible, incorporate suggested improvements to the model, but maintain the model's general structure at present;

(ii) Members engaged in krill fishing should be encouraged to provide input as to whether there are features that could be added in a simple fashion to the model that would remove some of the concerns about its realism. These might include, for example, consideration of the lost value of the catch from management strategies that affect the fishery's ability to target particular qualities of krill (e.g., WG-Krill-93/38), and the different fishing gear used and fishery strategies employed by the fleets of different fishing countries; and

(iii) this work might be facilitated by a direct dialogue between the Data Manager and scientists from fishing countries.

6.64 In summary, WG-CEMP agreed that the model in WG-Krill-93/14 served the purpose of demonstrating the utility of such an analysis for investigating the effects of potential precautionary measures. The Working Group emphasised that the model results or continued efforts to further refine the model should not be interpreted as a basis for implementing precautionary measures. Rather, the intention was for the model to assist with the continued dialogue to explore various options and possible consequences of strategies for a precautionary approach to the issue of potential impacts of localised fisheries on predator populations (SC-CAMLR-XI, paragraphs 5.39 and 5.40).

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

6.66 Dr H. Hatanaka (Japan) informed the Working Group that a discussion among Japanese krill fishermen, in consideration of WG-Krill-93/7, had concluded that there is no need to impose any kind of restrictions on the fishery and, therefore, that no fruitful results will come from further dialogue to identify the options for potential measures for protection. Dr Hatanaka also indicated he felt that recent developments, such as the adjustment in FIBEX biomass estimates and the recent decline in total krill catch, support the conclusions of the fishermen.

6.67 Most participants noted that the developments cited by Dr Hatanaka as evidence for a lack of the necessity for a precautionary approach did not bear directly upon whether or not it is appropriate to discuss a range of options for potential precautionary measures.

6.68 Many participants noted that there is still substantial uncertainty regarding the true implications of competition between predators and the fishery. Such uncertainty was a primary factor for the recognition by the Scientific Committee of the importance of continuing a dialogue on the consequences to krill fishing countries and to predator populations resulting from implementing various precautionary measures.

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

ESTIMATES OF PREY REQUIREMENTS FOR KRILL PREDATORS

Krill Consumption by Predators

7.1 Last year WG-CEMP made considerable progress on this topic (SC-CAMLR-XI, Annex 7, paragraphs 7.2 to 7.9) by:

(i) noting the existence of the most recent summaries for the South Georgia ISR and providing a new summary in respect of energy budgets for Antarctic fur seals;

(ii) providing new summaries with respect to penguins and fur seals for the Antarctic Peninsula ISR;

(iii) providing the first synthesis of energy and prey consumption budgets for crabeater seals; and

(iv) providing a full synthesis of relevant data for the Prydz Bay ISR.

7.2 In reviewing priorities in 1992, WG-CEMP had concluded that further work on this topic was of a lower priority than other tasks relating to predator-prey-fishery interactions currently being undertaken by WG-CEMP (SC-CAMLR-XI, Annex 7, paragraph 7.12).

7.3 Some Members of the Scientific Committee had indicated a strong interest in obtaining estimates of krill consumption by selected predators in Subareas 48.1 and 48.2 (SC-CAMLR-XI, paragraph 5.58).

7.4 WG-CEMP noted that the data assembled last year provided all the information necessary for estimating the krill consumption of a range of predators for most conceivable purposes.

7.5 Members who require yet more detailed information or who need to adapt the information provided for more specialised purposes should contact those responsible for the appropriate data compilations.

7.6 In order to maintain up-to-date references on population size, diet and energy consumption of predators, Members were urged to table copies of relevant publications at WG-CEMP meetings. No such documents had been tabled at the present meeting.

7.7 In respect of a suggestion by WG-FSA in 1991 (SC-CAMLR-X, paragraphs 6.55 to 6.56) that krill predation by fish might be incorporated into WG-CEMP's estimates of prey consumption, WG-CEMP noted that WG-FSA was better placed to summarise available data on krill consumption and energy budgets of fish. However, a continuing dialogue on this topic between WG-FSA and WG-CEMP would be valuable.

Predator Performance and Krill Availability

7.8 An approach to understanding functional relationships between krill availability and predator performance was initiated at the Joint Meeting of WG-Krill and WG-CEMP in 1992 (SC-CAMLR-XI, Annex 8) and is described in detail in paragraph 2 and the Appendix of that Annex.

7.9 It was advised that models should be developed for several different predator species and that the information required for each would be:

(i) adult average annual survival rate;

(ii) age-at-first breeding; and

(iii) from the viewpoint of the predator, a division of years into good, poor and bad, these categories nominally corresponding to circumstances in which, respectively, breeding success and adult survival are good, breeding success is poor but adult survival unaffected and both breeding success and adult survival are poor.

Additional data on the timing of the breeding season of the predator were requested.

7.10 The tasks of providing these data were allocated by SC-CAMLR-XI, Annex 7, paragraph 7.18. Data were contributed by Dr Trivelpiece (Adélie penguin), Drs Croxall and Boyd (black-browed albatross and Antarctic fur seal) and Drs Boveng and Bengtson (crabeater seal). These data were circulated in SC CIRC 92/13 (with a revised version in SC CIRC 93/18).

7.11 Analysis of these data according to the methods developed in SC-CAMLR-XI, Annex 8, Appendix 1 was carried out by Drs D.S. Butterworth and R.B. Thomson (South Africa) and reported in WG-Krill-93/43. Dr Butterworth presented a review of the main findings of his paper to WG-CEMP.

7.12 A brief description of some of the main features of the analyses conducted and problems encountered is reported in SC-CAMLR-XII/4, paragraphs 5.12 to 5.21. An important general conclusion was that variability in the annual recruitment of krill results in predator populations having less resilience to krill harvesting than deterministic evaluations would suggest. However, quantitative descriptions of these effects and of acceptable levels of fishing intensity could not be undertaken until uncertainties over the validity of some of the data provided for the predators (particularly on adult survival) had been resolved.

7.13 Dr Butterworth was thanked for his clear presentation to WG-CEMP of WG-Krill-93/43 and he and his co-author were thanked for undertaking such a comprehensive analysis so promptly.

7.14 In reviewing the predator data as submitted and interpreted, Members noted that a number of problems had arisen, in part through insufficiently clear explanation of the exact nature of the data required and in part through lack of time for dialogue between Members submitting data and those undertaking the analysis.

7.15 Specifically, most of the submitted data on proportions of years in different categories were based on subjective assessment and, even where objective criteria were specified, the categories tended to reflect good, average (rather than poor) and bad years. In respect of values for adult survival, those submitted were mainly mean rather than maximum values. In addition, those for Adélie penguins and Antarctic fur seals were also underestimates, in that no allowance had been made for band/tag loss and related problems.

7.16 To clarify the sources and nature of the predator data, as well as to provide information in response to the questions posed by WG-Krill (paragraph 5.20), the data submitted and the methods used to collect them were reviewed for each parameter and follow as paragraphs 7.17 to 7.28.

Adult Survival

Adélie Penguin

7.17 The study populations at Admiralty Bay, King George Island, South Shetland Islands were built up by flipper-banding 200 pairs of adult birds each year. The survival value reported derived from the re-sighting data for the birds from each group observed one year later. Although these data are entirely comparable across years, they will consistently under-estimate adult survival because of:

(i) Deferred breeding (i.e., birds breeding in years n and n + 2 but being unrecorded in year n + 1). This is thought to be a small effect and could be corrected for by examining the records of birds seen in year n + 2;

(ii) Band loss. A study using double-banded birds indicated a rate of band loss of 4 to 5%, (i.e., under-estimating annual survival by this amount). However, double-banding significantly increased mortality rate so a subsequent study, comparing single-banded and transponder-implanted birds, is in place and results should be available in December 1993;

(iii) Band-induced mortality. Even applying single bands may decrease annual survival; the above study will contribute to assessing the magnitude of this effect; and

(iv) Emigration from the study area. This is not believed to be a significant factor in Adélie penguin populations and no reports of breeding Adélies banded at Admiralty Bay have been received from other investigators working in nearby colonies on King George Island.

The study population has fluctuated considerably over the study years 1977 to 1993 but there is no statistically significant overall trend. However, the population has not yet recovered from the significant declines following the 1989 and 1990 winters and currently is at its historically lowest level.

Black-browed Albatross

7.18 The sources and methods used to derive these data are described in WG-CEMP-93/6 for the study at Bird Island, South Georgia. All birds breeding in selected study colonies are double-banded (with Monel metal and Darvic plastic leg bands). Almost every bird breeding in these colonies is recaptured annually and survival is calculated taking into account birds that defer breeding for one or more years. The value provided is the average, for both sexes combined, of the mean values calculated for each of the 15 years for which estimates are available. There is no emigration of breeding birds, no band loss and no band-induced mortality, so the survival estimates are likely to be of high accuracy. The study populations have declined at between 0.5% to 2.0%

annually over the study period (1976 to 1991), though without any statistically significant decrease in adult survival; however, the latter has been declining markedly since 1988.

Crabeater Seal

7.19 The methods used are described in detail in WG-CEMP-93/4. Basically the value submitted is the weighted average age-specific survival rate (estimated using a five parameter survivorship model) derived from catch-at-age data on 2 852 seals collected in the Antarctic Peninsula area between 1964 and 1990. The value, of 0.93, is therefore averaged across some 44 years of varying characteristics; to the extent that some years would be less than good, this value is an under-estimate. However, conditions in the 1950s to 1970s may have been particularly favourable for this species. Data on the actual population trends in crabeater seals are incomplete; census data from 1983 indicated lower seal densities than had been observed in the late 1960s and early 1970s (Erickson and Hanson, 1990[3]), but it is at present unknown whether this is a result of a decline in population abundance or other factors such as a change in distributions.

Antarctic Fur Seal

7.20 The adult survival rate estimate submitted (0.79) is the average of annual estimates based on re-sightings of tagged adult female seals from 1987/88 to 1991/92 at the main study site on Bird Island, South Georgia. It will be an under-estimate due to:

(i) Tag loss. This is a significant problem (though substantially less than with tagged pups) but difficult to quantify. Some data for double-tagged animals are available and these will be analysed to adjust the adult survival estimate; and

(ii) Emigration. Female fur seals at Bird Island show considerable site fidelity (Lunn and Boyd, 1991[4]) and tagged animals on other Bird Island beaches would readily be recognised so this is likely to be of negligible significance. Deferred breeding is allowed for in the estimate, and tag-induced mortality is believed to be negligible. Following very rapid expansion over the past 30 years (initially around 17% per annum, decreasing to 10% p.a.), the rate of increase of the population of breeding

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3 Erickson, A.W. and M.B. Hanson. 1990. Continental estimates and population trends of Antarctic ice seals. In: Kerry, K.R. and G. Hempel (Eds). *Antarctic Ecosystems. Ecological Change and Conservation*. Springer-Verlag, Berlin: 254-264.

4 Lunn, N.J. and I.L. Boyd. 1991. Pupping site fidelity of Antarctic fur seals at Bird Island, South Georgia. *Journal of Mammalogy*, 72: 202-206.

females at Bird Island has been less than 1% p.a. over the last five years. The South Georgia population as a whole, however, is still increasing at around 10% p.a. (Boyd, 1993[5]).

Age-at-First-Breeding

Adélie Penguin

7.21 The value submitted is the mean of ages at which tagged female chicks were first observed to breed in the years 1981 to 1987. Recruitment is highly variable between years (though without systematic trend) and the value will therefore be somewhat biased (probably downward) by the contribution of large numbers of birds recruiting in good years.

