ANNEX 4

REPORT OF THE WORKING GROUP ON ECOSYSTEM MONITORING AND MANAGEMENT

(Bergen, Norway, 12 to 22 August 1996)

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INTRODUCTION

Opening of the Meeting

1.1 The second meeting of WG-EMM was held at the Directorate of Fisheries, Bergen, Norway, from 12 to 22 August 1996.

1.2 Dr P. Gullestad, Deputy Director of the Directorate of Fisheries, welcomed participants to Bergen, and an outline of the Norwegian Antarctic Program was presented by Dr F. Mehlum from the Norwegian Polar Institute. Ambassador J. Bech, Special Adviser on Polar Affairs from the Ministry of Foreign Affairs, opened the meeting and spoke of CCAMLR's challenges and achievements.

1.3 On behalf of the Working Group, the Convener, Dr I. Everson (UK), thanked the Norwegian Government for the invitation to hold the meeting in Bergen, and expressed appreciation to Dr T. Øritsland from the Institute of Marine Research for his substantial work in preparation for the meeting.

Adoption of the Agenda and Organisation of the Meeting

1.4 A revised Provisional Agenda was introduced and discussed. A number of changes were made to Items 4 and 6 which included Item 6 being renamed 'Ecosystem Analysis'. A new Item 7 'Ecosystem Assessment' was added. The Agenda, as amended, was adopted (Appendix A).

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

1.6 The report was prepared by Drs I. Boyd (UK), D. Butterworth (South Africa), J. Croxall (UK), W. de la Mare (Australia), D. Demer (USA), G. Kirkwood (UK), K.-H. Kock (Chairman, Scientific Committee) and S. Nicol (Australia), Mr T. Ichii (Japan), Drs E. Murphy (UK), D. Miller (South Africa), W. Trivelpiece (USA), J. Watkins (UK) and the Secretariat.

DATA

2.1 In considering this agenda item, it was decided that data from surveys on harvested species (subitem (ii)), dependent species (iii) and environment (iv) would best be considered under specialised agenda items together with results of survey analyses, i.e. Item 3 ‘Harvested Species’ or Item 4 ‘Dependent Species’. Discussions under subitem (v) should be focused mainly on any unusual events in the Antarctic marine ecosystem observed in the past season and which are of particular relevance to fisheries management and CEMP. The Working Group agreed that this arrangement should also be followed at future meetings of WG-EMM.

Fisheries

2.2 A summary of fine-scale data from krill fisheries conducted in the 1994/95 season was presented by the Secretariat in WG-EMM-96/25. In general, this season was characterised by the same distribution patterns of krill catches as has been observed over recent years.

2.3 In the 1995/96 season, krill catches were reported by three members: Japan (60 559 tonnes), Poland (20 619 tonnes) and Ukraine (13 338 tonnes). The total reported catch was 94 516 tonnes. This was slightly less that the total catch in the 1994/95 season (118 714 tonnes).

2.4 Most catches were taken in Subareas 48.1 and 48.3, with very little being taken from Subarea 48.2 (Poland and Ukraine only) and no catches from the Indian Ocean sector. The bulk of Japanese catches were taken in Subarea 48.1 in December–June (about 50 000 tonnes) and the remainder taken during winter months in Subarea 48.3.

2.5 During the 1996/97 season, Japan plans to continue fishing for krill at the same level of about 60 000 tonnes (four vessels). The extension of the fishing season in Subarea 48.1 into winter months over the last few years, made possible by less severe ice conditions, serves the dual purpose of avoiding catching early season ‘green’ krill, thereby increasing the catch of colourless krill which are available later in the season in Subarea 48.1 and which the Japanese market has been demanding recently, and evenly distributing krill shipments to storage plants in Japan over the year.

2.6 Chile and Russia reported that they do not have plans to conduct krill fishing in the 1996/97 season. No information was available from Poland and Ukraine about plans for 1996/97. Since Poland has increased its catch in 1995/96, and also because scientists from Poland have not attended the past two meetings of WG-EMM, the Secretariat was asked to write to Poland and request information about its plans with regard to krill fishing.

2.7 In the past Australia has indicated that an Australian company intends to start fishing for krill. The Working Group was advised that no decisions had yet been taken in Australia in this regard.

2.8 Dr Nicol reported that information presented to the Workshop on Krill Fisheries (Vancouver, Canada, November 1995) indicated that some Canadian companies were experiencing an increased demand for northern euphausiids as food stock for the fish farming industry and that the potential for catches to increase in the Northern Hemisphere was limited. Therefore, Canadian fishing companies may be considering krill fishing in the Convention Area.

2.9 No information was available on krill catches in the CCAMLR Convention Area by any non-Member States.

Observer Scheme

2.10 In 1993, WG-Krill suggested that recording a krill fishing vessel's activity at random time intervals would provide an estimate of searching and towing times as required for the estimation of effort in catch per unit effort (CPUE) indices (SC-CAMLR-XII, Annex 4, paragraphs 5.31 and 5.32). It was agreed that this could only be achieved by the placement of scientific observers aboard fishing vessels. The guidelines for recording fishing vessel activity (time budget) were subsequently developed for inclusion in the *Scientific Observers Manual*, a draft of which was submitted to CCAMLR-XIV (SC-CAMLR-XIV/6).

2.11 The first set of records of a vessel's time budget was collected and submitted to CCAMLR by the Ukrainian scientific observer on board the krill fishing vessel *General Petrov* (WG-EMM-96/26). These data indicated that about 70% of the vessel's time was spent setting, hauling or trawling. It was noted that very little time was spent searching, and the vessel rarely had to pause its fishing activities in order to complete processing. The Working Group welcomed this dataset, which demonstrated that the methodology was practical, and encouraged further use of the system.

2.12 Logbooks for krill and finfish trawl fisheries are in preparation and will include time-budget forms. It was recommended that the logbooks and *Scientific Observers Manual* should be published in 1997 as a matter of urgency.

Coordination of Research in Subarea 48.1

2.13 Dr S. Kim (Republic of Korea) convened the ad hoc Subgroup on the Coordination of Research in the Antarctic Peninsula, and some Members (Brazil, Germany, Japan, Korea, UK and USA) discussed the progress of the second oceanographic cruise planned for the coming season. It was agreed that some elaboration of the purposes and methodologies would be needed in time for the 1996 Scientific Committee meeting and that a workshop on the survey results should be held before the next WG-EMM meeting, wherever possible.

HARVESTED SPECIES

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

3.1 WG-EMM-96/34 presented comparisons of the length frequencies of krill caught in a research trawl (IKMT) and a commercial trawl (PT 72/308) which targeted the same aggregation. The length distributions of krill in the IKMT varied considerably between hauls because each haul sampled a small portion of the heterogeneous aggregation. Conversely, the commercial trawl sampled a much larger portion of the aggregation and the resulting krill length distributions were much more consistent. The difference in mean lengths of krill was as much as 6 mm larger in the commercial trawl than in the research trawl. The length difference translated to a target strength (TS) difference of 2.1 dB or a factor of 1.6 (or 0.6) when calculating animal numerical density. It was concluded that:

(i) commercial trawls may under-sample small krill while research trawls may under-sample large krill; and

(ii) trawl selectivity should be taken into account when estimating animal densities from hydroacoustic surveys.

3.2 If a bias did exist, its effect would be less severe for estimates of biomass than for estimates of numerical density (e.g. those required for comparisons of predator consumption). The Working Group noted that the TS values reported in WG-EMM-96/34 were calculated from the mean lengths of animals in the samples, leading to a positive bias in mean TS estimation. The mean TS should be calculated as the density-weighted mean of the target strengths (i.e. in the linear domain) for each length class[1].

3.3 Potential research trawl (RMT-8) biases were discussed in WG-EMM-96/8 (e.g. day-night differences, swarm density effects, size-specific mobility, observer bias). Recognising these potential biases and that no objective method exists to characterise the local krill population, the authors concluded that the catches could still be used to estimate the prey population available to foraging macaroni penguins.

3.4 WG-EMM-94/42 reported a krill biomass survey conducted while transiting between randomly selected bottom trawl locations (bathymetrically stratified). Although the directions and lengths of these transects were random, the design could not be considered a true random stratified survey. Nevertheless, opportunistic surveys may warrant the use of non-optimal survey designs, and the development of methods for characterising the variance of such surveys is encouraged. The importance of using calibrated echosounders and, where possible, multiple frequencies for target classification was emphasised.

3.5 WG-EMM-96/8 reported a krill biomass survey where acoustic data were collected by a vessel following an icebreaker through the pack-ice in the Ross Sea. Potential problems associated with ice noise, vessel noise, and behaviour of targets relative to the lead vessel which could cause an underestimate of the biomass were noted.

3.6 WG-EMM-96/40 presented the latest in a series of experiments investigating the uncertainty of echosounder calibrations at 120 kHz. Results indicated that:

(i) TS measurements derived from integrated echo intensity were in closer agreement with theory than those derived from peak amplitude measurements;

(ii) TS measurements with a Simrad EK500 echosounder varied up to 1.4 dB over a 15-hour period for a stationary standard sphere; and

(iii) transducer efficiency decreased with water temperature.

The TS measurements of standard spheres, made with a hydrophone, 10 W transmitted power, a 0.3 ms pulse length, and a 290 kHz receiver bandwidth, differed from theoretical predictions by an

[1] Specifically because TS is modelled as a function of the logarithm of length (L), the average value of TS, E{TS(L)}, is less than the target strength of the average length, D TS{E(L)}. This is generally known as Jensen's inequality (De Groot, 1970).

average of 0.2 dB (mean SD = 0.2 dB). More substantial calibration uncertainty (>1 dB) may result from:

(i) variations in transducer performance related to changes in water temperature over the survey area; and

(ii) instabilities in the echosounder.

3.7 WG-EMM-96/46 reported the effect of single missing modes of vibration on the TS of a calibration sphere, possibly resulting from the method used for suspension. The paper concluded that missing a single mode of vibration could not account for the uncertainty in echosounder calibration that was reported in WG-EMM-95/70. Since different means of sphere suspension were used for the Cu (monofilament tether glued into a single bore) versus WC spheres (monofilament net bag), members questioned the plausibility of a single missing mode, and the premise that each of the four spheres in the study must necessarily omit the same modal component. Also discussed was the plausible solution of partial modal suppression of one or more high-order modes rather than complete modal omission. The paper (WG-EMM-96/46) will be revised before submission to ICES.

3.8 WG-EMM-96/28 reported calibration variability of 1.0 dB over a sea temperature range of 11.8°C for a Simrad EK500 echosounder configured with a 120 kHz transducer. Other members reported similar experiences. Considering these observations and the results of WG-EMM-96/40, it was concluded that echosounder calibration methods should take into account the range of water temperatures encountered in a survey area. Relevant sections of the CCAMLR recommended calibration procedures (SC-CAMLR-XI, Annex 4, Appendix H, points 2 and 3) were updated (Appendix D).

3.9 WG-EMM-96/41 reported on a feasibility study of the use of an Acoustic Doppler Current Profiler (ADCP) to determine animal velocities relative to ship and water movements. It was concluded that the proposed method could be applied to studies of krill behaviour such as vertical and horizontal migration, avoidance reaction, and flux. Caution was expressed regarding the possible use of an ADCP instrument for biomass estimation.

3.10 WG-EMM-96/71 summarised the ICES FAST Working Group meeting in Woods Hole, USA, during April 1996. Highlighted were shoal and swarm description techniques, use of multifrequency systems for target identification, and a draft proposal for a standard acoustic data format. A description of the data model developed for the acoustic data management and analysis software, ECHO, developed by the Australian Antarctic Division and CSIRO will be forwarded to Dr Y. Simard (Canada) for consideration.

Analysis and Results of Studies on Distribution and Standing Stock

3.11 A number of papers describing the results of krill biomass surveys were presented (Table 1). The Working Group noted that differences in the amount of detailed descriptions of methods made it very difficult to assess the comparability of echo classification used in these papers. A subgroup to investigate these methods was formed and the report is given in Appendix E.

Area 48

3.12 WG-EMM-96/5 described the distribution of krill in the Atlantic sector and adjacent waters with an emphasis on localities outside the current fishing grounds of the Scotia Sea. In a number of localities on the periphery of the Weddell Gyre, as well as in the coastal waters of the Antarctic continent, the location at which krill aggregations are formed is variable. In general, the biomass values within each of these localities are comparable with that associated with the fishing grounds in the Scotia Sea.

3.13 WG-EMM-96/56 also drew attention to the importance of the 'background' level of krill and of oceanic krill which is not targeted by the fishery. These may form a significant portion of the krill population and hence need to be taken into account in the estimation of standing stock within subareas.

3.14 In contrast, WG-EMM-96/28 presented the distribution of average mean area backscattering coefficient (S_a) values from an acoustic survey in Division 58.4.1. The conclusion presented was that the overall biomass estimate was not sensitive to contributions from weak scatters, i.e. the biomass estimate is dominated by acoustic backscatter from larger, generally monospecific, aggregations of krill.

Subarea 48.1

Scientific Surveys

3.15 Mean krill densities from two surveys conducted in the Elephant Island area during January and in February–March 1996 were high relative to those found in previous years (WG-EMM-96/23). Highest krill densities were found in wide bands to the north of King George and Elephant Islands.

3.16 One-year-old juvenile krill (modal length 28 mm) dominated during the first survey, whereas mature adult krill (modal length 48 mm) dominated during the second survey. Salp abundance was low.

3.17 WG-EMM-96/49 highlighted contrasts in the distribution of krill and myctophids between the slope/offshore and inshore regions around Seal Island as follows:

(i) krill showed more uniform distribution in the slope/offshore region in contrast to its very patchy inshore distribution;

(ii) krill showed no diel vertical migration in the slope/offshore region;

(iii) krill tended to be larger in body size and at a more advanced maturity stage in the slope/offshore region than in the inshore region. This segregation tends to break down in the post-spawning phase; juveniles are rarely sampled, adults appear to migrate onshore and superswarms may form at this time; and

(iv) myctophid fish occurred near surface at night in the slope/offshore region.

Subarea 48.2

Scientific Surveys

3.18 Results of a biomass survey for krill north of the South Orkneys in February/March 1996 were presented in WG-EMM-96/36. The survey consisted of thirteen parallel transects which were subsequently stratified on the basis of mean volume backscattering strength (MVBS).

3.19 This paper combined the results of the 1996 survey with those of a 1992 survey for the area to the south of the South Orkneys to give a total biomass estimate for the whole area of 2.6 million tonnes (the FIBEX estimate for this area was 6.9 million tonnes).

3.20 The density of krill in this area tended to increase inshore. The lowest densities were found in the deep oceanic waters of the Antarctic Circumpolar Current (ACC).

3.21 A significant diurnal vertical migration of krill was detected and a proportion of the krill population was found to be above the echosounder transducer at night and so was not sampled. To allow for this, a correction factor of 1.54 was applied to the night-time density estimates (Demer and Hewitt, 1995). It was suggested that the night-time and daytime data be analysed separately. This would allow tasks to be undertaken to determine whether the correction factor applied was appropriate for the region.

Subarea 48.3

Scientific Surveys

3.22 Results from the first year of a five-year study into the interannual variability of the distribution and abundance of krill in two areas in the vicinity of South Georgia were presented in WG-EMM-96/42. The location of the two survey boxes was chosen because of the high concentrations of krill found there in the past, the fishery activity in the region, the past whaling records and because of land-based field activities of the British Antarctic Survey on Bird Island.

3.23 The acoustic surveys consisted of 10 randomly-spaced parallel transects, 80 km in length, running approximately perpendicular to the shelf break in each survey box. The transects were sampled during daylight hours to avoid problems caused by vertical migration. Net hauls for target identification were carried out at night.

3.24 The density estimates for the two boxes were 40.57 g m^{-2} for box 1 (on the shelf break northeast of South Georgia) and 26.48 g m^{-2} for box 2 (on the shelf break north west of South Georgia). These values were much higher than those obtained in 1994 (box 1 – 1.87 g m^{-2}, box 2 – 7.43 g m^{-2}) and are reflected in the improved breeding success of predators at Bird Island (see section 7).

3.25 Krill were estimated to comprise 60% of the acoustic biomass in both boxes. The population size distribution of krill was essentially unimodal in both boxes (24 to 35 mm) although there was a small number of larger krill caught in box 2.

3.26 A further estimate of krill biomass on the South Georgia shelf was provided as a by-product of a finfish survey of the region in 1992 and was reported in WG-EMM-96/42. This survey utilised acoustic transects between trawl stations to arrive at a biomass estimate.

3.27 The Working Group considered the approach used in WG-EMM-96/42 to be useful in providing additional information on krill biomass. Attention should be paid to the analytical treatment of the results of such surveys, particularly regarding the coverage probabilities associated with the effect of design on the estimate of the mean densities. The Working Group encouraged the examination of these approaches. This survey resulted in a density estimate of 95 g m^{-2}, compared with earlier values for the same region of between 1.87 and 76 g m^{-2}.

Fisheries Data

3.28 Additional information on krill distribution is available from haul-by-haul data which have been recorded in the South Georgia area over the last three winter fishing seasons (WG-EMM-96/64). Analyses of these data show marked internal variability and indications of a seasonal pattern. The fishery was closely associated with bottom topographic features such as shelf edge and submarine bank and canyons. The authors discussed the results in relation to the ecology of krill and the interaction of the fishery with the local predator colonies.

3.29 The Working Group noted the utility of these results and recalled that it had in the past called for the submission of haul-by-haul data from the fishery. Further submission of such data was encouraged.

3.30 The density and biomass of krill aggregations as well as their shape and distribution patterns in the fishing grounds of Subarea 48.3, based on data collected by Ukrainian commercial trawlers during June and August 1995, were briefly reported (WG-EMM-96/70). The total biomass of krill on fishing grounds with an area of 180 km^2 was evaluated to be 300 000 tonnes.

Division 58.4.1

Scientific Surveys

3.31 WG-EMM-96/28 and 96/29 described the results of a survey in Division 58.4.1 based on an approved design (WG-Krill-94/18 and WG-EMM-95/43). This survey was specifically designed with the aim of estimating B_0 and was carried out from January to March 1996.

3.32 A range of additional measurements was also made during the course of this survey, including oceanographic sampling on eight of the 18 transects and a detailed suite of biological measurements ranging from primary productivity to whale observations.

3.33 The biomass of krill in the surveyed area (873 000 km^2) was estimated to be 6.67 million tonnes with a coefficient of variation (CV) of 27%. The survey covered most of the area that has been commercially fished in Division 58.4.1.

3.34 Krill were far more abundant in the west of the region (80 to 120°E) than in the east (120 to 150°E), which appeared to be related to the large-scale oceanographic conditions of the region, where a southward intrusion of warmer water (containing salps) approached the shelf/slope area.

3.35 Experience from the Japanese fishery indicated that the southeast Indian Ocean sector was an area which was subject to considerable diurnal fluctuations in the amount of krill in aggregations, particularly late in the season. During the reported survey, however, the majority of the krill was found in the top 80 m of the water column and aggregations, which rarely extended to the sea surface, were present during both day and night.

3.36 This survey was recognised as a significant contribution to the work of the Working Group and served to demonstrate that it was possible to carry out large synoptic surveys without many of the technical and organisational problems of the past.

Subarea 88.1

Scientific Surveys

3.37 The biomass of krill in the Ross Sea (Subarea 88.1) was reported from two surveys (WG-EMM-96/63) carried out during the Tenth Italian Expedition in November to December 1994. The survey included a marine mammal and bird census. The conduct of such multidisciplinary cruises was encouraged by the Working Group.

3.38 Two biomass estimates were reported; one, for 9 November to 15 December, provided a biomass estimate of 5.14 million tonnes for an area of 49 800 n miles^2, and the other, carried out between 17 and 28 December, provided a krill biomass estimate of 3.37 million tonnes for an area of 45 600 n miles^2.

3.39 The earlier survey encountered a 'superswarm' which was estimated to contain over 1.5 million tonnes of krill.

3.40 The results of these surveys showed a similar krill distribution pattern to other Antarctic waters, with *Euphausia crystallorophias* occurring inshore and *E. superba* being found over the shelf/slope region. This study highlighted that substantial quantities of Antarctic krill may occur in waters normally covered by ice.

3.41 The difficulties of surveying such large areas as Division 58.4.1 and Subarea 88.1 were pointed out, and it was suggested that further consideration should be given to the subdivision of these large statistical areas so that more appropriately sized management areas could be defined.

Indices of Harvested Species Abundance, Distribution and Standing Stock

CPUE

Subarea 48.1

3.42 Seasonal variations in CPUE indices (catch/tow and catch/towing time) of the Japanese fishery in Subarea 48.1 were reported for the 1994 season (WG-EMM-96/47). The main fishing grounds were mostly to the north of Livingston Island, and shifted to the Elephant Island area later in the season. CPUE values to the north of Livingston Island were relatively stable throughout the season, while those around Elephant Island were higher but very variable. Krill size was much larger (a modal length of 48 to 50 mm) than in the previous season.

3.43 Long-term variations in the CPUE of the Japanese fishery in Subarea 48.1 were reported for the period 1980/81 to 1994/95 (WG-EMM-96/50). There was a declining trend in CPUE both in the Livingston and Elephant Island areas from the mid-80s to the 1989/90 season. This trend reflects a number of factors, including an increasing demand for good quality krill (non-green) rather than high catch rates. From 1990/91, CPUE remained relatively constant in the Livingston Island area, whereas that in the Elephant Island area it increased to the earlier levels. The recent shift of the fishing period in the Elephant Island area to later in the season, when the phytoplankton bloom is over and krill are no longer green, may allow fishing vessels to operate at high efficiency and to return to high CPUEs.

3.44 The Working Group welcomed the detailed analyses of the long-term trends of CPUE in Subarea 48.1.

Subarea 48.3

3.45 Interannual variation in the CPUE of the Japanese fishery in Subarea 48.3 was reported for the winters of 1990 to 1994 (WG-EMM-96/51). It was noted that CPUE in winter appeared to correlate to the availability of krill as assessed by the performance of predators at Bird Island in the preceding, rather than the following summer season. For example, the poor krill summers of 1990/91 and 1993/94 were followed by low CPUE in the winters of 1991 and 1994 respectively, and the good krill summer of 1992/93 was followed by high CPUE in the winter of 1993. The low CPUE in the winters of 1991 and 1994 in Subarea 48.3 was comparable with low CPUE values in Subarea 48.1 in the preceding 1990/91 and 1993/94 summers.

3.46 Commercial catch data on the depth of fishing indicate that krill distribution in winter might be deeper than in summer (e.g. Kalinowski and Witek, 1983). WG-EMM-96/51 indicated that there was also an interannual variation in length frequency in Subarea 48.3, implying the existence of krill flux from the Peninsula area and the Weddell Sea.

3.47 Based on tow data in the above paper, Dr R. Hewitt (USA) pointed out a possible relationship between interannual variations in modal krill length and the range of tow depths. That is, it would appear from the data that larger krill undergo greater vertical migrations which means that the net must be towed deeper. Dr Murphy suggested that, based on WG-EMM-96/64, shallower net towing depth may also be associated with shallower bottom depths of fishing grounds.

Analysis and Results of Studies on Recruitment and Production of Harvested Species

3.48 Length composition data from the Japanese commercial catch for the period 1980/81 to 1994/95 were analysed to examine variation of the recruitment indices (R_2) in the Livingston Island area (WG-EMM-96/50).

3.49 Year-by-year recruitment indices from fishery data generally agreed with R_1 and R_2 of Siegel and Loeb (1995) that had been observed in the Elephant Island area. However, some differences were noted, resulting from distinct differences in length composition between krill from the Livingston and Elephant Island areas.

3.50 The Working Group noted that the calculation of a recruitment index from the commercial fishery data was a useful development which could provide valuable additional information. However, because the fishery data do not provide an unbiased estimate for the population, they cannot be directly compared to those derived from scientific surveys.

3.51 As requested in SC-CAMLR-XIV (Annex 4, Appendix D), a re-analysis of the long-term recruitment and density data from scientific surveys carried out in the Elephant Island area was presented in WG-EMM-96/45. The re-analysis confirmed the statistical significance of the observed fluctuations in krill density and recruitment.

3.52 Mr Ichii pointed out that recruitment of krill in the Elephant Island area is not necessarily representative of the wider spatial scale of the Peninsula region. From fisheries catch data over a 15-year period, it is apparent that in some years, there are occasional occurrences of distinct differences in length composition between krill from the Elephant Island and Livingston Island areas; differences which cannot be explained by fishing selectivity.

3.53 However, a comparison between the Elephant Island survey and large-scale Antarctic Peninsula surveys, concluded in four separate seasons, demonstrated that the differences between these areas in the proportion of recruits were less than 5% (WG-EMM-96/45).

3.54 In general, the acoustic data from the Peninsula region have tracked the density estimates obtained by nets but the time series of reliable acoustic data is much shorter.

3.55 The density estimated from net haul surveys is such that only highly significant changes can be detected. There may have been less substantial changes in the density index which have escaped detection because of the low statistical power obtained using data from net surveys.

3.56 The mean krill density was higher at the beginning of the time series (late 1970s, early 1980s). However, it was not clear whether this was a reflection of a persistent trend or of a serially correlated natural variability in density. It must also be borne in mind that density changes do not necessarily arise from recruitment variation alone, but can also be the result of changes in natural mortality or distribution patterns.

3.57 Further work to examine the consequences of the estimates of proportions of recruits and variations in krill density reported in WG-EMM-96/45 for the krill yield model is described in paragraphs 7.6 to 7.13.

3.58 Although data from scientific surveys are required to estimate proportional recruitment for the krill yield model, it would be useful to obtain fisheries-derived data for comparative purposes. The Working Group encouraged the submission of other time series of krill data for the estimation of recruitment variability from both scientific and fisheries sources.

3.59 It is likely that there is a sufficiently long time series of length-density data from Japanese, Australian and other scientific cruises in the Indian Ocean sector that could be used to examine changes in proportional recruitment. The Working Group encouraged the analysis of this dataset and the submission of the result.

Future Work

Indices of Local Prey Abundance

3.60 As indicated by the Subgroup on Statistics (Appendix H, Table 4), the development of indices of local distribution of harvested species 'needs considerable research'. Such research should involve and seek to integrate two main approaches:

(a) predator-based (top-down)
(b) prey pattern-based (bottom-up).

Predator-based Approach (top-down)

3.61 An index of local prey distribution is relevant if it is related to predator behavioural regimes and/or ecological requirements, particularly at the spatial and temporal scales over which the predator's foraging behaviour is integrated.

3.62 The scales at which data on predator performance are currently collected via existing standard methods range from temporal scales of days (foraging trip) to weeks (incubation shift) and months (breeding success, chick mass at fledging, adult mass at arrival) and years (survival); the spatial scales vary from tens to thousands of kilometres.

3.63 For most purposes relating to potential indices of local prey abundance, it is principally the shorter time and space scales (days/weeks and 10–100 km) that are of relevance.

3.64 Many aspects of predator performance, however, are closely linked to the dispersion and/or density of prey and are manifested through changes in foraging behaviour on scales of minutes to hours. Existing approaches to analysis of foraging behaviour data have chiefly been to attempt to identify structure within foraging trips (e.g. foraging bouts and their constituent elements; see Boyd et al., 1994; Boyd, 1996).

3.65 Some of the more relevant spatial and temporal scales are summarised in Table 2 which shows that black-browed albatrosses and penguins/fur seals tend to function at rather different spatial and temporal scales. However, whereas some penguin species and fur seals may operate at overlapping scales, there may be distinct differences in their predator/prey interactions by virtue of constraints imposed on them by physiology and behaviour, especially when they are rearing offspring. Thus fur seals, making longer trips, predominantly feed at night. Penguins chiefly feed during the day. These two types of predator may, therefore, interact (either by choice or constraint) with prey at different dispersions and/or densities.

Prey Pattern-based Approach (bottom-up)

3.66 A local index can be described using a variety of methods of spatial statistical techniques, as illustrated by measures of the intensity and scale of pattern in space and time (e.g. Lloyd's index of patchiness, negative binomial k, spectral methods, spatial auto-correlation or semi-variogram).

3.67 The most successful local indices will be those that involve congruence (spatial and/or temporal) of the top-down and bottom-up approaches (e.g. Figure 1) (see paragraph 3.64).

3.68 WG-EMM-96/22 provides some indices, readily calculable from standard acoustic survey data, on:

- (i) average prey density (i.e. overall mean volume back-scattering strength);
- (ii) average prey depth;
- (iii) average distance (over a specified depth range) from a particular predator colony; and
- (iv) prey persistence over time (by comparing prey density between sequential surveys).

While these may provide useful information at scales of weeks and 10–100 km, they may not provide information at the most relevant scales of predator-prey interactions.

3.69 Nevertheless, these generalised indices summarise distributions at scales similar to those represented by several predator indices; future investigation and development of such prey indices is encouraged.

3.70 Following the discussion outlined in paragraphs 3.66 to 3.69 above, the Working Group noted that the topic of krill aggregation in relation to the availability of krill (prey) to predators has a long history within CCAMLR (e.g. SC-CAMLR-X, Annex 5, paragraphs 5.2 to 5.9 and SC-CAMLR-XIII, Annex 5, paragraphs 4.42 to 4.44). In this context, additional work by Members should be directed to investigations of the characterisation of krill aggregations through measures of the aggregation structure (Nero and Magnuson, 1989; Weill et al., 1993), the intensity of dispersion (e.g. Hewitt, 1981) and the scale of dispersion (Weber et al., 1986).

3.71 In addition, information on other characteristics of the prey itself needs to be obtained and summarised. Aspects of prey of particular relevance to predators include: (i) size composition (e.g. statistics derived from length frequency distributions of biomass estimates); (ii) sex and maturity stage composition; (iii) energy content (which is strongly influenced by prey size, sex and maturity stage). At present such data can only be obtained through analysis of net haul samples.

Synoptic Survey of Area 48

3.72 The Working Group recalled the reasons for the need for a new synoptic survey of Area 48 outlined in last year's report (SC-CAMLR-XIV, Annex 4, paragraph 4.61) and agreed that the requirement still existed.

3.73 It was noted that advances in technology and data handling would make the conduct of such a survey much less complex than it had been in the early 1980s. Issues of data management should be addressed early in the planning stage.

3.74 The time budget for such a survey was presented at last year's meeting and members were asked to detail for presentation at SC-CAMLR-XV the requirements of such a survey and work towards an analysis of the logistic arrangements that would be necessary.