Black-browed Albatross

7.22 The data used to give the modal value are the average for both sexes combined (no significant difference between sexes) of the relatively small number of known-age birds which has been recruited in recent years (see WG-CEMP-93/6). There may be a bias similar to that for Adélie penguins but it will be less than 0.1 year. There is no indication of any trend in age of recruitment (unlike the situation in the wandering albatross).

Crabeater Seal

7.23 Data on age-at-sexual maturity (first ovulation) from counts of *corpora* in females aged by counts of tooth annuli were used to derive annual estimates for all seals in the collection referred to above (see WG-CEMP-93/4 for further details). There is a trend to increasing age of sexual maturity from 3.0 in the mid-1960s to nearly 5.0 in the late 1980s. The value proposed, of 3.8 years, is the mid-point of the whole data set; current values would be about one year greater. Butterworth and Thomson (WG-Krill-93/43) used a value of 5 years for age at first parturition. There may be some biases due to differential recruitment in good years but the large range of years should minimise this effect.

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5 Boyd, I.L. 1993. Pup production and distribution of breeding Antarctic fur seals *Arctocephalus gazella* at South Georgia. *Antarctic Science*, 5:17-24.

Antarctic Fur Seal

7.24 Data are based on the observed average age-at-first parturition of seals tagged as pups for the years 1983/84 to 1991/92. For their analysis, Butterworth and Thomson erroneously added one year to the estimate provided of 3.5 years. There is no evidence of any significant change in this parameter over the past decade (Boyd *et al.*, 1990[6]).

Interannual Variation

Adélie Penguin

7.25 These proportions were based on the variation in breeding success (proportion of chicks surviving to creche stage) for the years 1977 to 1992 (Trivelpiece *et al.*, 1990[7] and unpublished data).

Black-browed Albatross

7.26 The proportions provided were based on the variation in breeding success (proportion of chicks fledged from eggs laid) or of annual adult survival for the years 1975-76 to 1990-91 (WG-CEMP-93/6, Tables 5 and 10).

Crabeater Seal

7.27 The proportions were based on frequency data of estimated strength of cohorts from 1945 to 1988 (Testa *et al.*, 1991[8]; Boveng, 1993[9]) divided into thirds as described in WG-CEMP-93/4.

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6 Boyd, I.L., N.J. Lunn, P. Rothery and J.P. Croxall. 1990. Age distribution of breeding female Antarctic fur seals in relation to changes in population growth rate. *Canadian Journal of Zoology*, 68: 2209-2213.

7 Trivelpiece, W.Z., S.G. Trivelpiece, G.R. Geupel, J. Kjelmyr and N.J. Volkman. 1990. Adélie and chinstrap penguins: their potential as monitors of the Southern Ocean ecosystem. In: Kerry, K.R. and G. Hempel (Eds). *Antarctic Ecosystems. Ecological Change and Conservation.* Springer-Verlag, Berlin Heidelberg: 191-202.

8 Testa, J.W., G. Oehlert, D.G. Ainley, J.L. Bengtson, D.B. Siniff, R.M. Laws and D. Rounsevell. 1991. Temporal variability in Antarctic marine ecosystems: periodic fluctuations in the phocid seals. *Can. Journ. of Fisheries and Aquatic Sciences*, 48: 631-639.

9 Boveng, P.L. 1993. Variability in a crabeater seal population and the marine ecosystem near the Antarctic Peninsula. Ph.D. Thesis. Montana State University, Bozeman, Montana, USA.

Antarctic Fur Seal

7.28 The proportions were based on variation in average values of foraging trip duration, pup mortality and male and female pup growth rates for the years 1983/84 to 1991/92 (WG-CEMP-93/9 and 10; Lunn, 1993[10]). The submitted data were somewhat subjectively assessed overall as good/average/bad in the proportions 1:6:2. More objective assessment would have produced ratios of 3:4:2 (foraging trips), 2:5:2 (pup mortality) and 3:5:1 (growth rates).

Further Discussion on the Modelling Exercise

7.29 This review indicates that some quite substantial modifications to the data submitted and to the analyses based thereon are required.

7.30 In particular, those contributing the original data (i.e., Adélie penguin, Dr Trivelpiece; black-browed albatross and Antarctic fur seal, Drs Croxall and Boyd; crabeater seal, Drs Bengtson and Boveng) were asked to supply as much information as possible in terms of year-specific values, so that the actual distributions of data values (rather than some more or less arbitrary classifications of these) can be used in the analysis.

7.31 In addition, contributors were asked to submit information for the original datasets and sites that were used in the model concerning:

(i) the magnitude of under-estimates of adult survival, where appropriate (Adélie penguin, Antarctic fur seal);

(ii) maximum rates of population increase recorded for closed populations of each predator species;

(iii) observed rates of change in population size (together with statistical significance and likely reasons) for the population used to derive the submitted data over the study period; and

(iv) quantitative data on diet, indicating the degree of dependence on krill of each predator species.

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10 Lunn, N.J. 1993. The reproductive ecology of female Antarctic fur seals *Arctocephalus gazella* during lactation. Ph.D. Thesis, Open University: xv+201 pp.

These responses should take care of all but the last of the queries from WG-Krill (SC-CAMLR-XII/4, paragraph 5.20).

7.32 In respect of identifying other krill-dependent populations for which equivalent data are available (SC-CAMLR-XII/4, paragraph 5.20), WG-CEMP suggested that Adélie penguins at other sites, e.g. Béchervaise Island (see WG-CEMP-93/19) and the gentoo penguins at Bird Island, South Georgia, for which data have been provided in WG-CEMP-93/8, would be suitable.

7.33 All data requested in paragraphs 7.30 and 7.31 to undertake this re-analysis would be transmitted to the Convener of WG-CEMP by 31 December 1993. He would be responsible for their collation and transmission to the CCAMLR Secretariat for circulation to all Members and to all attendees at the 1992 and 1993 meetings of WG-Krill and WG-CEMP.

7.34 Some general discussion followed on the topic of assessing functional relationships between predators and prey through the type of model being used above.

7.35 Japanese scientists pointed out that factors other than krill availability contributed to the observed variation in survival, breeding success, reproductive performance and cohort strength from which the distributions of interannual variation were derived.

7.36 The Working Group noted that:

(i) the analyses being undertaken are still preliminary and can be refined further when relevant quantitative data on the influence of other environmental factors are available;

(ii) the evidence for breeding success, foraging trip duration, offspring growth and other reproductive performance variables being directly affected by food availability was many times stronger than any evidence of direct effects of ice, weather, etc. in the species and situations under consideration. However, it was recognised that survival rate can be affected by ice and weather conditions, especially in winter. Any years where poor survival and reproductive performance could be attributed to ice or weather should be clearly identified by contributors when submitting data;

(iii) krill availability to predators within their foraging range while rearing offspring, rather than krill biomass in some larger areas, is the most appropriate variable for assessing functional relationships;

(iv) krill availability to predators is affected not only by krill biomass and distribution, but also by aspects such as its aggregation patterns in relation to predators' foraging behaviour; and

(v) all analyses in WG-Krill-93/43 need repeating using the corrected data.

7.37 However, it was recognised that the present modelling initiatives were being undertaken because there were no suitable empirical data with which to derive functional relationships. Members were again encouraged to acquire appropriate data on relationships between estimates of krill biomass and krill availability to predators in order to enable realistic functional relationships to be assessed empirically.

7.38 It is unlikely that this can be done quickly. In the meantime, WG-CEMP agreed that models such as those developed in WG-Krill-93/43 offered a good starting point for examining these important relationships. Indeed, it was emphasised that the predator data being used in these models were among the best available for marine mammals and birds anywhere.

7.39 Members were encouraged to undertake their own analyses of the newly-submitted data so that more than one set of evaluations could be available for consideration.

LIAISON WITH WG-KRILL AND WG-FSA

8.1 The Working Group noted that numerous topics of common interest with WG-Krill and WG-FSA had been discussed under agenda items 4 to 7 (see paragraphs 4.30, 5.30 to 5.33, 6.52 to 6.58 and 7.7 to 7.39). In particular, efforts to model the functional relationships between predator performance and krill availability were cited as a good example of a productive collaboration between WG-CEMP and WG-Krill.

8.2 Last year, the Scientific Committee had agreed that it would be important to try to hold a joint meeting of WG-CEMP and WG-Krill in 1994 (SC-CAMLR-XI, paragraph 6.15). The Working Group recommended that every effort should be made to arrange such a meeting.

8.3 Last year, dialogue between WG-CEMP and WG-FSA was initiated to try to incorporate relevant data from certain fish species in the assessments forming part of SC-CAMLR-XI, Annex 7, Table 4 (Table 5, this Report). WG-FSA had noted that it would take time to refine the type of parameters to be included and to evaluate the applicability of the approach as a whole. It had invited submissions on this topic for its 1993 meeting.

OTHER BUSINESS

IUCN Assessment of Marine Protected Areas

9.1 At its 1992 meeting, the Working Group was informed of the IUCN initiative to assess the World's marine protected areas and identify priority areas for conserving global marine biodiversity. If funds were to be made available from the World Bank to help support conservation of global marine diversity, then providing some type of financial support to CEMP might be an effective way for the Global Environment Facility to achieve some of its objectives (SC-CAMLR-XI, Annex 7, paragraphs 9.4 and 9.5).

9.2 The Convener had been asked to investigate this matter further (SC-CAMLR-XI, Annex 7, paragraph 9.6) , to determine:

(i) whether these programs' goals corresponded to those of CCAMLR and the work of WG-CEMP;

(ii) the prospects and circumstances under which funding may be made available for this initiative by the World Bank;

(iii) whether or not WG-CEMP should consider recommending to the Scientific Committee that a proposal be developed requesting that the World Bank provide funds in support of CEMP.

9.3 He reported that he had been unable to make further progress with his investigation. The Working Group gratefully accepted an offer from Drs Bengtson and Penhale to pursue this matter further and report back to WG-CEMP at its next meeting.

Sixth SCAR Symposium on Antarctic Biology

9.4 Dr S. Focardi (Italy) reminded the Working Group that the Sixth SCAR Symposium on Antarctic Biology will be held from 30 May to 3 June 1994 in Venice, Italy. The deadline for notifying the Symposium organisers of an intention to submit a verbal or poster presentation is 1 October 1993. The themes of the Symposium will be Antarctic Biodiversity, Life History Strategies and Environmental Change and Human Impact. Meetings of the SCAR Subcommittee on Bird Biology and the SCAR Group of Specialists on Seals will immediately precede the Symposium.

9.5 The report of a meeting of Conveners of CCAMLR Working Groups, held in November 1992 and available to the Working Group as SC-CAMLR-XII/BG/12, contained a recommendation that the Science Officer present a poster describing the aims and achievements of CCAMLR to the Symposium.

9.6 The Working Group recommended that the Scientific Committee endorse this suggestion and in the meantime encouraged the Chairman of the Scientific Committee, Dr K.-H. Kock, to ask the Science Officer to submit a preliminary proposal for a poster to the Symposium organisers prior to the 1 October 1993 deadline.

SO-GLOBEC

9.7 The Working Group noted that information on the aims and organisation of SO-GLOBEC had been presented to WG-Krill (SC-CAMLR-XII/4, paragraphs 7.4 to 7.6).

9.8 Dr Croxall introduced WG-CEMP-93/29 which contained the draft report of the meeting of the SO-GLOBEC Top Predator Group. He emphasised that the development by this Group of a research program into the nature of interactions between zooplankton and higher predators was still at an early stage, and that the coordination with other groups working in the Antarctic (CCAMLR Working Groups, Scientific Committee and SCAR) was essential to identify areas of common interest and avoid duplication of effort. For this reason, the SO-GLOBEC Group had suggested that the topic of SO-GLOBEC should be placed on the agenda of both WG-Krill and WG-CEMP.

9.9 There was a particular requirement for SO-GLOBEC to develop a more detailed program for top predators (because this has hitherto received less attention than the zooplankton research program) and the assistance of CCAMLR and SCAR had been specifically invited in this regard. A workshop to consider this topic will be held, probably at Cambridge, UK, in 1994.

9.10 At its initial implementation meeting, the Top Predator Group had identified a number of target predator species, research objectives and candidate experimental sites which were in general more broadly defined than those of CEMP. Although the objectives of SO-GLOBEC and some of the scientific initiatives of CCAMLR may be similar, there are differences in time scales and specific aims between the two groups (in particular, SO-GLOBEC will run for a limited period of five to eight years). It is expected that SO-GLOBEC will emphasise the use of new technology and techniques, including extensive modelling, which may be of utility to CCAMLR in the future development of its research programs.

9.11 Concern was expressed that there would be potential for competition for finances between SO-GLOBEC and CEMP since there were some areas of similar research objectives. The involvement of CCAMLR and SCAR at this early stage in the planning of SO-GLOBEC should minimise these risks. In some areas of research, such as zooplankton ecology, the existence of the SO-GLOBEC program may make available data and resources not currently accessible to CCAMLR.

9.12 The Working Group endorsed the recommendation of WG-Krill that the Scientific Committee should consider nominating an observer to the SO-GLOBEC program (SC-CAMLR-XII/4, paragraph 7.10) and that the liaison between SO-GLOBEC and the Scientific Committee and its Working Groups should continue.

SCAR Antarctic Pack-ice Seals (APIS) Program

9.13 The Convener introduced a draft prospectus describing a new international research initiative on pack-ice seals, coordinated by the SCAR Group of Specialists on Seals (WG-CEMP-93/22). This draft prospectus, for the Antarctic Pack-ice Seals (APIS) Program, was produced at a workshop held in May, 1993, sponsored in part by CCAMLR (SC-CAMLR-XI, paragraph 7.18).

9.14 The APIS Program is being developed to address several research topics of direct relevance to CCAMLR, and especially to the work of WG-CEMP. For example, although crabeater seals have been selected as a CEMP monitoring species, implementation of CEMP activities in the pack-ice zone has been modest because of the limited availability of logistic and financial support. It is expected that the pack-ice seal research outlined in the APIS Program will represent a major contribution to CEMP.

9.15 Priority field research activities in this program are planned over the five-year period from 1995/96 to 1999/2000. Three of the five APIS operations areas fall within CEMP ISRs (Antarctic Peninsula/South Shetland Islands, Bellingshausen Sea, and Prydz Bay). Funding for these studies will primarily be sought from national programs.

9.16 The Working Group welcomed this new initiative, noting that both the APIS Program and CEMP would be able to contribute significantly to each other's work. The Working Group recommended that the APIS Program's development should be brought to the Scientific Committee's attention, and that efforts should be made to ensure that close coordination and effective communication are developed and maintained between these two programs.

Exploratory Fisheries

9.17 The Working Group noted the discussions of WG-Krill on exploratory fisheries (SC-CAMLR-XII/4, paragraphs 7.1 to 7.3), and considered a draft document prepared by the US Delegation outlining a possible approach to developing a procedure for evaluating fisheries during their exploratory phase (CCAMLR-XII/5). The Working Group agreed that the draft document provided a good basis for considering this issue. Suggestions on improving the draft were made to the authors, who indicated their intention to submit a revised version to WG-FSA, the Scientific Committee and the Commission.

SUMMARY OF RECOMMENDATIONS AND ADVICE

10.1 The Working Group made the following recommendations to the Scientific Committee:

(i) that a short newsletter, describing major results and conclusions of WG-CEMP, be prepared and distributed annually following the completion of the Scientific Committee meeting (paragraph 3.6);

(ii) that the draft Management Plan for the protection of Cape Shirreff and San Telmo Islands, South Shetland Islands be considered by the Scientific Committee (paragraph 4.1);

(iii) that Members maintain national registers of electronic tags and associated banding data (paragraph 4.27);

(iv) that funds be considered for supporting a workshop on at-sea behaviour methodology, tentatively proposed for 1995 (paragraph 4.20);

(v) that the Secretariat be asked to continue to receive and process JIC data on sea-ice distribution (paragraph 4.38);

(vi) that Members be strongly encouraged to submit to the CCAMLR Data Centre all available predator data collected in accordance with CEMP Standard Methods (paragraph 5.2);

(vii) that the Secretariat be asked to refine its model of krill fishery behaviour (paragraph 6.63);

(viii) that every effort should be made to arrange a joint meeting of WG-Krill and WG-CEMP in 1994 (paragraph 8.2);

(ix) that the recommendation of the meeting of Conveners of CCAMLR Working Groups (November 1992) for the Science Officer to participate in the Sixth SCAR Symposium on Antarctic Biology and to present a poster describing the aims and achievements of CCAMLR, be endorsed (paragraph 9.6);

(x) that the recommendation of WG-Krill of nominating an observer to the SO-GLOBEC program be supported (paragraph 9.12); and

(xi) that close coordination and effective communication be developed between CEMP and SCAR's Antarctic Pack-ice Seals (APIS) Program (paragraph 9.16).

ADOPTION OF THE REPORT AND CLOSE OF THE MEETING

11.1 The Report of the Meeting was adopted.

11.2 In closing the meeting the Convener thanked participants, rapporteurs, subgroups and the Secretariat for their work and assistance during the meeting. He noted that many CCAMLR Members had been actively involved in CEMP activities during the past year, and that these efforts and the papers presented at the meeting had contributed significantly to the meeting's success.

11.3 The Convener stated that, in his view, the work and challenges being addressed by CEMP reflected a fundamental tenet of the ecosystem approach embodied in the Convention. He congratulated the members of WG-CEMP for their excellent progress over the past nine years in developing a sound scientific program, which is serving as a pioneering effort to help incorporate an ecosystem perspective into considerations of conservation and management issues in Antarctica.

11.4 The Working Group expressed its gratitude to the Government of the Republic of Korea, the Polar Research Center of the Korea Ocean Research and Development Institute, and the Seoul National University for hosting the meeting. The Working Group further expressed its thanks to all those who assisted with the organisation of the meeting and for their warm hospitality.

Table 1: Summary of Members' CEMP activities on monitoring approved predator parameters.

Parameter		Species[1]	Country	Site Name/ Integrated Study Region/ Network Site	Year Started[2]	Data Submitted[2]	Being Prepared[2]
Penguins							
A1	Weight on arrival at breeding colonies	A	Australia	Magnetic Is Prydz Bay	1984		1990-91
		A	Australia	Béchervaise Is		1992-93	
		A	Argentina	Stranger Point/ King George Is	1988	1988-90	1991
		A	Argentina	Laurie Is S. Orkney Is	1988	1988-90	1991
			Argentina	Esperanza St.	1991	1991	
		A	Germany	Ardley Is/ S. Shetlands	1991		
		M	UK	Bird Is/ South Georgia	1990	1990-93	
A2	Length of the first incubation shift	A	Australia	Magnetic Is Prydz Bay	1984		1989-91
		A	Australia	Béchervaise Is/ Mawson	1991	1991-93	
		A	Argentina	Stranger Point King George Is	1988		1990-91
			Argentina	Esperanza St.	1991		1991
		A	Germany	Ardley Is/ S. Shetlands	1991		
A3	Annual trends in breeding population size	A	Australia	Magnetic Is Prydz Bay	1984		1990-91
		A	Australia	Béchervaise Is		1992-93	
		A	Argentina	Stranger Point/ King George Is	1988		1990-91
				Esperanza St.	1991		1991
		M,C	Brazil	Elephant Is S. Shetlands	1986	1992	
		A,C	Chile	Ardley Is S. Shetlands	1982		1989-92
		A	Japan	Syowa Station/ Network site	1970		1989-91

Table 1 (continued)

Parameter		Species[1]	Country	Site Name/ Integrated Study Region/ Network Site	Year Started[2]	Data Submitted[2]	Being Prepared[2]
A3 continued		M,G	UK	Bird Is/ South Georgia	1976	1990-93	
		A,C,G	UK	Signy Is/ Network site	1979	1990-93	
		A	USA	Anvers Is	1992	1993	
		A	Germany	Ardley Is/ S. Shetlands	1991		
A4	Demography	C	Chile	Ardley Is S. Shetlands	1982		1989-92
		M,C	Brazil	Elephant Is S. Shetlands	1986	1989-92	1989-92[3]
		M,C	USA	Seal Is S. Shetlands	1988		1990-93[3]
		A	USA	Anvers Is Palmer Station	1988		1989-93[3]
A5	Duration of foraging trips	A	Australia	Magnetic Is Prydz Bay	1984		1990-91
				Béchervaise Is	1992		
		C	USA	Seal Is S. Shetlands	1988	1988-93	
		A	USA	Anvers Is Palmer Station	1990	1990-93	
		M	USA	Seal Is		1990	
A6	Breeding success	A	Australia	Magnetic Is Prydz Bay	1984		1989-91
		A	Australia	Béchervaise Is	1992	1992-93	
		A	Argentina	Stranger Point/ King George Is	1988		1990-91
				Laurie Is/ Esperanza St.	1991		1991
		M,C	Brazil	Elephant Is S. Shetlands	1986	1990-92	
		C	Chile	Ardley Is S. Shetlands	1982		1989-92
		C,G	Korea	Barton Pen., King George Is	1992		1992-93
		M,G	UK	Bird Is/ South Georgia	1976	1990-93	

Table 1 (continued)

Parameter		Species[1]	Country	Site Name/ Integrated Study Region/ Network Site	Year Started[2]	Data Submitted[2]	Being Prepared[2]
A6 continued		A,C,G	UK	Signy Is/ Network site	1979	1990-93	
		M,C	USA	Seal Is S. Shetlands	1988	1988-93	
		A	USA	Anvers Is Palmer Station	1988	1990-93	
		A	Germany	Ardley Is	1991		
A7	Fledging weight	A	Australia	Magnetic Is Prydz Bay	1984		1990-91
		A	Australia	Béchervaise Is	1992	1993	
		M	Brazil	Elephant Is S. Shetlands	1986	1992	
		C	Brazil	Elephant Is S. Shetlands	1986	1990-92	
		M,G	UK	Bird Is/ South Georgia	1989	1990-93	
		C	USA	Seal Is S. Shetland Is	1988	1988-92	
		A	USA	Anvers Is Palmer Station	1988	1990-93	
		M	USA	Seal Is		1990	
		A	Germany	Ardley Is	1991		
		G	Korea	Barton Pen., King George Is	1992		1992
A8	Chick diet	A	Australia	Magnetic Is Prydz Bay	1984		1990-91
		A	Australia	Béchervaise Is Mawson	1991	1991-92	
		M,C	Brazil	Elephant Is S. Shetlands	1986	1992	
		C	Chile	Ardley Is S. Shetland Is	1982		1989-90
		M	UK	Bird Is/ South Georgia	1986	1990-93	
		G	UK	Bird Is/ South Georgia	1986	1990-93	
		C	USA	Seal Is S. Shetlands	1988	1988-91	1993

Table 1 (continued)

Parameter		Species[1]	Country	Site Name/ Integrated Study Region/ Network Site	Year Started[2]	Data Submitted[2]	Being Prepared[2]
A8 continued		A	USA	Anvers Is Palmer Station	1988	1990-93	
		A	Germany	Ardley Is	1991		
A9	Breeding chronology	A	Australia	Magnetic Is Prydz Bay	1984		
		A	Australia	Béchervaise Is/ Mawson	1991		1991-93
		C,M	USA	Seal Is S. Shetland Is	1988	1988-93	
		A	USA	Anvers Is	1988	1990-93	
Flying birds							
B1	Breeding population size	B	UK	Bird Is/ South Georgia	1977	1977-93	
B2	Breeding success	B	UK	Bird Is/ South Georgia	1977	1977-93	
B3	Age-specific annual survival and recruitment	B	UK	Bird Is/ South Georgia	1977	1977-91	
Seals							
C1	Cow foraging/ attendance cycles	F	Chile	Cape Shirreff	1988	1988	
		F	UK	Bird Is/ South Georgia	1979	1990-93	
		F	USA	Seal Is S. Shetland Is	1988	1988-93	
C2	Pup growth	F	Chile	Cape Shirreff/ Ant. Peninsula	1985	1984-85 1990-92	
		F	UK	Bird Is/ South Georgia	1973 1978	1990-93	
		F	USA	Seal Is S. Shetland Is/	1988	1988-93	

[1] A - Adélie penguin, M - Macaroni penguin, C - Chinstrap penguin, G - Gentoo penguin, B-Black-browed albatross, F - Fur seal

[2] All years referred to are split-years

[3] At present these data are not requested for submission to the CCAMLR Data Centre

Table 2: Directed research programs required to evaluate the utility of potential predator parameters.