3.75 The Working Group agreed that the completion of a synoptic survey within all or part of Area 48 was a high priority. It was agreed that completion of a synoptic survey was more feasible than previously thought because several Members are currently conducting long-term research programs which might be incorporated into a synoptic survey design and because other Members had expressed interest in participating in the survey. Therefore, the Working Group reviewed information available at previous meetings (WG-EMM-95/71; SC-CAMLR-XI, Annex 5, Appendix H; Trathan and Everson, 1994) and made the following recommendations:

(i) survey planning should be completed assuming a minimum of three ships participating in the survey for one month each. Surveys should be conducted simultaneously in the period January to February;

(ii) effort should be concentrated in Subareas 48.1, 48.2 and 48.3. If additional ships become available, the additional effort might be allocated to Subareas 48.4 and 48.6;

(iii) survey planning should take into consideration ongoing long-term sampling efforts of several national programs (e.g., UK five-year program, and US LTER and AMLR programs);

(iv) subareas should be examined to determine whether some regions may require no survey effort, and areas adjacent to the three subareas should be examined to ensure substantial krill concentrations are not omitted (e.g. the northwest corner of Subarea 48.3 may be omitted, whereas the area immediately above the northeast boundary of Subarea 48.1 should be included; Figure 2);

(v) sampling in each subarea should be conducted using an appropriate sampling design (e.g. SC-CAMLR-XIV, Annex 4, paragraphs 4.3 to 4.9). Strata should be defined for areas of known high krill density (e.g. areas most exploited by the fisheries; or areas surveyed annually by national programs – Figure 2);

(vi) whether to conduct sampling in daylight or throughout the 24-hour period should be discussed for each subarea;

(vii) acoustic sampling protocols (e.g. 120 kHz transducer frequency), data protocols (e.g. reporting data as MVBS) and documentation of measurement methods (e.g. see Appendix D) should be standardised;

(viii) standardised directed and random net sampling regimes consistent with those used in acoustic sampling should be used; and

(ix) standardised oceanographic sampling regimes (expendable bathythermograph (XBT) versus conductivity temperature depth probe (CTD); frequency of sampling, etc.) should be used.

Tracklines depicted in Figure 2 are presented to illustrate subparagraphs (i) to (v) above. Trackline distances are approximately 5 500 km in each subarea and the whole synoptic survey could be completed by three ships in approximately 20 days each (this does not include time for net sampling or oceanography). Specific sampling designs should be examined further.

DEPENDENT SPECIES

Sites

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

4.2 Further to his advice to WG-EMM in 1995 that the US would be closing the Seal Island site due to safety considerations, Dr R. Holt (USA) reported that only penguin fledging weight data had been collected at Seal Island in the 1996 season (WG-EMM-96/73). Surveys had been carried out to select a new site in the region that will be suitable for CEMP research. The location at Cape Shirreff had been selected. This had already been designated as a CEMP site and the site would now be run jointly by the USA and Chile.

4.3 Prof. D. Torres (Chile) reported on recent research undertaken at Cape Shirreff which included monitoring the size of Antarctic fur seal populations (WG-EMM-96/39). Fur seals continue to increase in numbers at Cape Shirreff at an average rate of ~9% per annum which, according to Dr Boyd, is similar to the apparent rate of increase at South Georgia. Therefore, this may be representative of the rate of increase generally for the Scotia Sea.

4.4 In addition, members reported that monitoring studies were continuing at Anvers Island (Antarctic Peninsula), Béchervaise Island (Prydz Bay), Bird Island (South Georgia), Edmonson Point (Ross Sea), Esperanza Station (Antarctic Peninsula), Laurie Island and Signy Island (South Orkney Islands), Stranger Point (South Shetland Islands), Syowa Station (Prince Olav Coast) and Ross Island (Ross Sea).

4.5 Dr Mehlum reported that Norway will be establishing a CEMP monitoring site at Bouvet Island during the forthcoming season. This will involve monitoring parameters relating to Antarctic fur seals and macaroni and chinstrap penguins using CEMP Standard Methods A3 to A9, C1 and C2.

4.6 Dr S.-H. Lorentsen (Norway) also provided information about Norwegian studies of Antarctic petrels at Svarthamaren (Queen Maud Land). This is the largest known breeding colony of Antarctic petrels and the site is recognised as an SSSI. However, it cannot be listed as a CEMP monitoring site until standard methods for monitoring Antarctic petrels are adopted.

4.7 Dr K. Kerry (Australia) also reported that monitoring studies of Adélie penguins at Casey Station and Dumont d'Urville using CEMP standard methods had taken place during 1996. These were coordinated with a major regional krill survey carried out by Australia (WG-EMM-96/29); there are no plans to repeat these studies in future.

4.8 Based on results from satellite-tracking of Adélie penguins in eastern Antarctica (WG-EMM-96/69; see also paragraph 4.84), Dr Kerry suggested that before establishing a CEMP site it would be prudent to assess (e.g. by using satellite tracking) the temporal and spatial overlap between the foraging range of penguins feeding their chicks and the area of an actual or potential fishery.

4.9 The Working Group noted that evidence of a lack of spatial overlap did not, however, indicate a lack of competition between predators and a fishery because, due to krill flux, a fishery could be affecting the krill population outside (e.g. upstream of) the predator foraging area. Moreover, there was no guarantee that krill fisheries would not expand into the foraging ranges of predators at some future date. Furthermore, penguin foraging ranges outside the chick-rearing period might be just as relevant for site selection.

4.10 Dr de la Mare suggested that site selection should take into account whether or not predators at the site are substantially dependent on krill.

Species

4.11 No proposals had been received suggesting incorporation of new species into the CEMP monitoring program.

Field Methods

Report of the Subgroup on Monitoring Methods

4.12 The Working Group considered the report of the Subgroup on Monitoring Methods (Appendix I) which had met in Bergen immediately prior to the current meeting of WG-EMM. Members of the subgroup and its convener, Dr Kerry, were thanked for their work and for preparing their report in time to be considered by the Working Group.

Review of Existing Standard Methods

4.13 The subgroup had reviewed each of the existing standard methods and suggested areas where changes were required. The report of the subgroup contains full details of proposed changes.

4.14 In approving the suggestions and recommendations of the subgroup, except as indicated below, WG-EMM provided additional comments. For convenience, Methods A1, A2, A5, A6 and A7, as drafted by the subgroup, have been modified in the subgroup report. Further details on these methods are provided in the paragraphs below.

4.15 The Working Group approved the alterations to Method A1 (adult weight on arrival at the breeding colony). In addition, Dr Lorentsen commented that it may be more appropriate to use a condition index (i.e. weight corrected for body size) rather than weight at arrival. It was noted that acceptance of this change or addition would be subject to the submission of an appropriate recommendation based on analysis of data, including comparing the alternative methods. Members able to collect and analyse such data were encouraged to conduct appropriate investigations and report to the Working Group.

4.16 The Working Group approved the alterations to Method A2 (duration of first incubation shift).

4.17 Dr P. Wilson (New Zealand) noted that Method A3 (breeding population size) in its present form does not allow for the collection and submission of data derived from aerial counts of penguins. If CEMP required submission of the extensive current and historical data on penguin population size in the Ross Sea collected using aerial photography, it would be necessary to prepare information on appropriate methodology for potential incorporation in a new procedure under Method A3. Dr Wilson offered to prepare materials for consideration during the next meeting of WG-EMM.

4.18 The Working Group approved the minor alterations to Method A5 (duration of foraging trips). The Working Group suggested that before other methods are incorporated into an appendix to the standard method (Appendix I, paragraph 54), it would be appropriate to have information on the accuracy of determining foraging trip duration by these other methods in comparison with radio frequency telemetry. It was recommended, however, that details of the method of attaching radio transmitters should be placed in an appendix to the standard method.

4.19 The Working Group approved the alterations to Method A6 (breeding success) and to Method A7 (chick weight at fledging).

4.20 In relation to the suggestion regarding Method A8 (chick diet) using the diameter of krill eyeballs as a substitute for carapace length (Appendix I, paragraph 61), the Working Group noted that major problems would arise from the sexual dimorphism in eye size and the difficulty in distinguishing between eyeballs of *E. superba* and *E. crystallorophias*. It was also noted that the accuracy of comparisons of length frequency of krill taken by nets and predators would be greatly improved if carapace length was also measured for krill caught by nets.

4.21 In respect of the preservation of samples taken using Method A8 (chick diet) (Appendix I, paragraph 62), Dr Kock noted that transference of krill samples to alcohol is likely to cause changes in krill mass and length. Equations for estimating krill length and mass have traditionally been based on formalin-preserved specimens. It was therefore recommended that krill samples for long-term storage should be preserved in buffered formalin. The formalin should be replaced at frequent intervals.

4.22 In relation to the recommendation of separating the first and subsequent vomits when sampling penguin chick diet (Appendix I, paragraph 65), which arose from detailed work on Adélie penguins in the Prydz Bay region (SC-CAMLR-XIV, Annex 4, paragraph 5.25), Dr Croxall commented that this procedure was not appropriate for all penguin species, not necessarily easy to implement in the field and might create additional complexity in reporting data to the CEMP database.

4.23 Dr Kerry, however, believed that for Adélie penguins the first and subsequent vomits should be analysed and reported separately, particularly since it has been demonstrated that there are different foraging strategies for male and female Adélies (WG-EMM-Methods-96/11) with males taking more food from the neritic zone. Food from such areas is more common in the first vomit as they are collected by birds as they return to their breeding colony.

4.24 The Working Group recommended that, for the present, appropriate text on the above subject should be added to the 'problems to be considered' section of the standard method.

4.25 The following observations were made concerning the problem of standardising estimates of wet weight of diet samples (Appendix I, paragraph 68):

(i) wet mass, rather than displacement volume, needs to be recorded for many applications in predator studies (especially conversion to energy content);

(ii) compression of samples using a standard heavy weight may create problems for subsequent determination of sex and maturity stage of krill; and

(iii) it might be more useful to emphasise the need to ensure consistency of technique at each site than to try to obtain overall standardisation across all sites and studies.

The Working Group therefore recommended that an advisory note on this topic be added to the 'problems to be considered' section of the standard method. It was considered that a workshop on this topic was not necessary at this stage.

New Standard Methods

4.26 The subgroup also considered proposals for new standard methods to be included within CEMP. These were reviewed by the Working Group and, after minor modification, were adopted and approved for publication in the *CEMP Standard Methods*. The approved new methods are for (i) attachment of instruments (WG-EMM-Methods-96/5), (ii) data collection using time depth recorders (TDRs) (WG-EMM-Methods-96/5) and (iii) monitoring methods for petrels, which include methods for the collection and analysis of chick diet in cape and Antarctic petrels (WG-EMM-Methods-96/4, WG-EMM-96/53) and monitoring population size, breeding success, recruitment and adult survival rate in Antarctic petrels (WG-EMM-95/86, 96/14, and 96/12).

Other Methodological Topics and Issues

Stomach Lavage of Procellariiformes

4.27 In respect of the subgroup's advice relating to the use of stomach lavage for albatrosses (Appendix I, paragraph 28), it was noted that the collection of regurgitations was probably far preferable to lavage in terms of minimising handling time and stress to the birds. The Working Group further noted that for many research purposes involving diet sampling, use of stomach lavage techniques would be preferable to methods which require the killing of birds.

Effects of Disease and Pollutants

4.28 The subgroup proposed that advice on appropriate methods for the collection of samples for toxicological and pathological analysis (WG-EMM-Methods-96/7 Rev. 1 and 96/13) should be added as an appendix to the *CEMP Standard Methods*. The Working Group endorsed this suggestion. In considering the text some additional observations were made (paragraphs 4.29 and 4.30).

4.29 Dr Boyd noted that it is also necessary to examine background levels of contaminants in tissues collected from birds or seals that have died of known causes, such as traumatic injury, where death is unlikely to have been caused by the poor health or condition of the individual. This is important because the collection of tissues from moribund individuals for examination of contaminant burdens has been shown to affect the measurements of contaminant concentrations. This is especially important for measurements involving lipid-soluble hydrocarbons. Dr Boyd also drew attention to the requirement, if total body burdens are to be measured, to measure the total body lipid content, in addition to the concentration of lipophilic hydrocarbons in a subsample of tissues. This would require considerably more work on the part of the investigators in the field, in addition to the need to develop appropriate protocols for carrying out this procedure.

4.30 Dr Kerry reiterated that the sole purpose of having methods for the collection of samples for toxicological analysis or the investigation of disease was to determine whether or not either were implicated in increased mortality or morbidity at CEMP sites.

4.31 Following on from the comments of Dr Boyd (paragraph 4.29), Dr Kerry noted that a number of laboratories had been studying the incorporation of pesticides and pollutants into the Antarctic organisms at different levels in the marine food chain. However, no baseline data are available for predators being monitored at CEMP sites and it would therefore be appropriate to obtain such baseline data. This could be done from biopsy material and other samples such as oil from the preen glands of birds as well as the samples from post-mortem material suggested by Dr Boyd.

4.32 The Working Group requested that the existing text should be reviewed in the light of the comments in paragraphs 4.29 and 4.30 above.

4.33 An appendix had also been included in WG-EMM-Methods-96/13 listing the materials required for the post-mortem analysis of carcasses. While the Working Group commended the comprehensiveness of this list, its extensive nature meant that it was unlikely that these materials would be available at remote field sites at short notice if unexpectedly high predator mortality occurred. Therefore, the Working Group requested that a listing of only those items considered absolutely essential for carrying out post-mortem analyses should also be provided. This would enable the minimum materials to be held at field sites where pathological studies are not a normal part of the ongoing research program. Similarly, the Working Group noted that the requirement for liquid nitrogen for sample storage in order to undertake biochemical analyses was unrealistic for many field sites.

4.34 It was emphasised that samples could only be analysed in specialist laboratories and that such analyses are very expensive. Contamination of collected samples is possible if the wrong containers are used and so care should be taken to have the correct containers in the field. Further, if samples are not collected or stored correctly then laboratory data will be difficult, if not impossible, to interpret.

4.35 The Working Group again drew attention to the need for scientists conducting field studies to consult with veterinary pathologists before going into the field to ensure that, if needed, urgent analysis of samples is possible and that any special sampling requirements of the laboratory can be accommodated (SC-CAMLR-XIV, Annex 4, paragraph 5.49).

Marking Birds for Long-term Studies

4.36 In relation to the use of implanted electronic tags (Appendix I, paragraph 39), it was noted that while these tags offered considerable potential for some CEMP purposes, they are unsuitable on their own for some other applications, such as detailed demographic studies. Such work still relies on externally visible marks; several research groups are currently investigating this problem.

4.37 Dr Croxall noted that the SCAR Workshop on Alternative Marking Methods for Penguins (Cambridge, UK, 31 July 1996) had received reports of successful subcutaneous implantation of tags into the upper leg and lower dorsum of king penguins. No tag loss had occurred in these studies, which were conducted over several consecutive years. Dr Kerry also noted that the same kind of tags had been used extensively in Adélie penguins where they had been implanted into the neck (WG-EMM-Methods-96/8). Although the use of the tags had been very successful and the survival of tagged adults was equal to or better than that of banded birds, a problem that had been detected was that tags may migrate from the site of implanting.

4.38 The Working Group recommended that the investigations of tag migration proposed by the subgroup (Appendix I, paragraph 41) should also include studies of the relative suitability of different implantation sites.

4.39 The Working Group noted that until the results of such studies were available it would be premature to develop standard methods for the use of implanted tags (Appendix I, paragraph 42), though scientists using these devices were encouraged to make details of their methods and experience widely known.

4.40 It was also noted that there was currently no central directory of research groups and studies using implantable transponder tags in Antarctic seabirds. This problem is compounded by the fact that South Africa, as notified to SCAR, can no longer continue to support the bird banding database for Antarctic seabirds without additional funding. The Working Group considered that it was important to ensure that information about the types and identification codes of bands and transponder tags should be available to the research community to ensure compatibility of numbering sequences and types of instrumentation at different sites as well as to provide a point of reference for bands or transponder identification sequences recovered from birds. The Working Group agreed this was an important issue but noted that there were financial implications for the maintenance of such a directory.

At-sea Behaviour

4.41 At its 1994 meeting, WG-CEMP began the process of developing indices of predator foraging performance and at-sea behaviour for inclusion in the monitoring program (SC-CAMLR-XII, Annex 6, paragraphs 4.15 to 4.23). Draft standard methods for the attachment and deployment of instruments were considered by WG-EMM at its 1995 meeting and in the following intersessional period these were circulated for comments. The circulation list is given in WG-EMM-96/16, Appendix 1. These standard methods were redrafted incorporating the comments received (WG-EMM-Methods-96/5) and they were considered and endorsed with minor modifications by the Subgroup on Monitoring Methods (Appendix I, paragraphs 8 to 12) at its meeting in August 1996.

4.42 In addition, at its 1995 meeting, WG-EMM approved the move towards holding a workshop to develop standard methods for the analysis and interpretation of data on at-sea behaviour. During the following intersessional period, Dr Boyd wrote to a small group of scientists, including several not involved in studies related to CEMP but representative of those involved in studying at-sea behaviour, to propose holding a workshop as defined under the terms of reference given by WG-CEMP (WG-EMM-96/16).

4.43 The response to this letter indicated that there is insufficient interest to justify holding a workshop that would include others involved in related research. Nevertheless, the Working Group re-affirmed its commitment to the development of standard analytical methods for at-sea behaviour, including those which would ensure that relevant data are easily reduced into a format that would allow them to be readily incorporated into the CEMP database.

4.44 In order to maintain the momentum of this initiative, the Working Group decided that this issue should be considered by the Subgroup on Statistics as an agenda item at its next meeting. This would have the advantage that individuals with specific expertise could be invited to attend without the need to convene a full-scale workshop. In particular, the subgroup should be asked to consider sample datasets and analyses, and provide advice on the most appropriate indices for inclusion in the CEMP database and the appropriate methods used to derive these indices.

4.45 In response to the suggestion by the Subgroup on Monitoring Methods that a standard method for attachment of instruments to flying birds be developed (Appendix I, paragraph 13), the Working Group noted that:

(i) many different types of instrument are being attached to and implanted into flying birds and a wide variety of attachment techniques are in use; it would be premature to try to recommend standard attachment procedures;

(ii) unlike the situation with attaching TDRs to seals, no proposals have yet been made for the collection of standardised data on the foraging performance of flying birds; and

(iii) the appropriate procedure would be first to define what would be measured and then to provide advice relating to standardisation of instrumentation and attachment technique necessary to facilitate such measurements.

Crabeater Seals

4.46 Following consideration of crabeater seals at the 1995 meeting of WG-EMM, where concern was expressed that no proposals for standard methods (and thereby the provision of data to CEMP) had been made, SCAR-GSS had been asked by the Chairman of the Scientific Committee to provide assistance with drafting standard methods for CEMP.

4.47 This request was considered by SCAR-GSS at its meeting during July 1996 and an excerpt from the draft report of this meeting was available to the Working Group (SC-CAMLR-XV/BG/10).

4.48 The response from SCAR-GSS emphasised the central importance of its research program on Antarctic pack-ice seals (APIS). This program, which is due to run until the end of the decade, addresses both of the main concerns raised by CCAMLR: directed research on crabeater seals and the development of monitoring methods. Dr Øritsland commented that the issue of monitoring on crabeater seals was a two-step process involving, first, the development of standard methods (which is currently being undertaken by APIS), followed by the development of monitoring procedures (which will follow the completion of APIS).

4.49 With regard to directed research, Dr Boyd, who is a member of SCAR-GSS, described the general function of APIS. The program provides a framework within which process-oriented studies, focused mainly on crabeater seals, can take place. This includes, wherever possible, collaborative links with groups examining lower trophic levels and sea-ice and, to this end, linkages are being developed between the SCAR-EASIZ and SCAR-ASPECT programs and APIS.

4.50 The response from SCAR-GSS also highlighted the recent APIS workshop on the development of methods for measuring the distribution and abundance of pack-ice seals, including survey design, data collection protocols (including at-sea behaviour) and data analysis procedures. SCAR-GSS emphasised the relevance of this to CCAMLR's requirements for the development of CEMP standard methods for crabeater seals and for eventually establishing a CCAMLR database on crabeater seals.

4.51 The Working Group acknowledged and welcomed the significant steps that had been taken by SCAR-GSS towards the development of census methods and a database for crabeater seals. It also noted the advice from SCAR-GSS that it would be most appropriate to wait until the main results from the APIS program have been analysed before establishing standard methods for monitoring crabeater seals.

4.52 Dr Boyd also commented that such monitoring procedures could follow the example described in WG-EMM-96/33 where seal populations were monitored using shore-based counts. Only when there is more information about the movement patterns of crabeater seals in relation to season and ice conditions, which will be available as a result of the APIS program, will it be possible to establish the effectiveness of this type of monitoring, develop protocols for monitoring crabeater seals in this manner and provide an interpretation of variations in parameter estimates. In addition, the standard survey methods could be used to measure predator distributions during krill surveys. An example of the type of survey in which these methods could be applied is given in WG-EMM-96/63.

Future Work on Standard Field Methods

4.53 The Working Group noted the comments of the subgroup concerning the possible requirement for a comprehensive review of the existing methods to examine their ability to meet CEMP objectives (Appendix I, paragraph 6). The Working Group felt that, given the extensive appraisal of methods undertaken at the present meeting, it was no longer urgent to carry out such a review. It was felt that a better procedure would be for anyone who felt that a particular method was inappropriate for meeting CEMP objectives to submit to WG-EMM a paper detailing their concerns.

4.54 The Working Group approved the following initiatives which were the subject of advice from the Subgroup on Monitoring Methods (Appendix I, paragraph 81):

(i) develop additional new methods for Antarctic and Cape petrels, especially those for breeding chronology (Appendix I, paragraph 30);

(ii) request a study of the effects on birds of using fresh or seawater for stomach lavage (Appendix I, paragraph 20);

(iii) request the Subgroup on Statistics to consider analysis of predator foraging performance data on at-sea behaviour (Appendix I, paragraph 16; see also paragraph 4.44); and

(iv) maintain close links with APIS (Appendix I, paragraph 46; see also paragraphs 4.46 to 4.52).

Analytical Methods

4.55 At its 1995 meeting, WG-EMM highlighted several areas in which the analysis and presentation of data from CEMP could be improved and extended. This included (i) the calculation of indices of dependent species parameters and, in particular, the need for an improved method to identify anomalous years; (ii) extension of indices to cover harvested species and environmental parameters and; (iii) improvements to the way in which data were presented. Consequently these issues were referred to the Subgroup on Statistics for consideration during the intersessional period.

Report of the Subgroup on Statistics

4.56 Dr D. Agnew (Data Manager) presented the report of the Subgroup on Statistics (Appendix H).

4.57 A new method had been developed by the subgroup to identify anomalous years in time series of indices of dependent species parameters. This was required because the old method was sensitive to the length of the time series and tended to indicate large numbers of statistically significant anomalies in the values of monitoring parameters.

4.58 The method, which was suggested by Dr B. Manly (New Zealand), was based upon the development of a table of critical values that depend on the length of the time series. These values were developed from bootstrap simulations based on the assumption that the data fitted an empirical normal distribution (see WG-EMM-96/14). Thus it was necessary to transform data so that they were normally distributed. Since few of the monitoring parameters are normally distributed this remains problematic.

4.59 Dr M. Mangel (USA) suggested that, as a further modification, it may be appropriate to develop tables of critical values for each of the parameters, depending on their empirical distributions. However, this would require identification of an appropriate distribution of each parameter to allow parametric bootstrap simulations to be carried out.

4.60 Dr Agnew had used the new method to identify anomalous years and reported that this method was a substantial improvement on the previously used method. However, in consultation with Dr Manly, some adjustments had had to be made to the method because in its original form the method had been over-conservative and therefore had identified too few anomalous years (WG-EMM-96/13). Dr Croxall commented that in some indices the method still failed to identify anomalous years where these would have been expected. Examples of this were noted in the review of anomalies and trends given below. The Working Group recommended continued work on the application of this method by modifying it further to provide an improved match with known major anomalies in indices.

4.61 The Subgroup on Statistics recommended that quantiles would be used as a method for defining anomalous years in cases where data were not normally distributed or where they could not be transformed to normality. Dr Kirkwood enquired about the methods used for analysing quantiles and asked if any data had been presented using this method. In response, Dr Agnew explained that this method had not yet been used, mainly because it was difficult to calculate quantiles with the software currently available for analysing the database.

4.62 Dr Agnew noted other modifications recommended for the calculation of indices by the subgroup. These are described in detail in the subgroup report (Appendix H).

4.63 There is a problem associated with data absent from cells in a matrix from a group of colonies collected for a long time series. Additional work is required in order to examine methods for interpolating missing data for years when at least one colony out of a group has been counted. Dr A. Murray (UK) agreed to investigate this problem intersessionally.

4.64 With reference to the use of Method C2 (fur seal pup growth rate) which may result in biases caused by early mortality in years of low food availability, Dr Holt asked whether the same effect was likely to occur due to predation. In response, Dr Agnew indicated that predation would not lead to the same bias so long as each pup had an equal probability of being subject to predation.

4.65 With reference to unusual environmental events, the Working Group endorsed the recommendation of the subgroup that observations of this nature should be entered into the comments field of the data submission forms.

Data Submissions

4.66 Dr Agnew described the structure and rationale of WG-EMM-96/4 which tabulated the summaries and analyses of the CEMP database updated with data submitted for 1996.

4.67 The Working Group expressed its appreciation for the very substantial effort that had been put into the compilation of this information, both by those submitting data to the CEMP database and by Dr Agnew for his clear summary of the data. The Working Group also recognised that this dataset now contained time series that were becoming long enough to allow meaningful comparisons to be made between parameters and across sites that would help greatly in undertaking ecosystem assessments.

4.68 The Working Group reviewed all the monitoring parameters described in WG-EMM-96/4 for anomalies and trends but the current problems associated with the statistical analysis of anomalies (see paragraph 4.45) were reiterated and the Working Group agreed that these should be interpreted with caution at this stage.

4.69 A 17% decline in breeding population size of Adélie penguins (Method A3) at Anvers Island during the 1990s was observed. Dr Trivelpiece reported that the longer time series from Admiralty Bay indicated that the breeding population had been variable from the late 1970s to the late 1980s but that similar declines to those at Anvers Island had been observed through the 1990s. Chinstrap penguins at Signy Island also showed a significant decline for the full time series (WG-EMM-96/10) and a similar trend was indicated for Adélie penguins at this site although it was not statistically significant. Similarly, there had been recent declines in Adélie penguin populations in the Ross Sea since the late 1980s.

4.70 The inclusion in the tables of values for percentage change between years in penguin breeding population size is most helpful. Dr Croxall's illustration of this with the example of gentoo penguins from Bird Island (WG-EMM-96/4, page 6) showed the usefulness of percentage change as an aid to identifying potentially anomalous years. In future it may be appropriate to carry out analyses of the percentage change values to identify anomalies.

4.71 Dr Croxall noted that the number of macaroni penguins at South Georgia has decreased by about 50% since 1976. A major part of this decrease at the study colonies occurred in the late 1970s, although another decrease took place after 1994 (a year of extreme local krill scarcity). Gentoo penguin populations at South Georgia show considerable interannual variation, but there appears to have been an overall reduction of about 20% in the Bird Island population since 1977.

4.72 Dr Croxall provided several examples where the new method for identifying anomalies had apparently failed to identify biologically significant anomalies. Gentoo penguin breeding success at Bird Island (Method A6a, WG-EMM-96/4, page 15) shows four years of almost complete breeding failure. The anomaly index was successful in identifying only one of these failures. In addition, it was unsuccessful in identifying at least one biologically significant positive anomaly when the breeding success of gentoo penguins at Bird Island was close to its biological maximum. Similar problems existed for measures of penguin chick diet (Method A8a and A8b).

4.73 Attention was drawn to an apparent trend in increasing chick meal size (Method A8a) for Adélie penguins at Anvers Island and a recent decline in this parameter at Béchervaise Island. Comments relating to the former site will need to be referred to the originators of the data but Dr Trivelpiece noted that changes in the method of food sampling might be involved. Dr Kerry noted that at Béchervaise Island any apparent trend would be due to the low value in 1995 where the few samples obtained were all from early in the chick-rearing period. No samples were collected later in the chick-rearing period because by then almost all the chicks had died.

4.74 The Working Group also noted the trend of increasing fledging success (Method A6c) in Adélie penguins at Anvers Island. In addition, it noted that depressed fledging weight of penguins (Method A7) at Bird Island was associated with years of low krill abundance at South Georgia during 1991 and 1994.

4.75 Mr Ichii drew attention to the data for the foraging trip duration of chinstrap penguins at Seal Island (WG-EMM-96/4, A5 figure 2). He explained that individuals foraging overnight showed little variation in trip duration (Jansen, 1996). Therefore, he recommended that only daylight foraging trips should be used as an index. The Working Group noted that several aspects of this index need further investigation (see Appendix I, paragraphs 52 to 54) and recommended that Mr Ichii's suggestion be considered in any future work.

4.76 In concluding its review of the parameters on dependent species, the Working Group recommended that questions relating to the statistical definitions of anomalies in parameters should receive further attention.

Directed Research on Harvested and Dependent Species

Fish

4.77 *Pleuragramma antarcticum* is an important prey species for seals, penguins and fish in the high latitudes and has been considered as a monitoring species in the initial phase of CEMP. WG-EMM-96/65 provided new information on the hatching season and the growth of larvae and early juveniles of the species in the vicinity of the Antarctic Peninsula. Preliminary results indicated that assuming that micro-increments detected in otoliths were deposited daily, two hatching periods exist: one in June–July and the other in December. The maximum rate of growth for larvae that hatched in June–July was found to occur in August.

4.78 The Working Group noted that these findings were in contrast to previous observations by Dr G. Hubold (Germany) and others (SC-CAMLR-XIV, Annex 5, paragraph 6.14) who suggested that *P. antarcticum* spawns once a year at the end of the austral winter with larvae hatching in spring. Verification of a daily deposition of micro-increments assumed in WG-EMM-96/65 was still pending and was considered to be crucial for the outcome of this study.

4.79 WG-EMM-96/43 presented information on the interannual variation in the condition index of mackerel icefish, *Champsocephalus gunnari*, at South Georgia. Interannual variation was high with the higher condition indices, indicative of good feeding conditions, corresponding to years when krill was abundant in the region. Years of krill scarcity resulted in low condition indices. These low condition indices were consistent with years when CEMP indices from land-based predators, such as breeding success and the proportion of krill in the diet of gentoo and macaroni penguins and black-browed albatross and foraging trip duration in fur seals also indicated that krill abundance was low.

Seabirds and Marine Mammals

Diet

4.80 WG-EMM-96/17 and 96/44 reported on the diet of the Cape petrel, *Daption capense*, during the chick-rearing period at two localities in the South Shetland Islands and during the post-hatching period at Laurie Island (South Orkney Islands). In both regions, krill and fish formed the predominant items in the prey, in terms of mass and numbers, whereas other prey, such as amphipods and squid, was of minor importance. The most common fish prey was the lanternfish *Electrona antarctica*. This was in contrast to results from studies in colonies of Cape petrels on the Antarctic continent where *P. antarcticum* accounted for most of the fish prey.

4.81 WG-EMM-96/32 emphasised the importance of fish in the diet of the South Polar skua, *Catharacta maccormicki*, at the South Shetland Islands. A variety of fish species was found in the diet of this species during the breeding season at Half-Moon Island. The myctophid *E. antarctica* was the most common prey species.

4.82 Dr Trivelpiece noted that *P. antarcticum* and *E. antarctica* were the predominant prey items of the South Polar skuas breeding in the long-term study region in Admiralty Bay, King George Island. The occurrence of *P. antarcticum* in the skua's diet was found to be highly variable between years and seemed to be linked to the presence of small krill in the area. Reproductive success of the South Polar skuas increased in years when *P. antarcticum* was present in their diet. The proportion of myctophids in the diet appears to have increased since the late 1980s. Dr Croxall noted that myctophids form the main part of the diet of king penguins and that the number of king penguins in the Southern Ocean has doubled over the last decade. Otoliths of myctophids have been found consistently in scats of fur seals at Bird Island, South Georgia, since about 1990.