Parameter	Member (species, area or site[b])	Data Collected (years)	Data Analysed (years)	Reference to Published Results[c]	Research to be Continued (years)	Principal Scientists, Institution
Penguins[a] Weight prior to moult						
At-sea diving behaviour and activity pattern	Australia (A-18)	1992-93	1992-93	Kerry *et al*., 1993; Kerry *et al*., (in prep.)	1994	K. Kerry, Aust. Antarc. Div.
	Germany (A,G-11)	1987-88	1989-90	Culik, 1993; Culik & Wilson, 1993; Culik *et al*., 1992, 1993; Cooper *et al*., 1993; Pütz, 1993; Weimerskirch & Wilson, 1992; Wilson, 1992; Wilson & Culik, 1992; Wilson *et al*., 1992, 1993a, 1993b	1993-94	
	Germany (A,C,G-2)	1991-92	1992-93	Culik, 1993; Culik & Wilson, 1993; Culik *et al*., 1992, 1993; Cooper *et al*., 1993; Pütz, 1993; Weimerskirch & Wilson, 1992; Wilson, 1992; Wilson & Culik, 1992; Wilson *et al*., 1992c, 1993a, 1993b		
	Japan, Australia (A-6)	1992-93				
	NZ (A-1)	1985-90	1985-90	Davis *et al*., 1988; Davis & Miller, 1993; Sadlier & Lay, 1990	1993-94	L. Davis, Univ. of Otago
	UK (G,M-4)	1989-93 1989	1989-90 1989	Williams *et al*., 1992a; Williams *et al*., 1992b Croxall *et al*., 1993	1994	J. Croxall, BAS (1991-93 P. Butler, Univ. B'ham)
	USA (C,M-2)	1988-1993	1989-1991	Bengtson & Eberhardt, 1989; Bengtson *et al*., 1990; Bengtson *et al*., 1991a; Bengtson *et al*., 1991b; Croll *et al*., 1991; Croll *et al*., 1992; Bengtson *et al*., 1993; Croll *et al*., (in prep.)	continuing	J. Bengtson, NMML
	USA (A,G,C-2)	1989-92	In progress		1994	W. Trivelpiece, Montana State Univ.
Weight recovery during incubation	Australia (A-18)	1991-93	1991-92	Kerry *et al*., 1993	1994-96	K. Kerry, Aust. Antarc. Div.
	NZ (A-1)	1987-89	1987-89	Davis & Miller, 1993		L. Davis, Univ. of Otago
	USA (A, C-2)	1984-85, 1988	1984-85, 1988	Trivelpiece & Trivelpiece, 1990	1994	W. Trivelpiece, Montana State Univ.
	USA (A-11)	1993		Trivelpiece & Trivelpiece, 1990	1994	W. Trivelpiece, Montana State Univ.

Parameter	Member (species, area or site[b])	Data Collected (years)	Data Analysed (years)	Reference to Published Results[c]	Research to be Continued (years)	Principal Scientists, Institution
Penguins (continued)						
Survival	Australia (A-18)	1991-93	1991-93	Clarke, (in prep.)	1994-95	K. Kerry, Aust. Antarc. Div.
	NZ (A-1)	1977, 1984	1977, 1984	Davis & McCaffrey, 1986		L. Davis, Univ. of Otago
	UK (G, M-4)	1987-91	1987-90	Williams & Rodwell, 1992	1994	J. Croxall, BAS
	USA (C-2)	1988-93			continuing	J. Bengtson, NMML
	USA (A-11)	1988-93				W. Trivelpiece, Montana State Univ.
Chick growth rate	Chile (A, G-2)	1982-93	1982-93		1994	J. Valencia, Univers. de Chile
	Japan, Australia (A-6)	1992-93			1993-94	Y. Watanuki, Nat. Inst. of Polar Res.; G. Robertson, Aust. Antarc. Div.
	Korea (C, G-2)	1992-93				S. Kim, Polar Res. Center, KORDI
	NZ (A-1)	1977, 1984	1977, 1984	Davis & McCaffrey, 1989		L. Davis, Univ. of Otago
	Norway (M,C-17)	1989-90				E. Røskaft, Univ. of Trondheim
	UK (G-4)	1977, 1980, 1987-90	1977, 1980, 1987-90	Williams & Croxall, 1990; Williams & Croxall, 1991		J. Croxall, BAS
	USA (C-2)	1988-93			continuing	J. Bengtson, NMML
Bioenergetics	Australia (A-18)	1991-93	1991-92	Kerry *et al*., 1993	1994-95	K. Kerry, Aust. Antarc. Div.
	Germany (A,C,G-11)	1987-88, 1989-90	1988-91	Bannasch & Fiebig, 1992; Culik, 1992a, b, c, d; Culik & Wilson, 1992; Wilson *et al*., 1992a, b; Wilson & Culik, 1993		
	Germany (A,C,G-2)	1991-92	1992-93	Bannasch & Fiebig, 1992; Culik, 1992a, b, c, d; Culik & Wilson, 1992; Wilson *et al*., 1992a, b; Wilson & Culik, 1993		
	NZ (A-1)	1984-85	1984-85	Green & Gales, 1990		B. Green, CSIRO, L. Davis, Univ. of Otago
	UK (G-4)	1991-93	Some	None		P. Butler, Univ. B'ham
Reproductive strategies	Japan, Australia (A-6)	1992-93			1993-94	Y. Watanuki, Nat. Inst. of Polar Res; G. Robertson, Antarc. Div.
	NZ (A-1)	1984-90	1984-90	Davis, 1991; Davis & Spiers, 1990	1993-94	L. Davis, Univ. of Otago

Parameter	Member (species, area or site[b])	Data Collected (years)	Data Analysed (years)	Reference to Published Results[c]	Research to be Continued (years)	Principal Scientists, Institution
Penguins (continued)						
Reproductive strategies (cont.)	Norway (M,C-17)	1989-90				E. Røskaft, Univ. of Trondheim
Flighted seabirds [a]						
Breeding population size	Norway (Cp-16)	1985				F. Mehlum, Norw. Polar Inst. (NPI)
	Norway (Cp, Ss-16)	1990		Haftorn *et al*., 1991; Mehlum *et al*., 1988; Røv, 1991		N. Røv, Norw. Inst. Nature Research (NINA)
	Norway (Cp, Ss-16)	1992	1991-92			S. Lorentsen, NINA
	Norway (Cp-16)	1993			1997	B. Sæther, NINA
Breeding success	Norway (Cp, Ss-16)	1990		Haftorn *et al*., 1991; Mehlum *et al*., 1988; Røv, 1990		N. Røv, NINA
	Norway (Cp, Ss-16)	1992	1992			S. Lorentsen, NINA
	Norway (Cp-16)	1993			1997	B. Sæther, NINA
Chick weight at fledging	Norway (Cp,Sp-16)	1990		Haftorn *et al*., 1991; Mehlum *et al*., 1988; Røv, 1990		N. Røv, NINA
	Norway (Cp,Sp-16)	1992	1991-92		1996	S. Lorentsen, NINA
	UK (Ba-4)	1989-93	1989-91	None	indefinitely	J. Croxall, P. Prince, BAS
	USA (Cp-2)	1990-1993			continuing	J. Bengtson, NMML
Duration of foraging trips	Norway (Cp-16)	1985				F. Mehlum, NPI
	Norway (Cp,Sp-16)	1990		Haftorn *et al*., 1991; Mehlum *et al*., 1988; Røv, 1990		N. Røv, NINA
	Norway (Cp,Sp-16)	1992	1991-92			S. Lorentsen, NINA
	Norway (Cp-16)	1993			1997	B. Sæther, NINA
	UK (Ba-4)	1989-93	Some	None	1994	J. Croxall, P. Prince, BAS
Activity budget at sea	UK (Ba-4)	1990-93	Some	None	1994	J. Croxall, P. Prince, BAS
Prey characteristics (diet)	Norway (Cp-16)	1990/92			1997	B. Sæther, NINA
	UK (Ba-4)	1976-77, 1980, 1986	1976-77, 1986	Croxall *et al*., 1988	1994	J. Croxall, P. Prince, BAS
Meal size	UK (Ba-4)	1976-78, 1980, 1986, 1991-93	1976-78, 1980, 1986	Croxall *et al*., 1988	1994	J. Croxall, P. Prince, BAS

Parameter	Member (species, area or site[b])	Data Collected (years)	Data Analysed (years)	Reference to Published Results[c]	Research to be Continued (years)	Principal Scientists, Institution
Flighted seabirds (continued)						
Adult mortality/ survival	Norway (Cp,Ss-16)	1992/93			1997	B. Sæther, NINA
Fur seals						
Reproductive success	Chile (2)	1987, 1990-93	1987	Oliva *et al*., 1987		D. Torres, INACH
	UK (4)	1979, 1981-93	1979, 1981-86, 1984-92	Croxall *et al*., 1988 Lunn & Boyd, 1993; Lunn *et al*., 1993; Lunn *et al*., (submitted)	indefinitely	I. Boyd, BAS
	USA (2)	1987-1993			continuing	J. Bengtson, NMML
Prey characteristics (diet)	UK (4)	1989-93	1989-90	Boyd *et al*., 1991	indefinitely	I. Boyd, BAS
	USA (2)	1988-1993			continuing	J. Bengtson, NMML
At-sea diving behaviour and activity pattern	UK (4)	1983, 1989-93	1983, 1989-90, 1989-93	Croxall *et al*., 1985 Boyd & Croxall, 1992 Boyd *et al*., (submitted)	1994-96	I. Boyd, BAS
	USA (2)	1987-1993	1989-1991	Bengtson & Eberhardt, 1989; Bengtson *et al*., 1990; Bengtson *et al*., 1991a; Bengtson *et al*., 1991b; Boveng *et al*., 1991	continuing	J. Bengtson, NMML
Bioenergetics	UK (4)	1988-89, 1991-93	1988-89 Some	Boyd & Duck, 1991 None	1994-96	I. Boyd, BAS, P. Butler, Univ. B'ham (1991-93)
Indices of physiological condition	UK (4)	1991-93	None	None	-	J. Arnold, I.L. Boyd, BAS
Fine structure of teeth	UK (4)	1973-93 1962-81	1973-89 1962-81	Boyd & Roberts, 1993 Bengtson, 1988	indefinitely	I. Boyd, BAS, J. Bengtson, NMML (1962-81)
	USA (4)	1983	1983	Bengtson, 1988		J. Bengtson, NMML
Population size	Norway (17)	1989-90		Bakken, 1991		V. Bakken, NPI
Crabeater seal						
Reproductive success	Norway (12)	1964	1964	Øritsland, 1970		T. Øritsland, Inst. Marine Research (IMR)
	USA (11,12)	1978-1990	1978	Bengtson & Sinniff, 1981	continuing	J. Bengtson, NMML