4.83 WG-EMM-96/31 presents results from six years of study of fish in the diet of blue-eyed shags, *Phalacrocorax atriceps*, at the South Shetland Islands. Results from 1995/96 were in close agreement with those presented to the Working Group in previous years. *Notothenia coriiceps* and *Harpagifer antarcticus*, which are the most abundant fish species in inshore waters, formed the bulk of the diet. *Gobionotothen gibberifrons* and *Notothenia rossii*, which were previously exploited in the area, comprised a low proportion of the diet with no apparent trend over the years.

Foraging

4.84 Foraging movements of dependent species were described in WG-EMM-96/12 and 96/69. Dr P. Trathan (UK) indicated that grey-headed albatrosses from South Georgia appeared to be targeting areas of high cephalopod abundance in the region of the Polar Frontal Zone to the north of South Georgia (WG-EMM-96/12). Dr Kerry reported that for six Adélie penguin colonies between 60°E and 140°E penguins feeding their chicks foraged between 100 and 120 km off shore (WG-EMM-96/69). This meant that for these birds along the Mawson coast there was potential for overlap with the fishery as shown by the location of fishery data given for squares of 30 n miles x 30 n miles. The overlap for colonies near Davis occurred only outside the chick-rearing period. At Casey and Dumont d'Urville the possibility of overlap has yet to be ascertained.

4.85 The foraging range of macaroni penguins from South Georgia was also examined from data on the at-sea distribution of macaroni penguins from ship observations during radial transects out from breeding colonies (WG-EMM-96/59). When weighted for the size of breeding colonies at South Georgia, this provided an estimate of the density distribution of breeding macaroni penguins foraging in the region of South Georgia.

4.86 Dr Trivelpiece noted that variability in the incubation shifts of Adélie penguins, described in WG-EMM-96/58, probably reflects variations in travel time to and from the food source rather than the quantity of food.

Population Dynamics

4.87 Dr Miller introduced WG-EMM-96/38 which examined trends in abundance and breeding success of macaroni and rockhopper penguins at Marion Island (Subarea 58.7). The Working Group welcomed the information contained in this paper. Although macaroni penguins at Marion Island eat few euphausiids, it is important that the Working Group should consider parallel data from other sites in the Southern Ocean. This provides a broader context for the interpretation of trends and anomalies at CEMP sites.

4.88 Dr Croxall described the long-term (20-year) patterns in breeding population size, breeding success and survival of black-browed albatrosses at Bird Island, South Georgia (SC-CAMLR-XV/BG/7). The study population decreased substantially in the late 1970s, recovered somewhat over the next decade and then declined significantly since 1988. Breeding success was significantly lower in the decade 1986–1996 than in the preceding decade, possibly reflecting more years of reduced krill availability in recent times. The early population decline coincided with notably low values of adult survival (1977–1979, 1981) which antedate any information suggesting incidental mortality associated with longline fisheries. Recent declines, however, involving both reduced adult survival and very low recruitment rates, are likely to be due primarily to incidental mortality.

4.89 Dr K. Shust (Russia) introduced WG-EMM-96/33 which describes counts of seals made at the Fildes Peninsula, King George Island. Five species of seals were observed. Elephant seals were the most abundant species. Monthly counts showed variation through the year in all species. Comparison between counts made during 1974, 1985 and 1996 showed little variation in the abundance of most species except Antarctic fur seals, which increased between 1985 and 1996.

4.90 WG-EMM-96/39 summarised CEMP activities of Chile at Cape Shirreff, South Shetland Islands. In addition to censuses of fur seals, which are dealt with in section 4, information was provided on numbers of elephant seals (536), Weddell seals (26), leopard seals (8), and crabeater seals (2) present in the area. Twenty-three penguin rookeries were recorded, with a total of 11 400 chinstrap and 294 gentoo penguin nests.

4.91 Shipboard marine mammal and seabird surveys have been conducted by Australia and Italy in the past year (WG-EMM-96/29 and 96/63). Dr M. Azzali (Italy) described the results of the Italian survey which was carried out within the pack-ice zone and used a 400-m-wide strip transect. The snow petrel was the most abundant species observed. Amongst the krill-dependent species, there was a positive association between krill density in the concurrent acoustic surveys and predator density, except for snow petrels, emperor penguins and South Polar skua, for which no correlation was observed. The Australian survey used the BIOMASS standard methods for seabirds and took place north of the sea-ice. Some of the practical problems of carrying out these observations on a ship which was also involved in oceanographic surveys were outlined, and preliminary analyses of the data were described. It was reported that passive acoustic methods for examining the distribution and abundance of odontocete whales had produced promising results.

4.92 The need for quantitative at-sea surveys of seabirds and marine mammals using standard methods was emphasised. New standard methodologies for seabirds and seals are being investigated for use in the Southern Ocean; Dr Croxall noted that a report on recent workshops on standardising quantitative seabird observations should be available soon and will be tabled at the next meeting of WG-EMM.

4.93 Mr Ichii presented WG-EMM-96/48 which provided the results of a survey of cetaceans in Division 48.4.1. The survey indicated spatial segregation of minke whales from humpback whales, and sperm whales from beaked whales. It was noted that the area covered by this study overlapped with that surveyed by Australia (WG-EMM-96/29). Moreover the Working Group recognised that the IWC-IDCR database could provide data useful to the Working Group for its ecosystem assessments.

ENVIRONMENT

Information Available

5.1 WG-EMM considered the comments of the Subgroup on Statistics relating to the monitoring of the environment (Appendix H). The development of two new indices was recommended by the subgroup following discussions at the WG-EMM meeting in Siena concerning the need to develop further indices (SC-CAMLR-XIV, Annex 4).

5.2 Use of the first of these indices, sea-surface temperature (SST), has been implemented by the Secretariat (WG-EMM-96/4). The second index recommended by the subgroup relates to the characterisation of current flow. During the Cape Town meeting (WG-Krill-94) the Working Group had considered aspects of krill flux and, although methods are being developed to examine this aspect, the work is still at an early stage. WG-EMM agreed that a practical index of current flow was important and needed to be developed.

5.3 The Working Group noted deliberations of the Subgroup on Statistics and its suggestions regarding various environmental indices (Appendix H, paragraphs 51 and 52). The outcome of WG-EMM's considerations of this matter can be found in paragraphs 6.35, 6.36, 7.40 and 7.41.

5.4 WG-EMM-96/13 reported on the development by the Secretariat, over the past year, of environmental monitoring indices. The main new development was the inclusion in the CCAMLR database of SST data obtained from the National Center for Atmospheric Research (NCAR) (USA).

5.5 These data are available at a spatial resolution of 1° latitude by 1° longitude (cells) with a temporal resolution of one month. The Secretariat identified those cells most closely adjacent to each CEMP site which were also ice-free during the summer period. The means for the three months from December to February were then calculated as an index of SST (WG-EMM-96/4).

5.6 WG-EMM agreed that inclusion of these data in the CCAMLR database was a useful development, although further consideration of an SST index would be possible only after interactions in the ecosystem had been studied.

5.7 WG-EMM reviewed the various indices of sea-ice which are included as part of CEMP (WG-EMM-96/4). The indices are: percentage ice cover, the date of sea-ice retreat past CEMP sites, the ice-free period, the distance from CEMP sites to the sea-ice edge and the number of weeks the ice is within 100 km of such sites. It was emphasised that these might not be the best indices for EMM purposes as they had been developed some time ago as part of CEMP.

5.8 General patterns of sub-decadal and regional variability in sea-ice indices were reported in papers presented at WG-EMM's meeting in Siena (WG-EMM-95/62 and 95/80).

5.9 Apparent correlations between sea-ice and SST indices were also indicated. Aspects of these links in the physical system were reported last year in WG-EMM-95/69 and 95/80. WG-EMM also acknowledged that there was a wider range of literature beyond the papers submitted to CCAMLR on aspects of the physical dynamics of the Southern Ocean.

5.10 It was suggested that some SST data did not fully accord with other analyses and that the index might not perform equally well in all areas. When selecting areas for deriving SST indices those where there may be rapid changes (e.g. at the frontal zones) or which include different water masses should be avoided. Values derived for areas close to the coast may also be less reliable. The Working Group requested members with relevant knowledge to examine the data and the areas from which they derive, and to recommend necessary adjustments and improvements.

Bathymetry

5.11 WG-EMM reiterated last year's conclusion regarding the value of detailed bathymetric data for an understanding of both ecological and fishery interactions. This was reiterated in WG-EMM-96/64, and there was some discussion on the interaction of water circulation with bottom topography and the contribution these factors make towards observed prey distributions. It was suggested that the compilation of detailed datasets in the same form as reported in WG-EMM-96/64 would be useful for other areas.

5.12 Dr E. Hofmann (USA) informed WG-EMM that high resolution bathymetric data were available for the west Antarctic Peninsula region and that such a dataset could be obtained from her. WG-EMM thanked Dr Hofmann for this offer.

5.13 Prof. Torres drew WG-EMM's attention to the fact that Chile had produced a bathymetric chart (No. 14301, 1994) on a scale of 1 : 50 000 for the sea area around the Cape Shirreff CEMP site and the San Telmo Islands.

Sea-ice

5.14 At its last meeting WG-EMM requested the Secretariat to prepare a document outlining the development of sea-ice indices in the Antarctic Peninsula region. The document had been prepared (WG-EMM-96/15). Members felt this paper gave a useful background to the sea-ice indices reported in WG-EMM-96/4.

5.15 Last year WG-EMM also considered the role of sea-ice in the ecosystem and recognised that this matter needed to be addressed intersessionally by a correspondence group (SC-CAMLR-XIV, paragraphs 6.48 and 6.49). Dr Miller, convener of this group, reported on developments over the past year. He noted that the group's major tasks were to identify key hypotheses, liaise with other programs and identify future requirements.

5.16 Dr Miller also informed WG-EMM that he had encountered problems, which probably resulted from the fact that the group's task was unclear, and required broader input from outside the group's membership. The Subgroup on Statistics suggestion of a workshop to develop relevant studies of the sea-ice offered a useful way forward.

5.17 The Working Group thanked Dr Miller for his efforts with the difficult task of addressing the issue of sea-ice characterisation. It was acknowledged that WG-EMM should consider other ways in which this could be achieved and the Working Group's discussions below should be viewed in this light.

5.18 Dr Trivelpiece informed the group of a conference on ice ecology, to be held in the USA in March 1997, which could provide useful background information. Developments within SCAR, particularly the EASIZ program, were also noted.

5.19 A more detailed discussion of the development of sea-ice indices followed. Dr Hewitt presented data on the areal extent and duration of sea-ice cover for the west Antarctic Peninsula region (WG-EMM-96/24). The data were derived from the same dataset as that used in the calculation of the CEMP indices (WG-EMM-96/4).

5.20 The analyses used pixel data (25 x 25 km resolution) to describe the presence or absence of sea-ice cover greater than 15% by area. This was displayed for each month as a function of a year. Following some discussion concerning the size and geographical coordinates of the box from which the information was derived, as well as the local oceanography and bottom topography, WG-EMM considered the approach to be a useful development which attempted to characterise sea-ice variation. The derived data encompass some of the aspects of ice variability which are likely to be most important in krill recruitment processes.

5.21 Four periods of extensive ice cover over the last 17 years are evident in the dataset. The first of these periods was centred on August 1980 with a relatively short seasonal duration. The second was centered on August–September 1986 and was extended over more months (within the year) and between years (e.g. in 1987 extensive ice cover peaked in July–August). The third ice event was centered on June–July 1991 and was more extensive between years than within the year. The fourth appears to be centered on August 1995 and looks as if it will be extensive both within the year and between years.

5.22 It was again noted that the above data reflect the larger-scale and/or longer-term processes generating variability in the sea-ice field reported in WG-EMM-95/69 and 95/80 submitted last year.

Circulation

5.23 WG-EMM-95/29 presented information on environmental aspects of an integrated study of the physical and biological components of an area off the coast of east Antarctica (Division 58.4.1) during 1996. Further analyses of data would be presented at later meetings of WG-EMM. It was noted that the direction of flow in open-ocean areas followed the general pattern expected in the West Wind Drift (WWD), whereas it was much more confused in the coastal regions. This has implications for the retention of organisms within an area. These results also emphasised the value of including other types of plankton, such as phytoplankton and salps, when attempting to understand processes determining krill distribution. WG-EMM acknowledged the importance of such integrated oceanographic and biological study programs and looked forward to the presentation of results of such analyses in the near future.

5.24 Links between atmospheric circulation patterns and hydrographic conditions in the WSC were considered in WG-EMM-96/35. The paper emphasised the complexity of the surface flow patterns in the region and indicated that the position of the WSC varies and that these variations are linked to atmospheric conditions. The hydrographic data on which the analyses were based were presented in WG-EMM-96/36. WG-EMM noted that processes generating oceanographic variability are likely to be of major importance in the marine ecosystem. Understanding the spatial and temporal scale of associated fluctuations in the regime of the physical environment is therefore crucial.

5.25 Data on current flow and krill distribution were presented and the question of krill flux in an area near the South Orkney Islands was addressed (WG-EMM-96/37). The Working Group had requested this type of study at earlier meetings. It considered this to be a very valuable study and noted the results with interest. Further development of such studies was encouraged as a matter of priority.

5.26 WG-EMM-96/12 reported results from an integrated physical and biological study. This work involved the use of satellite-tracked predators to identify general areas where predators were foraging. Oceanographic work along with remotely sensed SST data were then used to characterise regional oceanography. The importance of interactions between the water circulation and bottom topography in generating mesoscale oceanographic patterns was emphasised.

5.27 WG-EMM-96/61 presented preliminary results from a regional circulation model for the Antarctic Peninsula region and the southwest Atlantic. The model has been developed to address questions of transport and residence times of krill in the areas considered by the 1994 Workshop on Evaluating Krill Flux Factors (SC-CAMLR-XIII, Annex 5, Appendix D). Higher resolution models are being developed for the Western Antarctic Peninsula region and South Georgia. The initial results indicate that the area is characterised by extensive gyres with a spatial scale of about 200 km. The implications of this finding were in accordance with existing perceptions of the area's ocean dynamics topography.

General

5.28 WG-EMM-96/21 considered long-term changes in the climate and their implications on the marine food web in the Antarctic Peninsula area. The authors cite several studies which demonstrate a trend of increasing temperature and decreasing frequency of winters with extensive ice cover. They also note the correlation between winters of low ice cover and the occurrence of a population bloom of *Salpa thompsoni* during the following spring.

5.29 The authors estimate that a salp bloom could consume a substantial portion of primary production during the spring and thereby deprive adult krill of sufficient food to support their energy requirements. This would delay the maturation of adult krill, leading to poor spawning, and resulting in a weak year class.

5.30 A decrease in the frequency of strong krill year classes would result in lower average krill abundance and a reduction in the food available to obligate krill consumers. The reduction in juvenile survival and in population size of Adélie penguins were noted as supporting evidence.

5.31 Carbon cycle effects would also be expected: during years of good krill recruitment and elevated population size, a relatively large proportion of the primary production passes through krill to vertebrate predators, and is also transported to the sediments via dense, resilient fecal pellets. During years of salp blooms, less newly-fixed carbon will pass through the krill-based food web, and more will be transported into the microbial loop via relatively delicate salp fecal pellets.

5.32 It was emphasised that there is considerable information of direct relevance to understanding the observed characteristics of the physical environment being produced outside WG-EMM.

5.33 WG-EMM-96/60 raised the possibility of combining environmentally-based and fishery-based models, building on principles from agriculture and forestry. In discussion, it was recognised that a range of approaches would be useful in developing ecosystem assessments. Such an exercise would provide a useful feedback into the development of more detailed fishery models. It would also be a useful check of the validity of such models. WG-EMM encouraged the development of a range of modelling approaches to problems encountered in monitoring and managing the ecosystem.

5.34 WG-EMM-96/68 detailed a size-structured model for krill growth. The model utilised a physiological basis for growth allied to seasonal changes in food supply. The results indicated the need of krill to encounter food during winter. Sea-ice algae or microzooplankton are required during winter to maintain observed growth rates. WG-EMM agreed that the study reiterated the value of a range of modelling approaches which would help as a way of clarifying key environmental variables and the relevant time scales for monitoring.

5.35 It was noted a number of times, in discussion of the environmental variables, that the Working Group does not have a large group of people experienced in analyses of the physical components of the ecosystem. It was agreed that it would not be useful to try and increase too much the participation of such people. However, it was acknowledged that it was extremely valuable to have the input of physical oceanographers in particular.

5.36 Various mechanisms for ensuring the appropriate level of input of views on the physical environment into the Working Group were discussed. It was suggested that members ensure that intersessionally they communicate as much as possible with scientists engaged in more physical aspects of Southern Ocean research. This would help to identify key aspects of the physical environment and ensure that new developments were brought to the notice of WG-EMM. This is particularly important as the Working Group begins to consider links between environmental and biological components of the ecosystem, consistent with its philosophical approach as identified in 1995.

5.37 WG-EMM agreed that a small e-mail correspondence group should be formed in order to improve dissemination of literature on the physical aspects of the Antarctic marine environment.

5.38 Last year WG-EMM was notified of the forthcoming SCAR-COMNAP meetings on environmental monitoring (October 1995 and March 1996). Dr P. Penhale (USA) presented a paper (WG-EMM-96/62) summarising the developments of the meetings. The key points raised were noted by the Working Group and it was suggested that CCAMLR should continue to be kept informed of developments in this area.

5.39 Dr Kock notified the Working Group of a forthcoming meeting on the Southern Ocean organised by the IOC. Dr Kock would be attending this meeting in his capacity as Chairman of the Scientific Committee.

ECOSYSTEM ANALYSIS

By-catch of Fish in the Krill Fishery

6.1 Japanese scientists continued their investigations on the by-catch of fish in the Japanese krill fishery in the vicinity of the South Shetland Islands in February–March 1996. WG-EMM-96/52 provided preliminary information on the species composition and the amount of by-catch taken by the trawler *Chiyo Maru No. 3*. Onboard sampling and the presentation of results closely followed the standardised procedures agreed on by the Scientific Committee. Fish were encountered in 41 out of 147 hauls observed. Juveniles of notothenioid fish were primarily found in hauls carried out over the shelf, while mesopelagic species occurred only in tows over the shelf break and in oceanic waters. *Lepidonotothen larseni*[2] was the most abundant notothenioid, and *Electrona carlsbergi* the mesopelagic species most frequently encountered in the by-catch. The by-catch of fish tended to be highest when the krill CPUE was small.

6.2 The Working Group welcomed the continuing efforts of Japanese scientists to provide information on the by-catch of juvenile fish in the krill fishery. The Working Group suggested that this data should be augmented by length compositions of the most abundant species and then incorporated into the comprehensive review of the by-catch of fish in the krill fishery which is currently being undertaken by a group of specialists in this field and coordinated by the Science Officer, Dr E. Sabourenkov. An interim report on the status of this review will be submitted to the meeting of WG-FSA in October 1996. Prof. Torres informed the Working Group that Chile will provide information in the near future on the by-catch of fish in its krill fishery from 1991 to 1994.

6.3 The Working Group noted that most of the by-catch studies have been conducted during the austral summer. It reiterated requests from previous years to extend these studies to other seasons to cover spatial and seasonal differences in the occurrence of fish in krill catches, in order to better assess when fish are most vulnerable to the krill fishery. Mr Ichii suggested that stomach contents of fish taken incidentally in the krill fishery should be analysed more often in order to obtain a better understanding on the association of juvenile fish with krill aggregations.

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[2] Formerly known as *Nototheniops larseni*

6.4 To focus discussion, the Working Group considered the scales over which changes in krill standing stock or recruitment were observed and the implications of this on the degree of isolation and of advection between areas.

6.5 There was evidence that in the 1995/96 season strong krill recruitment had occurred in both Subareas 48.1 (WG-EMM-96/23) and 48.3 (WG-EMM-96/18), suggesting that factors affecting recruitment in this year had been similar across the southwest Atlantic sector of the Southern Ocean.

6.6 However, results from a large-scale survey in Area 58 (WG-EMM-96/29) showed only average recruitment in contrast to the high values observed in Subarea 48.1, indicating that changes were not occurring synchronously throughout the Southern Ocean.

6.7 Considering variation at smaller scales, the Working Group was reminded of two datasets presented to WG-EMM-95. Great variation in penguin chick survival at Béchervaise Island (WG-EMM-95/33) illustrated that local krill availability can vary widely from year to year. Data on krill recruitment estimated from penguin diet samples at Palmer Station (Anvers Island) and King George Island (WG-EMM-95/64) showed that the indications of strong recruitment at the two locations were one year out of phase.

6.8 Indices for distribution, abundance and depth of krill were derived from data collected during the US AMLR surveys off Elephant Island between 1990 and 1996 (WG-EMM-96/22). It was pointed out that the variation of these indices within the restricted foraging range of penguins was less than that occurring in the main survey area. Thus it appeared that krill aggregations may be reliably found in some areas. In addition, it was suggested that these areas may act as foci from which krill distributions extend outward in years of high krill abundance.

6.9 Summarising these discussions, the Working Group recognised that it was important:

(i) to establish the degree of linkage between major concentrations of krill;

(ii) to determine the size of areas in which similar variation takes place; and

(iii) to establish to what extent variation could be explained by changes in krill production within the area as opposed to movement of krill from area to area.

Furthermore, the implications of these points with respect to the size of management areas used by CCAMLR should be considered.

6.10 The Working Group discussed in some detail the estimates of krill recruitment proportion in Subarea 48.1 and the links between this and the extent of winter sea-ice.

6.11 At the previous meeting of the Working Group, WG-EMM-95/64 showed that the krill population structure derived from krill length frequencies taken from penguin diet samples at Palmer Station (Anvers Island) was different from that at Admiralty Bay (King George Island). These differences had been linked to a one-year time lag in pack-ice cycles between the areas.

6.12 During discussion it became apparent that the relationship between these factors was more complex than previously thought.

6.13 Oceanographic conditions at Palmer Station, at the western end of the Antarctic Peninsula, were likely to reflect those in the Bellingshausen Sea. However, while it was likely that the southern side of the Bransfield Strait would reflect Weddell Sea characteristics, the northern side of the Bransfield Strait could reflect Drake Passage and possibly even Bellingshausen Sea characteristics. Thus the same krill population structure might be expected from the study sites at Anvers Island and Admiralty Bay.

6.14 The effect of sea-ice on the biology of krill was also seen as complex. In 1995 there was extensive winter ice cover, large numbers of 1+ krill, good recruitment – one of the highest values for the proportions of recruits recorded over 18 years – and few salps (WG-EMM-96/21). Depending on the ice conditions in the 1996 winter, another strong year class is expected to emerge from spawning during the 1995/96 season.

6.15 During the winter of 1994 there was above-average extent of ice, and low krill and salp abundances during the summer of 1994/95 (WG-EMM-96/21). Low krill abundance was attributed to poor krill recruitment from spawning during 1992/93 and 1993/94. The lack of a salp bloom was attributed to above-average ice cover during the winter of 1994.

6.16 An analysis of these phenomena has been prepared by Siegel and Loeb (1995) who proposed that increased ice cover may act in two ways. First, it may enhance feeding of the adult population during winter and inhibit a spring salp bloom. This results in early spawning for the krill and successful recruitment. Second, greater ice cover improves the chances of survival of the larvae through the winter after spawning.

6.17 Dr S. Kawaguchi (Japan) considered, however, that if ice cover acts in these two ways, there should be more years with a high proportion of recruits than were observed in the scientific net surveys. Some evidence of a high proportion of recruits was observed from the fishery data when this was to be expected but was not detected in the scientific surveys. This evidence suggests that there may be a high possibility of underestimation of the proportion of krill recruits.

6.18 Some members cautioned that it is difficult to interpret proportions of recruits from commercial catches because these do not represent random samples from the population.

6.19 The Working Group noted that while the exact link between sea-ice and krill recruitment was not simple, it was suggested that the present relationship had some predictive power and that this should be explored further.

6.20 The recruitment indices available to the Working Group at present are estimates of proportional recruitment and thus have a number of restrictions. For instance, in a year of low stock abundance even low levels of absolute recruitment may appear as a high proportional value.

6.21 The Working Group recognised the importance of deriving an absolute recruitment index as the next step. However, it was also pointed out that even at the present level of development, recruitment indices derived from research cruises, the fishery and predators, together with ice indices, have considerable utility for both explanation and prediction of variations in the ecosystem.

6.22 The Working Group also recognised that while a medium-term goal of WG-EMM was to understand the underlying process of variation, in the short term the implications of the large variation in the values of proportional recruitment for the krill yield model were very important.

6.23 The present krill yield model is based on the assumption that the krill stock varies around a median level with no trend in recruitment. Bearing in mind the considerable effort put into investigating the links between climate change and sea-ice, and between ice cover and krill recruitment, it is possible that a long-term change in krill biomass and recruitment might be confirmed. The Working Group recognised that further development of the model may be required to take account of such changes (see Appendix F).

6.24 Finally, the Working Group noted that, while the environment affects krill growth and mortality, in the model such environmental effects are assumed to be absent. This question should be considered in the future, for instance using the approach described in WG-EMM-96/68.

Harvested Species and the Krill Fishery

6.25 A compilation of information on the location of the commercial krill fishery in Area 48 (WG-EMM-96/64) confirmed that key locations were fished regularly from year to year. Many of these key locations (particularly in Subareas 48.1, 48.3 and west of the South Orkneys in Subarea 48.2) were related to the position of shelf breaks or current gyres. Other fishing sites in Subarea 48.2 were more variable and were more likely to be related to the position of the ice edge or position of the current fields prevailing at that time.

6.26 In Area 58 the longitudinal position of the fishery was much more variable but it still tended to occur in the shelf break/slope region (WG-EMM-96/28).

6.27 WG-EMM-95/69 presented at the last meeting of WG-EMM, considered links between CPUE data from the Russian fishery in Subarea 48.3 and environmental parameters. Dr Murphy indicated that further analysis of these data had been undertaken and that the relationship between CPUE and SST was more complex than described in WG-EMM-95/69.

6.28 He also pointed out that, since searching time was very short in this particular fishery, the krill CPUE index based on towing time (WG-EMM-95/69) could provide an index of local density.

6.29 Attention was drawn to WG-EMM-96/4, in which the relationship between Japanese krill catches in tonnes/hour in Subarea 48.1 (index H1) and the percentage ice cover in the same subarea (index F2a) showed some agreement, with poor CPUE and low ice cover occurring in 1985, 1990 and 1993.

Interactions between Ecosystem Components

Dependent Species and the Environment

6.30 Some discussion on this topic took place during the Working Group's earlier reviews of harvested species, dependent species and the environment. Much of this discussion related to the potential interactions between ice cover, productivity and survival of prey and consequent effects on productivity and survival of predator populations (see paragraphs 3.53 to 3.57; also SC-CAMLR-XIV, Annex 4, paragraph 5.119, 6.22 to 6.32, 6.44 and 6.45).

6.31 Dr Trathan noted that the investigation reported in WG-EMM-96/10 was stimulated by the suggestions of Fraser et al. (1992) that sea-ice cover profoundly influenced penguin populations, and that recent declines in sea-ice cover in the Antarctic Peninsula region would be predicted to have opposite effects on Adélie and chinstrap penguin populations (based on the very different affinity of these two species for sea-ice habitat). No long-term trends were evident in the data on local sea-ice conditions at Signy Island, South Orkney Islands, 1947 to 1992 or on regional sea-ice conditions in this area from 1973 to 1988, although there were pronounced quasi-periodic fluctuations. However, this may simply reflect differences between the western Antarctic Peninsula, influenced mainly by Bellingshausen Sea conditions, and the South Orkney Islands, influenced mainly by Weddell Sea conditions. At Signy Island, predator population size and breeding performance, monitored annually since 1979, showed no correlation with local ice conditions. However, with regional sea-ice conditions there were relationships between winter sea-ice at a time (different for each penguin species) just before its maximum extent and subsequent penguin breeding population size.

6.32 Dr Trivelpiece reported that WG-EMM-96/58 indicated that almost all aspects of Adélie penguin biology are influenced by environmental variability at one scale or another. The results also indicated that the absence of breeding Adélie penguins along 500 km of coastline in the central Antarctic Peninsula region reflects the need for breeding birds to replenish body reserves in the early spring post-laying period by returning to predictable sea-ice habitat. Birds breeding at colonies in the southern Antarctic Peninsula can reach appropriate sea-ice areas in the Bellingshausen Sea. Breeders from northern colonies can travel to appropriate areas in the Weddell Sea. However, in between these areas distances to sea-ice may be too great for viable breeding populations to persist. The gap in Adélie penguin distribution is filled by abundant breeding populations of chinstrap penguins, a species which does not require access to sea-ice. The presence of submarine canyons which create sufficient upwelling of warm Circumpolar Deep Water (CDW) to provide open-water conditions earlier in the breeding season may have provided conditions favouring the establishment of large Adélie penguin colonies adjacent to these canyon areas.

6.33 Dr Kerry reported that both fledglings and post-moult adults leave the breeding colony at Béchervaise Island (67°S 63°E) in late February and March and overwinter at least until June in the pack-ice zone in close proximity to the continental shelf break. During this period they move progressively westward at approximately the speed of the sea-ice. Precise locations compared with sea-ice conditions derived from AVHRR satellite data show that they have access to the sea through leads or broken pack-ice (Kerry et al., 1995).

6.34 The sea-ice zone is also a key habitat for emperor penguins; results of satellite-tracking work emphasise the dependence of breeding birds on access to polynyas for breeding (Ancel et al., 1992). Post-fledging chicks, however, may cover large distances, travelling outside the sea-ice zone nearly as far north as the Polar Frontal Zone (Kooyman et al., 1996). Dr Kerry reported that Kirkwood and Robertson (in press) found through satellite tracking, dive analysis and stomach sampling that in the winter and spring of 1993 and 1994 emperor penguins feeding chicks at Auster rookery foraged in a polynya over the continental shelf and in a polynya at the junction between the fast-ice and pack-ice. Females in winter fed along the continental slope and males in spring fed in waters over a canyon that runs across the continental shelf and forms a polynya. Both sexes fed on *E. superba*, which constituted between 51 and 70% of the diet by mass. This evidence suggests that krill may be abundant in winter and early spring in waters over the shelf slope and in canyons on the continental shelf.

6.35 The report of the Subgroup on Statistics (Appendix H, paragraphs 51 and 52) noted that, although data relating to sea-ice as viewed from CEMP sites and local weather conditions and snow cover are defined in CEMP standard methods (F1, F3, F4), no data are currently being submitted and therefore no indices can be calculated. WG-EMM encouraged Members collecting these data to prepare standardised formats for data submission and to suggest how appropriate indices might be calculated.

6.36 The Working Group noted that methods for calculating indices of sea-ice (number of ice-free days and distance from CEMP sites to sea-ice edge) had already been implemented and that preliminary analyses of SST data were also available. Of the other environmental indices listed in Appendix H, paragraph 52, only for water flux had no progress been made in developing a standard method.

Dependent Species and Harvested Species

Diet, Energy Budgets and Foraging Ranges of Birds and Marine Mammals

6.37 The Working Group has made a standing request to Members to monitor and update annually data on diet, energy budgets and foraging ranges of birds and marine mammals in the Convention Area (SC-CAMLR-XIV, Annex 4, paragraph 5.101).