Parameter	Member (species, area or site[b])	Data Collected (years)	Data Analysed (years)	Reference to Published Results[c]	Research to be Continued (years)	Principal Scientists, Institution
Crabeater seal (continued)						
Age at sexual maturity	Norway (12)	1964	1964	Øritsland, 1970		T. Øritsland, IMR
	USA (11,12)	1978-1990	1978-1983	Bengtson & Sinniff, 1981; Bengtson & Laws, 1985	continuing	J. Bengtson, NMML
Cohort strength	USA (11,12)	1978-1990	1978-1990	Bengtson & Laws, 1985; Testa *et al*., 1991; Boveng, 1993	continuing	J. Bengtson, NMML
Indices of physiological condition	USA (11,12)	1982-1990	1982-1990	Bengtson *et al*., 1992	continuing	J. Bengtson, NMML
Instantaneous growth rates						
Prey characteristics (diet)	Norway (12)	1964	1964	Øritsland, 1977		T. Øritsland, IMR
At-sea diving behaviour and activity pattern	USA (11,12)	1986-1990	1986-1990	Bengtson & Stewart, 1992; Bengtson *et al*., 1993	continuing	J. Bengtson, NMML
Seasonal movements and habitat use	Norway (12)	1993				A. Blix, Univ. of Tromsø
	USA (11,12)	1986-1990	1986-1990	Bengtson *et al*., 1993	continuing	J. Bengtson, NMML
Minke whales						
All parameters[d]	Japan (1,13)	? - 1992/93			continuing	H. Kato, Nat. Res. Instit. of Far Seas Fish.

a Penguins: A - Adélie; C - Chinstrap; M - Macaroni/Royal; G - Gentoo
Flighted birds: Ba - Black-browed albatross; Cp - Antarctic/Cape petrel; Sp - Snow petrel; Ss - South polar skua

b Areas:
1. Ross Sea
2. South Shetland Is
3. South Orkney Is
4. South Georgia Is
5. Macquarie Is
6. Davis Station
7. Syowa Station
8. Dumont d'Urville Sea
9. Crozet Is
10. Balleny Is
11. Antarctic Peninsula
12. Weddell Sea
13. Mainly from the Indian Ocean (IWC Areas III and IV)
14. Marion Is
15. Kerguelen Is
16. Svarthammaren, Queen Maud Land
17. Bouvet Is
18. Mawson Station

c The complete list of references is given below.
d The following parameters are studied in Minke whales: Reproductive rate; Age of sexual maturity; Cohort strength; Feeding activity pattern; Diet; School size and distribution.

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Table 3: Summary of Members' research required to provide essential background information needed to interpret changes in monitored predator parameters.

Research Topic	Countries Proposing Directed Research	
	Programs Currently Underway	Programs Proposed to Commence (season of initiation)
PENGUINS		
- Foraging areas	Japan, USA, South Africa, Australia	
- Energy requirements	USA, UK, Germany	
- Seasonal movements	South Africa	
- Relationships between monitored parameters and physical environment (e.g., distribution and structure of sea-ice and frontal systems)	Chile, Australia, UK/USSR, USA, South Africa (frontal systems)	
FUR SEALS		
- Local abundance/population structure	Argentina, Chile, UK, USA	Brazil
- Energy requirements/life history	UK, USA	
- Foraging areas	USA, UK, Japan (1990/91, with USA)	
- Relationships between monitored parameters and physical environment (e.g., distribution and structure of sea-ice and frontal systems)	Chile (partial), USA, UK/USSR	
CRABEATER SEALS		
- Foraging areas	USA, Sweden	
- Energy requirements/life history	USA, Sweden	
- Stock discreteness/seasonal movements	USA, Sweden	
- Relationships between monitored parameters and physical environment (e.g., distribution and structure of sea-ice and frontal systems)	USA	
- Abundance/population structure		USA (1993/94)

Table 4: Most recent krill biomass estimates from areas within CEMP Integrated Study Regions (ISRs). These estimates are not applicable to the entire ISRs, but only for the portions of the ISRs for which survey data are available. Figure 1 indicates the zones within the ISRs for which these biomass estimates apply (shown as shaded area).

ISR	Survey Type	Year	Status	Area ('000 km^2)	Density (g.m^{-2})	Biomass (10^6 tonnes)	Reference
South Georgia	Acoustic	1981	recalculated from FIBEX data	25	59.7	1.51	WG-Krill-92/20
Antarctic Peninsula	Acoustic	1981	recalculated from FIBEX data	129	105.8	13.6	SC-CAMLR-XII/4, Table 4
Prydz Bay	Acoustic	1992	Australian survey	268	7.4	1.98	WG-Krill-92/23

Table 5: Assessment of predator and prey studies, 1988 to 1993. Predator parameters were obtained from WG-CEMP-92/8 and 12 unless otherwise referenced in the tables. Data are given qualitative rankings High, Medium, Low, Very Low (H, M, L, VL). The symbols +, 0, - indicate temporal changes in parameters. Foraging duration is expressed as relative length of foraging trips to sea (S = short, M = medium, L = long). Data changed since 1992 are indicated by an *. Columns under "Krill" have been left blank (paragraphs 6.39 and 6.40).

5.1 Site: Anvers Is, Subarea 48.1

Year	Adélie		Krill				Environment		
	Breeding Population Size/Change	Breeding Success	Catch		CPUE	Biomass	Snow	Sea-Ice	Ocean
			100 km radius	Subarea					
1988		-							
1989		-							
1990		M							
1991		L							
1992	(First census)	H							
1993	M -	H							

5.2 Site: Cape Shirreff, Livingston Is, Subarea 48.1

Year	Antarctic Fur Seal[1]		Chinstrap[2]		Krill				Environment		
	Breeding Population Size/Change	Breeding Success	Breeding Population Size/Change	Breeding Success	Catch		CPUE	Biomass	Snow	Sea-Ice	Ocean
					100 km radius	Subarea					
1988	L	M									
1989											
1990		L*									
1991	M +	H	?						H*		
1992	H +	H	0						M*	+Brash	
1993	H +	H							L*		

[1] WG-CEMP-92/53 [2] *Boletin Antártico Chileno*, Vol. 11 (1): 12-14.

5.3 Site: Admiralty Bay, King George Is, Subarea 48.1[1]

Year	Gentoo		Adélie		Chinstrap		Krill				Environment		
	Breeding Population Size/Change	Breeding Success	Breeding Population Size/Change	Breeding Success	Breeding Population Size/Change	Breeding Success	Catch		CPUE	Biomass	Snow	Sea-Ice	Ocean
							100 km radius	Subarea					
1988	M -	M	H +	M	L -	M							
1989	M +	H	H +	H	M +	H							
1990	M -	M	M -	M	M -	L							
1991	L --	M	L --	L	L --	L							
1992	H ++	H	L +	H	M +	H							
1993	H +	H	L -	M	M +	M							

(This summary table was constructed without benefit of reviewing the actual data and may contain source errors)

5.4 Site: Ardley Island and Stranger Point combined, King George Island, Subarea 48.1. Esperanza data used for 1991 for Stranger Point.

Year	Adélie[1] - Ardley		Chinstrap[2] - Ardley		Adélie[3] - Stranger		Krill				Environment		
	Breeding Population Size/Change	Breeding Success	Breeding Population Size/Change	Breeding Success	Breeding Population Size/Change	Breeding Success	Catch		CPUE	Biomass	Snow	Sea-Ice	Ocean
							100 km radius	Subarea					
1988	H	H	M	M	L -	H							
1989	H	M	M	H	L -	H							
1990	M	L	H	L	M -	M							
1991	L	M	L	M	M -	L							
1992	M	?	L	M	+	?							

1 WG-Krill-92/21; WG-CEMP-92/54 2 WG-CEMP-92/54 3 WG-CEMP-92/6; WG-CEMP-92/45

Note: Esperanza data for 1991; Stranger Point not available

5.5 Site: Seal Island, Elephant Island, Subarea 48.1

Year	Chinstrap[1]				Antarctic Fur Seal[2]				Krill				Environment		
	Breeding Population Size/Change	Breeding Success	Fledging Weight	Foraging Duration	Pups Born Number/ Change	Foraging Duration	Pup Growth Rate	Weight at Age	Catch		CPUE	Biomass	Snow	Sea-Ice	Ocean
									100 km radius	Subarea					
1988	M ?	M	H	S	M +	M	M	H							
1989	L -	L	H	M	VL -	?	H	L							
1990	H +	H	M	L	M +	M	L	L							
1991	M -	L	L	S	L -	L	H	L							
1992	H +	M	M	M	M +	M	M	H							
1993	H -	M	M	S	M 0	L	M	?							

1 Data are from the CCAMLR Data Centre and documents WG-CEMP-90/21, 91/11, 91/33, 92/17 and 93/27

2 Data are from the CCAMLR Data Centre and documents WG-CEMP-89/21, 90/34, 90/41, 91/11, 92/17 and 93/27

5.6 Site: Signy Is, South Orkneys, Subarea 48.2

Year	Adélie		Chinstrap		Gentoo		Krill				Environment		
	Breeding Population Size/Change	Breeding Success	Breeding Population Size/Change	Breeding Success	Breeding Population Size/Change	Breeding Success	Catch		CPUE	Biomass	Snow	Sea-Ice[1]	Ocean
							100 km radius	Subarea					
1988	H +	M	L -	H	H ++	H						H	
1989	H 0	L-M	L 0	H	H +	H						H	
1990	M* -	L-M	M +	L	H +	L						L	
1991	L --	M	L -	H	H -	M						M	
1992	M* +	H	L-M +	H	M -	H						H	
1993	M 0	H	M +	H	H +	M						?	

[1] Murphy, *et al.*, unpublished data *

5.7 Site: Bird Island, South Georgia, Subarea 48.3

Year	Gentoo				Macaroni				Black-browed Albatross			Krill				Environment		
	Breeding Population Size/Change	Breeding Success	Krill in Diet	Meal Size	Breeding Population	Breeding Success	Krill in Diet	Meal Size	Breeding Population Size/Change	Breeding Success	Growth Rate[1]	Catch		CPUE	Biomass	Snow[2]	Sea-Ice[3]*	Ocean
												100 km radius	Subarea					
1988	M -	M	M*	H*	M -	L	-	-	L - - -	VL	-					H	H	
1989	H ++	M	H	M-H*	H* +	H	M	M*	M ++	M	H					M	M	
1990	H -	L-M	M*	M*	M -	H	M	M*	M 0	M	L					M	L	
1991	L - -	VL	L	L	L -	H	L	L	L-M -	VL	M					M	L	
1992	M +	H	M*	M	M +	M	H	H	L *-	M	H					H	M-H	
1993	M 0	H	H	M-L	M 0	M-H	H	M	L +	H	H					M	L-M	

[1] P.A. Prince, unpublished data [2] Black-browed albatross only [3] Lunn *et al.* (WG-CEMP-93/10)

5.8 Site: Bird Island, South Georgia, Subarea 48.3

Year	Antarctic Fur Seal[1]								Krill				Environment		
	Pups Born No/Change[1]		Birth Mass[2]	Perinatal Period[2]	Foraging Trip	Growth Rate	Wean Mass[2]	Breeding Success[3]	Catch		CPUE	Biomass	Snow	Sea-Ice[1*]	Ocean
									100 km radius	Subarea					
1988	H	0	H	M	S	M*	M	M						H	
1989	H	-	H	M	M	M*	H	M						M	
1990	H	+	H	M	S*	M	M	M*						L	
1991	L	--	L	S	VL*	M*	L	H*						L	
1992	M	+	M	M	M	M*	M	L*						M-L	
1993	H	+	M	M	M-L	M-L	M	M						M-L	

1 Lunn *et al.*, in press (WG-CEMP-93/10)
2 Data from Lunn and Boyd, in press (WG-CEMP-92/41), Lunn *et al.*, in press (WG-CEMP-93/9), Boyd, unpublished data
3 Boyd, unpublished data

5.9 Site: Béchervaise Island, Mawson, Division 58.4.2

Year	Adélie			Krill	Environment		
	Breeding Population Size/Change	Breeding Success[3]	Krill in Diet*	Biomass[1]	Snow	Sea-Ice	Ocean
1991	Start year	Start year*	Start*		L*	M*	
1992	+[2]*	0*	0*		L*	M*	
1993	0	0	0		Ma	M	

1 WG-Krill-92/23

2 *Proc. Nat. Inst. Polar Res.*, 6 (1993)

0 = no change

Snow: L = little snow or none; Ma = medium snow during pre-egg stage
Mb = medium snow during chick fledging; H = snow in colony for most of the season

Ice: H = fast ice continuous to horizon late January; M = open water to horizon mid-January
L = late December

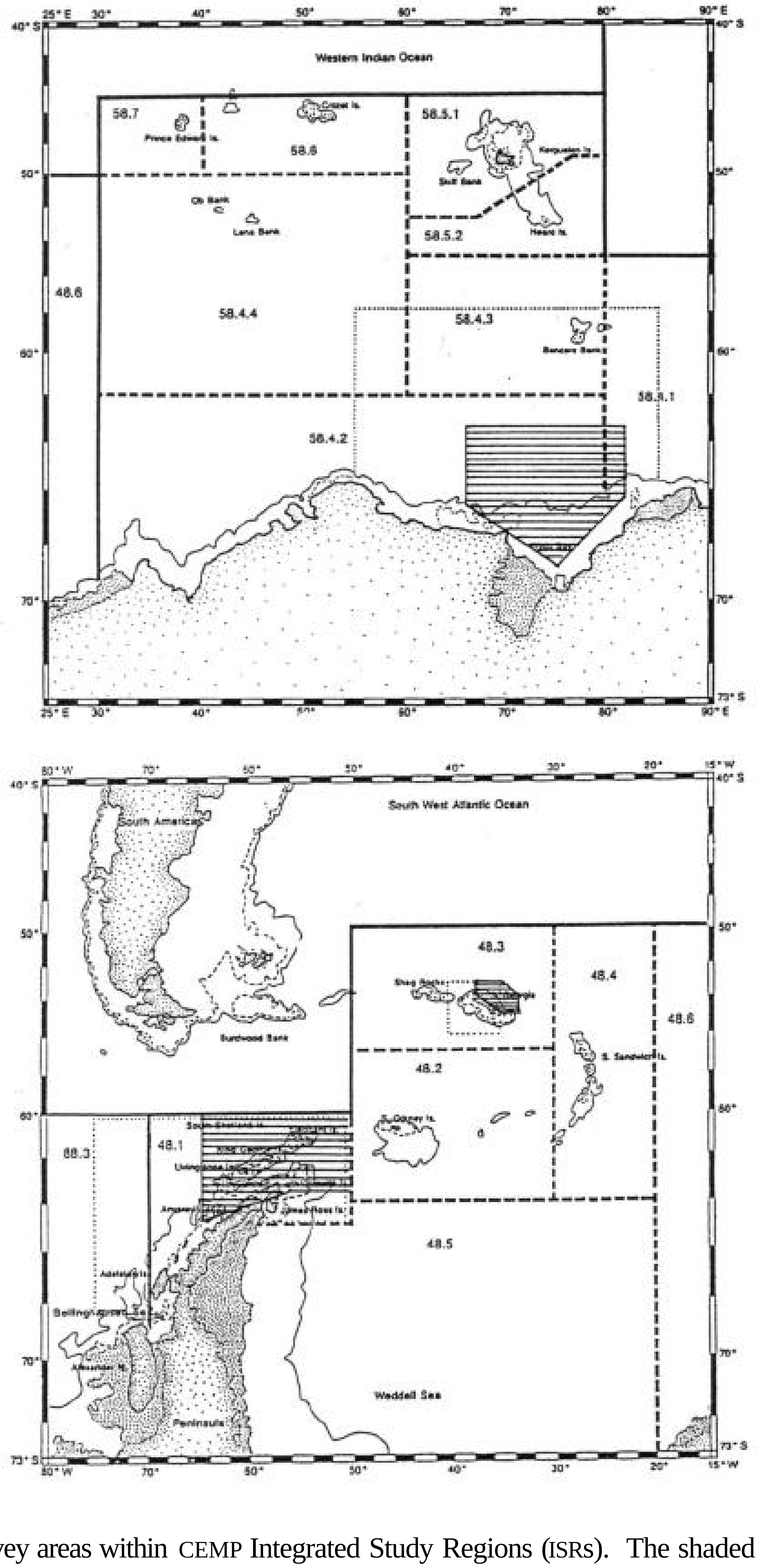

Figure 1: Survey areas within CEMP Integrated Study Regions (ISRs). The shaded areas indicate the zones within the ISRs for which survey data are available and for which the biomass estimates given in Table 4 are relevant.

AGENDA

Working Group for the CCAMLR Ecosystem Monitoring Program
(Seoul, Republic of Korea, 16 to 23 August 1993)

1. Opening of the Meeting

2. Adoption of the Agenda

3. Review of Members' Activities
   (i) Recent Studies
   (ii) Plans for Future Work

4. Monitoring Procedures
   (i) Predator Monitoring
      (a) Sites and Species
      (b) Field Research Procedures
      (c) Procedures for Calculating Indices and Trends
   (ii) Prey Monitoring
   (iii) Environmental Monitoring
      (a) Land-based Observations
      (b) Remote Sensing

5. Review of Monitoring Results
   (i) Predator Data
      (a) Status of Data Submissions
      (b) Report on Indices and Trends
   (ii) Prey Data
      (a) Review of WG-Krill Report
      (b) Fine-scale Catch Data
      (c) Members' Fine-Scale Surveys
   (iii) Environmental Data
      (a) Sea-ice Patterns
      (b) Other Environmental Events or Trends

6. Ecosystem Assessment
   (i) Review of Background Information
      (a) Predator Studies
      (b) Prey Studies
      (c) Environmental Studies
   (ii) Potential Impact of Localised Krill Catches
   (iii) Formulation of Advice and Recommendations to the Scientific Committee

7. Estimates of Prey Requirements for Krill Predators
   (i) Krill Consumption by Predators
   (ii) Predator Performance and Krill Availability
   (iii) Plans for Future Progress

8. Liaison with WG-Krill and WG-FSA

9. Other Business
   (i) IUCN Assessment of Marine Protected Areas
   (ii) Sixth SCAR Symposium on Antarctic Biology
   (iii) SO-GLOBEC
   (iv) SCAR APIS Program
   (v) Exploratory Fisheries

10. Summary of Recommendations and Advice

11. Adoption of the Report

12. Close of the Meeting.

APPENDIX B

LIST OF PARTICIPANTS

Working Group for the CCAMLR Ecosystem Monitoring Program
(Seoul, Republic of Korea, 16 to 23 August 1993)

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APPENDIX C

LIST OF DOCUMENTS

Working Group for the CCAMLR Ecosystem Monitoring Program
(Seoul, Republic of Korea, 16 to 23 August 1993)

WG-CEMP-93/1	PROVISIONAL AGENDA
WG-CEMP-93/2	LIST OF PARTICIPANTS
WG-CEMP-93/3	LIST OF DOCUMENTS
WG-CEMP-93/4	PARAMETERS FOR A MODEL OF THE FUNCTIONAL RELATIONSHIPS BETWEEN KRILL ESCAPEMENT AND CRABEATER SEAL DEMOGRAPHIC PERFORMANCE Peter L. Boveng and John L. Bengtson (USA)
WG-CEMP-93/5	DRAFT MANAGEMENT PLAN FOR THE PROTECTION OF CAPE SHIRREFF AND THE SAN TELMO ISLANDS, SOUTH SHETLAND ISLANDS, AS A SITE INCLUDED IN THE CCAMLR ECOSYSTEM MONITORING PROGRAM Delegations of Chile and the United States of America
WG-CEMP-93/6	POPULATION DYNAMICS OF BLACK-BROWED AND GREY-HEADED ALBATROSSES *DIOMEDEA MELANOPHRIS* AND *D. CHRYSOSTOMA* AT BIRD ISLAND, SOUTH GEORGIA P.A. Prince, P. Rothery, J.P. Croxall and A.G. Wood (United Kingdom)
WG-CEMP-93/7	A MINIATURE STORING ACTIVITY RECORDER FOR SEABIRD SPECIES Vsevolod Afanasyev and Peter A. Prince (United Kingdom)
WG-CEMP-93/8	POPULATION CHANGE IN GENTOO PENGUINS *PYGOSCELIS PAPUA* AT SOUTH GEORGIA: POTENTIAL ROLES OF ADULT SURVIVAL, RECRUITMENT AND DEFERRED BREEDING J.P. Croxall and P. Rothery (United Kingdom)
WG-CEMP-93/9	FACTORS AFFECTING THE GROWTH RATE AND MASS AT WEANING OF ANTARCTIC FUR SEAL PUPS AT BIRD ISLAND, SOUTH GEORGIA N.J. Lunn, I.L. Boyd, T. Barton and J.P. Croxall (United Kingdom)
WG-CEMP-93/10	REPRODUCTIVE PERFORMANCE OF FEMALE ANTARCTIC FUR SEALS: THE INFLUENCE OF AGE, BREEDING EXPERIENCE, ENVIRONMENTAL VARIATION AND INDIVIDUAL QUALITY N.J. Lunn, I.L. Boyd, and J.P. Croxall (United Kingdom)

WG-CEMP-93/11	TOOTH GROWTH IN MALE ANTARCTIC FUR SEALS (*ARCTOCEPHALUS GAZELLA*) FROM SOUTH GEORGIA: AN INDICATOR OF LONG-TERM GROWTH HISTORY I.L. Boyd and J.P. Roberts (United Kingdom)
WG-CEMP-93/12	DISTRIBUTIONS AND PREDATOR-PREY INTERACTIONS OF MACARONI PENGUINS, ANTARCTIC FUR SEALS, AND ANTARCTIC KRILL NEAR BIRD ISLAND, SOUTH GEORGIA George L. Hunt, Jr (USA), Dennis Heinemann (USA) and Inigo Everson (UK)
WG-CEMP-93/13	AGGREGATION PATTERNS OF PELAGIC PREDATORS AND THEIR PRINCIPAL PREY, ANTARCTIC KRILL, NEAR SOUTH GEORGIA Richard R. Veit (USA), Emily D. Silverman (USA) and Inigo Everson (UK)
WG-CEMP-93/14	SELECTING SAMPLING FREQUENCY FOR MEASURING DIVING BEHAVIOUR I.L. Boyd (UK)
WG-CEMP-93/15	CEMP INDICES: SEA ICE DATA Secretariat
WG-CEMP-93/16	CEMP INDICES AND TRENDS 1993 Secretariat
WG-CEMP-93/17	DIVE BOUT OF CHINSTRAP PENGUIN AT SEAL ISLAND, ANTARCTICA Yoshihisa Mori (Japan)
WG-CEMP-93/18	ANALYSIS OF DATA FROM TIME-DEPTH RECORDERS AND SATELLITE-LINKED TIME-DEPTH RECORDERS: REPORT OF A TECHNICAL WORKSHOP Delegation of the United States of America
WG-CEMP-93/19	THE EFFECTS OF CEMP MONITORING PROCEDURES ON ADELIE PENGUIN COLONIES Judy Clarke, Knowles Kerry (Australia)
WG-CEMP-93/20	REPORT: WORKSHOP ON RESEARCHER-SEABIRD INTERACTIONS - JULY 14-18, 1993, MONTICELLO, MINNESOTA William R. Fraser and Wayne Z. Trivelpiece, Conveners (USA)
WG-CEMP-93/21	PRELIMINARY ESTIMATES OF CPUE TRENDS FOR THE CHILEAN KRILL FISHERY IN SUBAREA 48.1 FROM 1987 TO 1993 V. Marín (Chile)
WG-CEMP-93/22	ANTARCTIC PARK ICE SEALS: INDICATORS OF ENVIRONMENTAL CHANGE AND CONTRIBUTORS TO CARBON FLUX SCAR Group on Specialists on Seals