Diet

6.38 WG-EMM-96/11, 96/31 and 96/32 provide information on the quantitative composition of fish diets of black-browed and grey-headed albatrosses at South Georgia, and blue-eyed shags and South Polar skuas at the South Shetland Islands. WG-EMM-96/17 and 96/44 provide details of the diet of Cape petrels at the South Shetland and South Orkney Islands, showing that in 1995/96, although krill predominated in their diet, myctophids were also common.

6.39 WG-EMM-96/8 and 96/9 were primarily intended to address questions of krill selectivity by predators and the difference in selectivity between predators and research nets. However, these papers also contain considerable information on the size, sex and reproductive status of krill (and on the overall proportions of krill in the diet) taken by a range of top predators at South Georgia in 1986.

Energy Budgets

6.40 New data relevant to population energy budgets are contained in WG-EMM-96/7 (at-sea energy expenditure of Antarctic fur seals), and WG-EMM-96/66 (overall energy budgets of macaroni penguins and Antarctic fur seals at South Georgia).

6.41 WG-EMM-96/19 summarises data relevant to the calculation of energy budgets and food requirements of Southern Ocean krill predators. This was welcomed as a most timely and comprehensive document. Authors of early CCAMLR compilations on this topic (e.g. Croll, 1990 (WG-CEMP-90/30 Rev. 1); Croxall, 1990, 1991 (WG-CEMP-90/31, 91/37), Bengtson et al., 1992 (WG-CEMP-92/25)) and others familiar with this field were urged to review WG-EMM-96/19 in order to contribute additional information and to identify any errors or anomalies.

Foraging Ranges

6.42 New data on foraging ranges of top predators are provided in WG-EMM-96/12 (grey-headed albatrosses at South Georgia), WG-EMM-96/49 (chinstrap penguins at Seal Island), WG-EMM-96/58 (Adélie penguins in the Antarctic Peninsula region), WG-EMM-96/59 (macaroni penguins at South Georgia) and WG-EMM-96/69 (Adélie penguins along the coast of eastern Antarctica).

Interactions between Dependent Species and their Prey

6.43 Mr Ichii presented two papers (WG-EMM-96/49 and 96/55) which provide additional analyses of aspects of the data collected at and near Seal Island in 1994/95 (see SC-CAMLR-XIV, Annex 4, paragraphs 5.98 and 5.99). This study assessed krill and myctophid abundance (from acoustic surveys) in relation to diet and foraging of chinstrap penguins. Krill densities were higher over shelf areas (i.e. near shore) where myctophids were scarce or absent, but lower offshore, where myctophids were more common. Krill in offshore areas tended to occur in layers and were larger, more advanced in maturity stage and included gravid females (possibly more easily caught by predators); in inshore areas krill tended to occur in dense and discrete swarms and were smaller, less advanced in maturity stage and contained a greater proportion of males. Chinstrap penguins foraged in two distinct modes: birds making daytime (and shorter) trips foraging inshore, while those making longer trips (including overnight periods) foraged offshore. It was suggested that the advantages of foraging offshore – in an area of reduced overall krill abundance – included less patchy krill distribution, larger and easier-to-catch krill and the presence of myctophids.

6.44 Japanese and US researchers were commended for collecting such a range of valuable data and combining them into an interesting and informative summary. There were considerable discussions in regard to the analysis and interpretation of the data.

(i) The actual locations where penguins were feeding were apparently unknown except for a small number (7) of birds actually tracked while at sea; assignment of study birds to inshore/offshore categories was presumably therefore only made on the basis of the type of foraging trip undertaken.

(ii) The assignment of birds whose diet was sampled to daytime and overnight foraging categories appeared to be inferred from the time of return of birds without knowledge of their departure times.

(iii) Because birds foraging overnight also had the opportunity to forage in the daytime, the location where specific prey were captured had to be inferred. It would also be valuable to know the reproductive success of birds making daytime trips compared to those making overnight trips.

(iv) If the birds studied included both individuals of a pair during the brood-guard period, then the timing of return of one bird automatically determined the departure time of its partner; there were potential biases from this source in respect of departure time and also in respect of the sex of the birds.

(v) Dr Kim noted that the oceanographic studies in the Elephant Island area in 1994/95 (see SC-CAMLR-XIV, Annex 4, Appendix I) indicated that the ocean frontal zone north of Elephant Island moved south by 15 n miles during the course of the study. This could account for some differences in krill size as well as foraging distance of penguins between the two study periods (leg 1 and leg 2), described in WG-EMM-96/49.

(vi) The few diet samples taken in 1994/95 showed a very small proportion of myctophids. For the five years of samples (1988–90, 1991, 1994) the data submitted to CEMP suggested that only in 1994 did myctophids contribute more than 1% of the overall diet by mass (WG-EMM-96/4). Using a different method, the results of analysis of Mr Ichii's data indicate that the proportion by mass of myctophids ranged from 14–41% for overnight foragers (0–1% for daytime ones). However, Dr Croxall suggested that although myctophids may occur regularly in the diet of overnight (but not daytime) foraging birds from Seal Island, they appear to make a substantial contribution only in years when krill is scarce.

6.45 Dr Croxall introduced WG-EMM-96/7, which examined at-sea energy expenditure in relation to diving activity of Antarctic fur seals at South Georgia in 1992 and 1993. The results show a negative relationship between energy expenditure and several measures of diving activity, i.e. the more that an animal dived, the less energy it expended. Although the authors had expected a positive relationship, this finding suggests that most energy expenditure at sea may be associated with surface swimming, e.g. searching for krill swarms, and that those animals which spend the greatest proportion of their time diving are those that are most successful at finding swarms. It may well be that travelling, rather than feeding, is the expensive part of a foraging trip. The study also showed that there was no relationship between foraging efficiency and foraging trip duration; i.e. those animals with shorter-than-average foraging trips did not forage more efficiently than those with longer-than-average trips. However, it was stressed that this study was carried out in years of normal krill abundance and that the results might well be different in years with reduced krill availability.

6.46 In introducing WG-EMM-96/66, Dr Croxall noted that although it had been prepared in response to requests relating to the calculation of precautionary catch limits in Subarea 48.3 (see SC-CAMLR-XIV, Annex 4, Appendix H), it summarised extensive data relating to predator-prey interactions for the two most important top predators of krill in this subarea. The population energy budget provided includes information based on activity-specific energetics, in relation to age, sex and stage of life and reproductive cycle, estimates of population age structure for each sex and calculation of food intake in respect to, *inter alia*, each size class of krill.

Modelling Relations between Dependent Species and Prey

6.47 Dr Mangel introduced WG-EMM-96/20, which described the development of the first model to investigate the effects of fisheries on krill predators which considered processes at the level of a key interaction (foraging trip), rather than at the level of population effects.

6.48 The main components of the model are descriptions of:

(i) the spatial and temporal patterns of krill;

(ii) the mode of operation of the fishery (in a season lasting 100 days and operating within 200 km of the shore) and its effects on krill;

(iii) the foraging performance (determined by explicit decision rules) and survival of a model predator (here the Adélie penguin) throughout each of the five stages of its breeding season, incorporating a detailed empirical energy budget for chick-rearing; and

(iv) the effect of the removal of krill by the fishery on Adélie penguin reproductive success and adult survival.

The main aim of the model was to compare penguin reproductive success (chick survival) and adult survival in the absence and presence of a fishery.

6.49 In the model:

(i) krill biomass potentially available to predators and the fishery fluctuates in accordance with an age-structured stochastic recruitment model which generates the long-term frequency distribution of krill biomass (Butterworth et al., 1994);

(ii) fishing (conducted according to rules on minimum local biomass for starting and stopping fishing, daily and seasonal catch limits, etc.) is assumed to change the spatio-temporal structure (determined by diffusion and advection) of the krill available to predators foraging from their breeding site;

(iii) offspring survival depends on the cumulative amount of krill delivered, such that when the deficit exceeds 40% of the requirements for rearing a healthy chick, the chick dies; and

(iv) parental survival is influenced by the time it needs to spend at sea to accumulate krill to meet its own needs (during incubation) and also those of its offspring (during chick rearing).

6.50 The results of tracking accumulated food deficits of parents and offspring and accumulated adult mortality while foraging, in situations with and without fishing, are expressed as relative reproductive success and relative parental survival. The values derived from the present model indicate that:

(i) reproductive success (i.e. chick survival) declines in linear fashion with respect to krill catches by the fishery at an overall rate 50% greater than the rate at which krill is removed by fishing; and

(ii) relative parental survival is also a linear function of krill catches but with an overall slope of 0.65, i.e. parental survival declines at a rate 35% less than that at which krill are caught by the fishery.

6.51 The Working Group felt that this model has great potential for investigating interactions between predators, prey and fishery at the scales of greatest interest and concern to CCAMLR. The success of the model in reflecting biologically realistic trade-offs between adult and offspring survival was also noted.

6.52 Questions were raised about the model and its performance, concerning the:

(i) robustness of the model, given that the equations for reproductive success are based on a large number of parameters and assumptions;

(ii) likelihood that different distributions of krill could change the results substantially;

(iii) conservative nature of the assumption that the fishery proceeds to exploit krill from behind the direction of advection whereas predators operate from the opposite direction;

(iv) effect of using different types of fishing tactics (e.g. different options for different parts of the fleet, lie-in-wait tactics etc.); and

(v) degree of independence between the density-dependent responses relating to krill density/food availability and decreased survival with time at sea.

6.53 In response Dr Mangel stated that:

(i) the sensitivity analysis described in the paper indicates considerable robustness, particularly to the lesser-known parameters;

(ii) the model could be adapted for different krill distributions;

(iii) the fishery could proceed across the 'midpoint' peak of the krill distribution so the model was not entirely conservative in this respect;

(iv) other types of fishing tactics could fairly readily be incorporated; and

(v) the responses of the two factors are not independent but interact (i.e. there is a deficit-mortality interaction).

6.54 In response to questions concerning further development of the model, Dr Mangel noted that using observed krill densities would be productive and that further work on the nature and magnitude of differences between adult and offspring survival would be desirable.

6.55 The Working Group noted that the implications of this approach and its initial results would be of particular relevance to ecosystem assessment issues.

6.56 Dr Butterworth summarised the background to modelling functional relationships between predators and prey leading to the development of initial models for Antarctic fur seal, black-browed albatross and Adélie penguin. At last year's meeting (SC-CAMLR-XIV, Annex 4, paragraphs 5.104 to 5.113) problems that had been encountered in developing these models were discussed; agreement on how to proceed with the models was summarised in SC-CAMLR-XIV, Annex 4, Appendix F.

6.57 These models relate distributions of survival rate estimates to distributions of krill biomasses as predicted by the krill yield model, through functional relationships. To fit the data, it is necessary to relate the survival rate distributions to krill 'availability' rather than krill biomass, where the 'availability' in any one year is obtained by multiplying the biomass output of the krill yield model by a lognormally distributed random error term.

6.58 Progress had been made intersessionally on the models for Antarctic fur seals and black-browed albatrosses (WG-EMM-96/67). For Antarctic fur seals, using the revised procedure for correcting adult survival rates, the model indicated that the resilience of the Antarctic fur seal population at South Georgia to krill harvesting is strongly dependent on the estimate of the maximum annual growth rate (R) which the population can achieve. For R = 10% (the rate currently prevailing at South Georgia) a krill harvesting intensity rate (γ_{half}) of slightly more than 0.1 would be needed to reduce the seal population to half its pre-exploitation level. It was noted that this value of γ_{half} is close to γ = 0.116 as evaluated from the krill yield model to correspond to a median krill escapement of 75% of the level without fishing, the criterion currently used in respect of precautionary catch limits for the krill fishery. Further work may need to address the consequences of estimation imprecision and model uncertainty on the estimate of γ_{half} and the effect of density dependence on adult survival of fur seals.

6.59 For black-browed albatrosses the data are derived from a population declining (at least partly due to longline fishery-induced incidental mortality) from an undisturbed maximum to an average level of depletion taken to be 0.85 of the undisturbed level. The extent of the resilience of this species to krill harvesting will greatly depend on the value of β, a scaling parameter related to the effect of density dependence on survival. If β is as low as 0.55, then the albatross population becomes extinct; at higher values of β, population stabilisation would be possible under the present level of fishery-induced mortality. To resolve this problem, estimates of survival rates for black-browed albatrosses in the absence of fishery-induced mortality are needed.

6.60 Dr Croxall indicated that estimates of survival rates of adult black-browed albatrosses in the absence of fishery-induced mortality could be obtained by selecting from the data (a revised version of which is provided in SC-CAMLR-XV/BG/7) the values for 1976 to 1989 inclusive. These are from the period before there was evidence of any effect of incidental mortality on adult black-browed albatrosses. It was agreed to conduct this re-analysis intersessionally. Dr Kirkwood enquired whether the model would be improved by the use of *priors* in a Bayesian analysis and noted that density dependence is assumed to operate linearly; other assumptions (e.g. a power model) might produce different results. It was agreed that the sensitivity of the model to different functional forms for the density-dependent term should be checked.

6.61 Further work recommended on krill-predator modelling studies is detailed in Appendix F.

Fisheries and Dependent Species Overlap

6.62 For a number of years the Secretariat has been calculating the critical period-distance (CPD) index, the catch in the critical period-distance (100 km from land-based predator colonies over the December–March period of the breeding season). Last year WG-EMM requested that the Subgroup on Statistics re-examine critically the CPD index and the conceptual framework upon which it was based (SC-CAMLR-XIV, Annex 4, paragraphs 5.92 to 5.96).

6.63 In its report (Appendix H) the subgroup noted that problems associated with the overlap concept may have been due to the several different scales involved. It identified four general levels at which the analysis of niche overlap may be considered, as follows:

(i) precautionary overlap;
(ii) potential overlap;
(iii) realised overlap; and
(iv) dynamic overlap.

6.64 These were described in more detail in the subgroup report (Appendix H, paragraph 37 and Table 3).

6.65 The subgroup suggested that in order to make refinements in the existing CPD calculations of potential overlap, it required additional data on monthly estimates of diet composition and on maximum and modal foraging range, by colony locations, in areas of fishing operations. Development of the realised overlap index should proceed in parallel with development of the potential overlap index as it is perceived as a refinement of the latter.

6.66 The subgroup noted that the dynamic overlap analysis was potentially very appropriate for modelling fishery-predator interactions but information required for this approach is substantial and may not be currently available at the scales required.

6.67 The Working Group thanked the Subgroup on Statistics for this valuable contribution.

6.68 The results of the calculation of overlap indices were presented by Dr Agnew (WG-EMM-96/4). This paper includes both the potential and realised overlaps, the latter incorporating a modification suggested by Dr K. Hiramatsu (Japan) (see Table 3).

6.69 Indices 1 and 3 increased from 1985 to 1989, and have been declining since that time. Indices 2 and 4 have been declining since 1986. The Working Group agreed that each index provided different information. The fishery has been steadily reducing the amount of spatial congruence with predator foraging. In absolute terms, the amount of overlap with predators was greatest at a time when catches in Subarea 48.1 were high in the late 1980s. The recent decline in all indices has resulted from the fishery shifting to the autumn and winter months in Subarea 48.1 for operational reasons (see paragraph 2.5).

6.70 Mr Ichii indicated that CPD is a product of the past when there was uncertainty about the overlap between the fishery and predators. This index takes no account of the size and distribution of colonies, nor of the distance of the fishery from colonies of different sites, and therefore is not only inappropriate in terms of the theory of ecological niche overlap, but also distinctly overestimates the overlap between the fishery and predators. Now that the extent of overlap has been found to be less than expected (Agnew, 1995), the CPD index should be dropped in favour of calculating the realised overlap (Agnew and Phegan, 1995). The realised index incorporates the above information and should indicate more realistic and reasonable overlaps.