WG-CEMP-93/23 PRELIMINARY STUDY ON THE BREEDINGS OF CHINSTRAP AND GENTOO PENGUINS AT BARTON PENINSULA, KING GEORGE ISLAND
Hyoung-Chul Shin and Suam Kim (Republic of Korea)

WG-CEMP-93/24 ANALISIS DE LOS CENSOS DE *ARCTOCEPHALUS GAZELLA* EFECTUADOS EN EL SITIO DE ESPECIAL INTERES CIENTIFICO NO. 32, ISLA LIVINGSTON, ANTARCTICA
Anelio Aquayo L. and Daniel Torres N. (Chile)

WG-CEMP-93/25 BLUE-EYED SHAGS AS INDICATORS OF CHANGES IN ITTORA FISH POPULATIONS
Richardo Casaux and Esteban Barrera-Oro (Argentina)

WG-CEMP-93/26 THE DIET OF THE BLUE-EYED SHAG, *PHALACROCORAX ATRICEPS BRANSFIELDENSIS* AT THE WEST ANTARCTIC PENINSULA
Richardo Casaux and Esteban Barrera-Oro (Argentina)

WG-CEMP-93/27 US AMLR PROGRAM - 1992/93 FIELD SEASON REPORT
Delegation of the USA

WG-CEMP-93/28 THE AUTUMN FORAGING RANGE OF ADELIE PENGUINS FROM BECHERVAISE ISLAND, ANTARCTICA
Knowles Kerry (Australia)

WG-CEMP-93/29 SOUTHERN OCEAN GLOBEC

OTHER DOCUMENTS

WG-KRILL-93/7 AN ASSESSMENT OF THE IMPACT OF KRILL FISHERY ON PENGUINS IN THE SOUTH SHETLANDS
T. Ichii, M. Naganobu and T. Ogishima (Japan)

WG-KRILL-93/8 STATUS OF THE KRILL STOCK AROUND ELEPHANT ISLAND IN 1991/92 AND 1992/93
V. Loeb (USA) and V. Siegel (Germany)

WG-KRILL-93/9 FINE-SCALE CATCHES OF KRILL IN AREA 48 REPORTED TO CCAMLR FOR THE 1991/92 FISHING SEASON
Secretariat

WG-KRILL-93/10 KRILL CATCH DISTRIBUTION IN RELATION TO PREDATOR COLONIES 1987 TO 1992
Secretariat

WG-KRILL-93/14 PRELIMINARY MODEL OF KRILL FISHERY BEHAVIOUR IN SUBAREA 48.1
D.J. Agnew (Secretariat)

WG-KRILL-93/16	A REVIEW OF THE FEEDING CONDITIONS OF THE BALEEN WHALES IN THE SOUTHERN OCEAN Akito Kawamura (Japan)
WG-KRILL-93/22	HYDROGRAPHIC FLUX IN STATISTICAL AREA 58 OF CCAMLR IN THE SOUTHERN OCEAN Mikio Naganobu (Japan)
WG-KRILL-93/23	CHLOROPHYLL DISTRIBUTIONS AROUND THE SOUTH SHETLAND ISLANDS Haruto Ishii, Taro Ichii and Mikio Naganobu (Japan)
WG-KRILL-93/25	CPUES AND BODY LENGTH OF ANTARCTIC KRILL DURING 1991/92 SEASON IN THE FISHING GROUNDS NORTH OF LIVINGSTON ISLAND T. Ichii (Japan)
WG-KRILL-93/26	NOTE ON RELATIONSHIP BETWEEN THE ANTARCTIC KRILL AND ANNUAL VARIATION OF ICE EDGE DURING 1979 TO 1992 M. Naganobu and S. Kawaguchi (Japan)
WG-KRILL-93/27	NOTE ON MATURITY OF KRILL IN RELATION TO INTERANNUAL FLUCTUATIONS OF FOOD ENVIRONMENT IN THE SEAS AROUND THE SOUTH SHETLAND ISLANDS M. Naganobu and S. Kawaguchi (Japan)
WG-KRILL-93/29	ENVIRONMENTAL GRADIENTS OF THE ANTARCTIC KRILL (*EUPHAUSIA SUPERBA* DANA) IN THE WHOLE OF THE ANTARCTIC OCEAN Mikio Naganobu and Yuzo Komaki (Japan)
WG-KRILL-93/33	A NOTE ON THE CHLOROPHYLL MEASUREMENT BY SATELLITE REMOTE SENSING IN THE ANTARCTIC OCEAN T. Ogishima, M. Naganobu and S. Matsumura (Japan)
WG-KRILL-93/38	FACTORS INFLUENCING ANTARCTIC KRILL DISTRIBUTION IN THE SOUTH SHETLANDS T. Ichii, H. Ishii and M. Naganbou (Japan)
WG-KRILL-93/39	ESTIMATION OF CHLOROPHYLL DISTRIBUTIONS OBTAINED FROM SATELLITE IMAGES (NIMBUS-7/CZCS) IN THE ANTARCTIC OCEAN Noritsuga Kimura, Yoshihiro Okada, Satsuki Matsumura and Yashiro Sugimori (Japan)
WG-KRILL-93/41	ABUNDANCE OF *EUPHAUSIA SUPERBA* IN THE WESTERN BRANSFIELD STRAIT REGION DURING THE KARP CRUISE IN THE 1992/93 SUMMER Seung-Min Choi and Suam Kim (Republic of Korea)
WG-KRILL-93/43	POSSIBLE EFFECTS OF DIFFERENT LEVELS OF FISHING ON KRILL ON PREDATORS - SOME INITIAL MODELLING ATTEMPTS D.S. Butterworth and R.B. Thomson (South Africa)

WG-KRILL-93/45	ANTARCTIC KRILL, *EUPHAUSIA SUPERBA* DANA, DEMOGRAPHY STUDIES IN THE SEAS OF SODRUZHESTVO AND COSMONAUTS (INDIAN OCEAN SECTOR OF ANTARCTICA) E.A. Pakhomov (Ukraine)
WG-KRILL-93/47	PENGUIN FORAGING BEHAVIOR IN RELATION TO THE DISTRIBUTION OF PREY Donald A. Croll, Roger P. Hewitt, David A. Demer and John K. Jansen (USA)
WG-KRILL-93/49	ACOUSTIC ESTIMATES OF KRILL BIOMASS IN THE ELEPHANT ISLAND AREA: 1981-1993 David A. Demer and Roger P. Hewitt (USA)
CCAMLR-XII/5	EVALUATING NEW AND EXPLORATORY FISHERIES Delegation of the United States of America
SC-CAMLR-XII/4	REPORT OF THE FIFTH MEETING OF THE WORKING GROUP ON KRILL (Tokyo, Japan, 4 to 12 August 1993)
SC-CAMLR-XII/BG/3	REPORT OF A COORDINATION MEETING OF THE CONVENERS OF THE WORKING GROUPS ON KRILL, CEMP AND FISH AND THE CHAIRMAN OF THE SCIENTIFIC COMMITTEE

REPORTS OF MEMBERS' ACTIVITIES WITH REGARD TO CEMP

This appendix contains descriptions of Members' activities in relation to CEMP that were submitted to this meeting by participants (Argentina, Australia, Chile, Germany, Italy, Japan, the Republic of Korea, Russia, South Africa, Sweden, UK and USA).

2. Argentina carried out the Ecosystem Monitoring Program in three places: King George Island (Stranger Point), Antarctic Peninsula (Hope Bay) and the South Orkneys (Mossman Peninsula) under the direction of Dr Daniel F. Vergani and Lic. Zulma Stanganelli. The main work was conducted on Adélie penguins; population trends and breeding success were the principal parameters measured.

3. Directed research on prey started with studies on fish in the South Shetland Islands. This investigation was carried out through observation of diet of blue-eyed shags (*Phalacrocorax atriceps*) to see variation of food suitability. This survey was directed by Lic. E. Barrera-Oro and Lic. R. Casaux.

4. During the 1992/93 austral summer Australia continued with its CEMP monitoring program and associated Adélie penguin research at Béchervaise Island near Mawson Base. CEMP Standard Methods for parameters A1, A2, A3, A6 and A7 have been carried out and analysed using both manual and automated methods. In addition, dietary samples for A8 have been collected and data from satellite trackers, time-depth recorders and the automated weighbridge system pertaining to parameters A4 and A5 are presently being analysed.

5. Australia's weighing and identification system was operational on the island throughout the season, assisting in the collection of data for CEMP. This system will continue to be used for a number of years into the future and it is planned to install a second of these at Magnetic Island near Davis during the 1993/94 summer. A third system will also be set up in the future at an undisturbed site, the location of which is yet to be determined.

6. In 1992/93 Chile conducted censuses and pup growth studies on fur seals at Cape Shirreff and the San Telmo Islands. These data complement census data collected since 1965/66. Population sizes of fur seals were 50 (1966), 1 741 (1973), 8 929 (1987), 10 768 (1992) and 13 242 (1993) for Cape Shirreff and the San Telmo Islands combined. Additional data on environmental parameters, and population censuses of Weddell and southern elephant seals were

also collected at Cape Shirreff, and a marine debris survey was conducted there. Studies will continue in 1993/94 with the introduction of monitoring following CEMP Standard Methods.

7. On Ardley Island, studies of seabird populations were carried out in 1992/93 and will be continued in 1993/94. Observation of penguins' early nesting period was conducted in October 1992. These studies were directed by Dr José Valencia, of Universidad de Chile, with the support of the Instituto Antártico Chileno. The penguin census, and observation of birds during the early nesting period, will continue in 1993/94.

8. Germany has no program monitoring predator species in any of the Integrated Study Regions. German CEMP-related research focuses on the at-sea behaviour of Adélie penguins including swimming speed, directions, foraging range, diving depth and feeding activity. In order to obtain more information on prey ingestion and meal size at different diving depths, a unit was developed to record stomach temperature following ingestion of prey organisms. These investigations are part of an ongoing program which started in 1984. They are conducted at Ardley Island by a group of researchers from the Institute of Marine Science at Kiel (Drs B. Culik and R. Wilson).

9. Italy continues to study the ecological genetics and the evolutionary biology of Antarctic and sub-Antarctic crustaceans. The levels of genetic polymorphism were evaluated in populations of Amphipods, Isopods and Euphausiids. Genetics similarity indexes were calculated for Amphipods of the genus *Paramoera* from Terranova Bay. DNA sequence analysis of mitochondrial genes was studied in *Euphausia superba* by means of PCR and direct sequencing.

10. Italy also studies physiological and toxicological aspects and biochemical responses to heavy metals and xenobiotics contamination in Antarctic organisms. Biomarkers are used to evaluate the exposure level and their ecological effects on the Antarctic ecosystem; attention is focused on the upper trophic levels of the marine food chain.

11. Italy is planning to commence work from its station at Terranova Bay in cooperation with Australia; it is hoped to install an automated penguin monitoring system (APMS), developed by Australia, and it will be fully operational in the 1994/95 season. In addition, at the site of the APMS, manual observations according to CEMP Standard Methods will be carried out.

12. Japan continues to monitor the annual trends in breeding population size of Adélie penguins near Syowa Station. Studies on Adélie penguins will be conducted in the Indian Ocean sector in cooperation with Australia in 1993/94.

13. Japan continues to investigate the biology and population size of minke whales through selective catching in the Southern Ocean. Studies of krill ecology in relation to hydrological parameters as well as survey design will also continue. Japan intends to continue cooperative work on CEMP monitoring.

14. The monitoring program for chinstrap and gentoo penguins by KARP (Korea Antarctic Research Program) is being initiated in the rookery at Barton Peninsula, King George Island. Because of the late observation, only fledgling measurements were taken during the 1991/92 breeding season. In the 1992/93 breeding season, however, a preliminary survey on breeding chronology, breeding success, and chick growth and chick banding was conducted. It is reported in WG-CEMP-93/23. The program will be continued in the 1993/94 breeding season. It is part of a land-based marine ecology program which includes micro-organism, coastal fish population, benthic animal and macroalgae.

15. CEMP-related studies conducted by the Russian Federation have been recently concentrated on the prey-species Antarctic krill. During the last two years, available historical fine-scale data from krill fisheries in Subareas 48.1, 48.2 and 48.3 (1974 to 1987) have been processed to study location of catches. The first results of the study were submitted to WG-CEMP last year (WG-CEMP-92/30). This study will be continued.

16. Krill distribution and biology studies have been planned for the 1993/94 season as a part of the Russian Antarctic Expedition (RAE-39). These studies will be conducted in the coastal area of the Bellingshausen Sea.

17. South Africa's CEMP-related activities have suffered in recent years from irregular funding and a lack of clarity concerning national priorities. This situation has now changed and three major areas of research of interest to CEMP have been allocated funds for the immediate future. These are:

(i) continuation of monitoring at the Prince Edward Islands of gentoo/macaroni penguins (including CEMP parameters) and seals (elephant and fur);

(ii) initiation of a study of biogenic fluxes at the Robertskollen Nunatak (a breeding site for snow petrels) in 1994/95; and

(iii) commencement of studies at various frontal zones and other ecoclines (e.g., oceanic islands and the ice edge) in the Southern Ocean. This includes a planned krill aggregation study at South Georgia in 1993/94; and a cooperative study with UK scientists.

18. Sweden has no monitoring activity according to CEMP. Basic research on king penguins and elephant seals is undertaken in cooperation with BAS (UK); research on crabeater seals is in cooperation with USA.

19. United Kingdom land-based research in support of CEMP is conducted at Signy Island, South Orkney Islands, and Bird Island, South Georgia. Parameters measured in 1993 were identical to those recorded in 1992 (SC-CAMLR XI, Annex 7, Appendix D, paragraph 20).

20. In addition the detailed demographic studies on grey-headed and black-browed albatrosses and on Antarctic fur seals were continued and these now provide annual data on population size, adult survival, juvenile survival (recruitment), breeding frequency and breeding success for albatrosses and age-specific fecundity rate, maternal mass, pup birth mass and breeding success for fur seals.

21. Additional directed research is being carried out on: a) chick growth, foraging trip duration, meal size and at-sea activity budgets of albatrosses, especially black-browed albatross; b) aspects of diving performance and at-sea activity budgets in Antarctic fur seals; c) activity-specific energy budgets, using implanted recorders to measure heart rate and other parameters in gentoo penguins, black-browed albatrosses and Antarctic fur seals.

22. Of papers listed in 1992, WG-CEMP-91/23 is now published (*Can. J. Zool.* (1992) 70: 919-928). Of papers tabled last year WG-CEMP-92/37 (*Auk*. (1992) 109: 223-234), WG-CEMP-92/38 (*J. Zool.* (1993) 230: 31-47), WG-CEMP-92/39 (*Antarcti. Sci.* (1993) 5: 17-24), WG-CEMP-92/40 (*J. Zool.* (1993) 229: 55-67), and WG-CEMP-92/42 (*Phil. Trans. Roy. Soc. Lond. B.* (1992) 338: 319-328) were published. WG-CEMP-92/41 is still in press (*Symp. Zool. Soc. Lond.*).

23. Nine papers involving predators are tabled this year. WG-CEMP-93/6 reviews 17 years' data from population studies on black-browed and grey-headed albatrosses at South Georgia, including annual data on breeding population size, adult and juvenile survival rates, breeding frequency and success. The paper, which also includes relevant methodological data (as requested in support of the existing Standard Method B3 for black-browed albatrosses), documents significant population declines (especially in grey-headed albatrosses), mainly due to substantial decreases in juvenile survival in recent years. The specification of the device used to record at-sea activity budget data for albatrosses is described (together with sample results) in WG-CEMP-93/7. WG-CEMP-93/8 reviews inter-annual variation in population size and breeding success in gentoo penguins over 16 years at South Georgia. It documents the significant effect that a relatively small number of years of very poor reproductive performance (and subsequent deferred breeding and reduced adult survival) can

have on the overall trends and fluctuations in the population. For Antarctic fur seals, WG-CEMP-93/9 reviews interannual variation in pup growth rates at South Georgia over nine years; WG-CEMP-93/10 reviews reproductive performance over the same years. Of particular interest to WG-CEMP is the use of foraging trip duration as an index of prey availability in models partitioning variance in reproductive success due to differences in age, experience, year and the effect of physical and biological environment. WG-CEMP-93/11 demonstrates the considerable potential of using data from fine-scale examination of sectioned teeth to provide information on inter-annual variation in body growth as index of environmental conditions. There are correlations between years of known poor reproductive performance and indices of ENSO effects. On the topic of predator-prey interactions, WG-CEMP-93/12 and 13 both deal with relationships between distribution of top predators and krill from simultaneous visual and acoustic surveys around Bird Island, South Georgia. Non-random distribution of predators was very evident as was the strong influence of the distribution of krill swarms. Although Antarctic fur seals and macaroni penguins were especially aggregated at krill swarms, correlations were found over a wide variety of spatial scales, but particularly at 10 to 100 km.

24. Finally, WG-CEMP-93/14 deals with aspects of the collection of diving data with time-depth recorders that may have important implications for data analysis. This contributes directly to WG-CEMP interest on this topic (SC-CAMLR-XI, Annex 7, paragraph 4.18).

25. No krill surveys were carried out in 1992/93. A research cruise, to investigate predator-krill interactions in detail, will be carried out in 1993/94. This will include krill surveys, mainly at meso and fine scales.

26. United States activities in 1992/93 directly related to CEMP consisted of:

(i) land-based predator studies at Seal Island, near Elephant Island and at Palmer Station, Anvers Island;

(ii) repeated surveys of hydrographic conditions, phytoplankton production, and krill abundance and distribution in the waters surrounding Elephant Island; and

(iii) analyses of data on crabeater seal demographics, ecology and behaviour.

Preliminary reports on these activities are provided in the AMLR field season report (WG-CEMP-93/27).

27. At Seal Island, directed research and monitoring activities were conducted on fur seals, chinstrap penguins, macaroni penguins and Cape petrels. The following Standard Methods parameters were monitored: A5, A6a and c, A7, A8, A9, C1 and C2. In addition, directed research on foraging ecology and chick growth rates was continued, and efforts were initiated to develop an automated land-based tracking system of penguins and seals to determine foraging locations. At Palmer Station, Standard Methods parameters A3, A5, A6a, b and c, A7, A8 and A9 were monitored for Adélie penguins. This was conducted in conjunction with the long-term ecological research (LTER) program of the National Science Foundation (NSF).

28. Two 30-day cruises were conducted aboard the NOAA Ship *Surveyor* from mid-January to mid-March, 1993 in the vicinity of the Seal Island CEMP site and Elephant Island. Chlorophyll *a* concentrations, primary production rates, organic carbon concentrations, phytoplankton species compositions, nutrient concentrations, and solar irradiance were measured and mapped. In addition, the distribution and abundance of krill were measured using sampling nets and acoustic instrumentation.

29. Analyses of crabeater seal demographic and ecological data were completed, incorporating data collected over the past several decades. One element of this analysis involved calculating adult survival rates, age at sexual maturity, and cohort strengths; these estimates were provided for the modelling exercise on functional relationships being conducted by WG-Krill and WG-CEMP.

30. In addition to the AMLR CEMP studies, a joint NSF/AMLR study of predator/prey interactions was conducted during June, 1993, aboard the NSF Ship *Nathaniel B. Palmer* in the waters surrounding South Georgia. NSF-sponsored scientists conducted research investigating the distribution and abundance of sea birds while AMLR scientists collected similar data on krill.

31. Finally, in support of the NSF's LTER program, three oceanographic cruises were conducted by the NSF Ships *Polar Duke* and *Nathaniel B. Palmer* in November 1992 and January and May 1993. Primary production rates, Chlorophyll *a* concentrations, organic carbon concentrations, microbial production rates, nutrient concentrations and irradiance were investigated in an area from Palmer Station to Rothera Station. Krill distributions were measured using nets and acoustic instrumentation.

32. Anticipated CEMP-related field work in 1993/94 will include penguin and fur seal monitoring and directed research at Seal Island and penguin monitoring at Palmer Station. Shipboard surveys of hydrographic conditions, phytoplankton production, krill distribution and abundance, krill demography will be conducted around Elephant Island. In addition, the LTER Progam will conduct research similar to that conducted this year. Pending the availability of logistic support, investigations

of pack-ice seal distribution and abundance, habitat use and seasonal movements, and foraging ecology are also planned.

33. During the Norwegian Antarctic Research Expedition 1992/93, studies were continued on Antarctic petrels and south polar skuas at Svarthammaren, Queen Maud Land by the Institute of Nature Research, Trondheim. A total of 1 200 individually-marked Antarctic petrels (adults and chicks) in four study sites were weighed at regular intervals, and the breeding success of all pairs recorded. Heavy snowfall and subsequent high temperatures caused high mortalities of chicks. Two experiments involving increased energetic costs were carried out to study relationships between adult body size and parental investment in chicks. South polar skua studies included mapping of territories and marking (including satellite marking of four individuals) to investigate social structure and migrations.

34. Crabeater seal studies (carried out by the Department of Arctic Biology, University of Tromsø) included investigations of the digestibility of krill using the Mn-marker method (digestible energy of 83.8 ± 2.2 was lower than that of *Thysanoessa* sp. in North Atlantic minke whales 92.2 ± 2.8). Eight moulted crabeater seals were equipped with satellite PTTs with TDRs. Seals stayed in the pack-ice zone, moving along the edge of the shelf with about 150 dives per day during the first few weeks. In late April and May most seals migrated into deep waters in the north, reaching as far as 63°S before returning to the South in early June. Diving frequencies were maintained at a high level, indicating active feeding. Maximum distances covered and diving depths reached were 3 875 km and between 232 and 528 m, although most dives were for less than 2 minutes and 50 m depth.

35. Tentative plans to initiate a monitoring program for Antarctic fur seals and chinstrap and macaroni penguins on Bouvet Island could be carried out during NARE 1993/94.