6.71 Dr Croxall responded by noting that discussion of the nature, extent and potential consequences of overlap between the krill fishery and dependent predators had a long history in the Scientific Committee and its working groups. Almost all aspects relevant to the assessment of this interaction have been debated at length previously[3] and there had been various attempts to suggest that the fishery and predators took krill of different sizes, that they exploited krill at different depths and, latterly, that overlap between the main fishing and penguin foraging areas is low at fine spatial scales. He recollected that the original CPD index (potential overlap *sensu* Appendix H) was developed to try to monitor a situation whereby a substantial krill fishery consistently operates within the foraging range of krill-dependent predators at a critical time of year for the predators. The point at issue now is whether it is possible to replace the current CPD index, which has resolution at relatively broad spatial (100 km) and temporal (3–4 month) scales at which krill flux is potentially of less importance, with a fine-scale index (realised overlap *sensu* Appendix H) which ignores flux.

6.72 Some members felt that the fine-scale approach as described in WG-Joint-94/8 and Agnew and Phegan (1995) clearly has some merit, but it is important to note that neither the approach, nor the parameter values, nor the conclusions in the latter document have been critically examined by the Scientific Committee or its working groups. Furthermore, the model is sensitive to the parameter values used and those selected by Agnew and Phegan (1995), which (except for gentoo penguins) are conservative in terms of calculating foraging range even for species at Seal Island, are not typical of values prevailing at other sites in Subarea 48.1 and certainly not applicable to other subareas of

3 SC-CAMLR-X, paragraphs 6.27 to 6.39 and Annex 7, paragraphs 5.12 to 5.22; SC-CAMLR-XI, paragraphs 5.24 to 5.31 and Annex 7, paragraphs 6.37 to 6.57; SC-CAMLR-XII, paragraphs 8.31 to 8.45 and Annex 6, paragraphs 6.48 to 6.56; SC-CAMLR-XIII, paragraphs 7.8 to 7.18 and Annex 4, paragraphs 4.1 to 4.3; SC-CAMLR-XIV, paragraphs 5.18 to 5.20 and Annex 4, paragraphs 5.87 to 5.99 and 7.25 to 7.30.

Area 48. Finally, the model does not include fur seals, one of the species contributing substantially to the definition of spatial boundaries in the original CPD index. Therefore, even if krill flux were not an issue in assessing effective overlap between the activities of fisheries and predators at this time of year, the conclusions offered by Agnew and Phegan (1995) lack generality, being at best site and parameter dependent; considerable further work is required on fine-scale analysis and until this is done it would be premature to dispense with broader-scale assessments.

6.73 Dr Trivelpiece pointed out that it is important to recognise that there is potential for considerable overlap between the fishery and predators at other times during the breeding season when predators are no longer constrained by the need to provision chicks. Of particular importance is the post-fledging period when large numbers of chicks begin foraging independently and adults are feeding intensively in preparation for their annual moult. This period may be particularly important in Subarea 48.1 as the Japanese krill fishery is now most active during this period each year.

6.74 Dr Kerry noted that fledgling Adélie penguins tracked by satellite from Béchervaise Island move from their natal colony in late February and March and forage in the vicinity of the shelf break. This means they are foraging in an area of potential overlap with the krill fishery (WG-EMM-96/69).

6.75 It was noted that progress on analysis of finer scales of overlap, as envisioned under the realised and dynamic overlap models, would require data on the densities of predators as a function of distance from the breeding areas. In addition, some measure of movement of krill (krill flux) would need to be incorporated into the realised and dynamic overlap models.

6.76 In discussions on the importance of flux to the calculations of niche overlap it was suggested that flux is considered to be of minor relevance at the subarea scale but that it becomes increasingly important at finer scales of analysis. Flux may also be more important in some areas than in other areas at comparable scales (e.g. flux in the Peninsula versus Prydz Bay regions).

6.77 It was suggested that if an area with a known fishery catch and predator population is defined, then flux may not be important. However, a fishery upstream may affect predators downstream, and under these circumstances flux may be an important consideration.

6.78 The niche overlap of interest is actually the krill resource in an area which is not the area of the fishery. The original CPD index was designed to provide a measure of the degree of congruence between predators and fishing in areas of overlap. Dr Miller suggested that it may be desirable to refine this original concept by linking it with an approach that would describe the functional links between predators and the fishery during a critical period of time.

6.79 Dr Hewitt suggested that an experiment might be designed for Subarea 48.1 that coupled a synoptic survey of the krill resource with calculations of predator demand and fishery catch and then examine the differences. However, Dr Butterworth cautioned the Working Group that the two approaches measure krill in different units; the synoptic survey in tonnes, the fishery catch in tonnes per unit of time (in this case a year).

6.80 The Working Group suggested that progress could be made intersessionally on the realised overlap index if the Agnew and Phegan model were evaluated critically in terms of its assumptions and the values of parameters used. It was agreed that such a task could appropriately be initiated by referring the model to the Subgroup on Statistics and also inviting submissions to this group on additional or alternative values of parameters, including those suitable for extending the generality of the model beyond the Seal Island area. In particular, the Secretariat was asked to request data or analyses describing, for all relevant sites and species:

(i) monthly estimates of typical diet composition (along the lines of index A8b), maximum and modal foraging range, and direction;

(ii) finer scale foraging data where possible (such as specific foraging distribution functions in different directions from a colony); and

(iii) estimates of the above derived from close and/or similar sites if the information is not available for the specific CEMP site.

These data should apply to the current biological and temporal dimensions of the CPD calculations (the land-based phase of land-breeding predators, e.g. December to March). Additional contributions on times outside of the chick-rearing period are also solicited, especially the time immediately following fledging when adults and juveniles may still be concentrated around CEMP sites. Fine-scale fisheries data will continue to be required for all areas to evaluate calculations of overlap using the data requested above.

6.81 It was expected that this process would lead to one or more versions of a realised overlap model being developed that could be applied to some combination of species, sites, islands, island groups and subareas, depending on the nature of and variation in the empirical data.

6.82 The indices of overlap provided by this approach would be expected ultimately to replace those currently calculated using the potential overlap model, which would, however, continue to be calculated for the time being, particularly until implications relating to krill flux are better understood.

6.83 In due course, it would be appropriate to calculate for examination the performance of realised overlap models using different assumptions concerning the nature and magnitude of krill flux in appropriate areas.

6.84 It was also noted that the Mangel model (WG-EMM-96/20) could be developed to perform similar functions both in estimating realised niche overlap and in developing a dynamic overlap model. Further such work on the Mangel model was strongly encouraged.

Analysis of Data from CEMP Indices

6.85 Much of the discussion under Agenda Items 3 to 5 has included consideration of trends and anomalies in individual CEMP indices presented in WG-EMM-96/4. This section of the report describes integrated analyses of the indices.

6.86 WG-EMM-96/22 presented an investigation of the relationships between various indices of prey availability at Seal Island derived from the AMLR acoustic surveys (overall average volume backscattering strength, mean distance of prey from Seal Island, mean depth of prey and persistence over time) and indices of predator performance. Chinstrap foraging duration was positively correlated with depth of the prey field and its distance from Seal Island, and longer foraging durations were associated with heavier stomach weights and lower proportions of krill in the stomachs. The strongest correlations were found between chinstrap fledging weight and breeding success, but neither of these parameters were correlated with foraging duration, stomach weight or the proportion of krill in the diet.

6.87 Three explanations were suggested for the lack of correlation between indices of prey availability and breeding success for chinstrap penguins in WG-EMM-96/22:

(i) the short time series (8 years) and the low variability in breeding success may reduce the ability to detect relationships. It was noted that the method used for measuring breeding success at Seal Island only monitors chicks from hatching to the start of creching; this is only a minor factor in determining overall breeding success.

(ii) aspects of the dispersion of prey may be more important than its local abundance. There is clearly a need for the development of indices derived from the distribution of the prey field, perhaps as some combination of patchiness and depth. Theories of the response of foraging animals to patch composition and distribution, as derived from behavioural ecology studies, may prove useful in interpreting the behaviour of predators in such a prey field. For instance, where patches are identical, foraging time (a combination of travelling time and patch residence time) and distance may be expected to be positively correlated, but if patches are not identical the relationship between foraging time and distance is not easily predicted.

(iii) chinstrap breeding success may not be food-limited in the Elephant Island area (but see paragraph 6.91 below).

6.88 WG-EMM-96/22 indicates that paradoxically fur seal foraging duration appeared to be negatively correlated with distance of the prey field from Seal Island, and positively correlated with pup growth rate, the latter despite expectations that longer foraging duration would be associated with lower pup growth rates. Indices from Bird Island show similar positive correlations with pup growth and foraging durations of less than 100 hours, with pup growth only declining as foraging duration increases beyond 100 hours. Mean foraging duration has never risen beyond 100 hours at Seal Island. These results may indicate that fur seals have never been food-limited at Seal Island, possibly switching to a higher reliance on fish in poor krill years.

6.89 Whatever the reason, these results indicate that some CEMP indices may show rather different and more complex responses than those which were previously assumed.

6.90 WG-EMM-96/27 also examined the Seal Island CEMP indices, and found positive correlations between chinstrap breeding success and the density of krill in the larger South Shetlands area derived from net haul surveys. A regression model was constructed which linked breeding success to sea-ice extent in the previous two winters ($R_2 = 0.78$), on the basis of the conceptual model of Siegel and Loeb (1995) where successful krill recruitment is enhanced by prolonged sea-ice cover in the winters immediately before and after adult spawning. Because krill recruitment was also positively correlated with sea-ice extent and breeding success, its inclusion did not significantly improve the fit to the model.

6.91 This model, therefore, successfully captured most of the environmental influences on breeding success. The paper then used various indices of fishing activity to try to account for the residuals of the model. This approach was proposed as a method for determining the relative contributions that environmental change and harvesting activity may make to observed changes in predator parameters, since one of the core aims of CEMP is the separation of the effects of these two factors.

6.92 This approach was welcomed as the first attempt to draw together in a formalised fashion the multivariate data from the CEMP program. It was noted that it would only be possible to detect contemporaneous local effects of harvesting activity using such an approach, and that it would be vulnerable to being confounded by changes in regional prey abundance such as have been noted in Subarea 48.1 (see paragraph 6.72). The approach also assumed largely unchanging behaviours of predators and fishermen, assumptions which are unlikely to be satisfied. It was further pointed out that although the model was currently couched in linear terms, some of the relationships, especially with recruitment proportion, might be better modelled by non-linear relationships.

6.93 The Working Group agreed to hold a workshop to address the uncertainties regarding the relationship between indices of harvested and dependent species at specific site and also between subareas in Area 48. The main focus would be on examining long time series of data in the area.

ECOSYSTEM ASSESSMENT

Assessments Based on CEMP Indices

7.1 Considerable progress has been made this year in the analysis of the CEMP indices, particularly the identification of anomalies and trends. Some further work is required, however, particularly on the treatment of indices which are not normally distributed, before the working group can be confident of its identification of anomalies. It therefore agreed that it could not yet present a table of statistically reliable anomalies, but would instead present Table 4. Since Table 4 is a categorical presentation of normal deviates of the indices (derived through statistical analysis of the CEMP data), it is half-way between the previous qualitative, and somewhat subjective, presentation of data in last year's report (SC-CAMLR-XIV, Annex 4, Table 3) and a future quantitative presentation of anomalies.

7.2 Bearing in mind Table 4, and other indicators contained in papers presented to the meeting, the Working Group derived the following ecosystem assessment for 1995/96:

(i) Subarea 48.1: there was evidence from prey surveys of a very strong 1994/95 krill year-class (62% of the population was year 1) and that krill was quite abundant. This strong year-class followed two successive years of cold winters with extensive ice cover, in keeping with the hypothesis linking sea-ice to krill. The high abundance is in contrast to the relatively low levels of krill abundance that have been recorded since 1989. Predator breeding success was high.

(ii) Subarea 48.2: there are no time series data on prey abundance, but the predators experienced a good breeding year, in common with the situation in Subarea 48.1.

(iii) Subarea 48.3: there was evidence from prey surveys and predator indices that krill was more abundant than it has been in previous seasons. In common with most of Area 48, the subarea experienced lower water temperatures than usual, and predators experienced a better than average breeding year.

(iv) Area 48: based on the above assessment, it is clear that there is some coherence between events in Area 48, with 1995/96 being a cold year with better-than-average krill abundance and predator performance.

(v) Division 58.4.2: following the total failure of breeding Adélie penguins at Béchervaise Island in 1995, the result of a local krill shortage, most breeders returned in 1996 although breeding success was a little lower than normal. No information on prey abundance was available.

(vi) Division 58.4.1: a krill survey discovered higher krill abundance in the western portion of the subarea, than in the eastern portion, although no other historical surveys were available to enable an assessment of the relative abundance of krill in the 1996 season to be made.

(vii) Subarea 88.1: predator performance in the Ross Sea was at an average level in 1996.

7.3 The Working Group congratulated the Secretariat on its new analysis and presentation of the CEMP indices, and requested that similar presentations be made in future years. Further work is now needed to develop ways of further summarising and interpreting the indices beyond those presentations provided by the Secretariat. However, the Working Group suggested that this be undertaken by individual research communities with specific experience of individual CEMP sites rather than the Secretariat. Examples of the sorts of multivariate analyses which could be developed further at all CEMP sites were presented in WG-EMM-96/22 and 96/27. The full dataset of raw CEMP data, and a table of the indices calculated by the Secretariat (by site, year, species, sex and method) are now available for Members to use in such investigations within the rules of access to CCAMLR data.

Estimation of Potential Yield

7.4 Because annual krill recruitment varies naturally, the biomass of the krill population fluctuates even in the absence of exploitation. Thus this biomass could be above or below its median level at the time a pre-exploitation survey takes place. The krill yield model, which provides recommendations for precautionary catch limits for krill on the basis of such surveys, takes the existence of these fluctuations into account in its calculations. However, if extra information becomes available which allows estimation of the trend and extent of the difference between the krill biomass and its median pre-exploitation level at the time of a survey, the krill yield model could be refined to take this into account and thereby provide an improved estimate of potential yield.

7.5 Paragraph 4.48 of the Working Group's 1995 report (SC-CAMLR-XIV, Annex 4) draws attention to evidence presented suggesting that the 1981 FIBEX survey, which provides the biomass estimate upon which recommendations for a precautionary catch limit in Subareas 48.1, 48.2 and 48.3 have been based, took place in a year of relatively high krill abundance.

7.6 WG-EMM-96/45 presented refined indices of krill recruitment and density in the Elephant Island area for most years from 1977/78 to 1994/95. The density index was suggestive of relatively high krill abundance at the time of the FIBEX survey.

7.7 The extent of the variation in both the recruitment and the density index reported in WG-EMM-96/45 appeared inconsistent with the level of recruitment variability currently input for calculations using the krill yield model. Either this level of variability has increased, or the median recruitment level itself has changed over the period covered by these data for the Elephant Island area.

7.8 The question was raised as to whether the trends indicated by these Elephant Island data reflected only local variations, or changes in krill abundance on a regional scale.

7.9 In response, Dr Hewitt cited correlations between krill abundance levels in the Antarctic Peninsula and South Georgia regions in both 1994/5 and 1995/6 as supportive of the hypothesis that the Elephant Island survey data are reflective of regional-scale effects (see also paragraph 6.5).

7.10 A further question raised was whether the Elephant Island krill density index could reasonably be considered to be linearly proportional to krill abundance on a regional scale. For example, this index suggests a fall in krill abundance of some 10-fold or more from the time of the FIBEX survey (which estimates the krill biomass in Subareas 48.1, 48.2 and 48.3 to have been some 35 million tonnes) to the 1990/91 season. Given that the customary annual consumption of the krill predators of these subareas amounts to a few million tonnes, the assumption of linear proportionality of the index implies that wide-ranging deleterious effects on predators in these subareas should have been evident in 1990/91.

7.11 Although there is evidence:

(i) of declines in some predator populations in Area 48 (especially macaroni penguins and black-browed albatrosses in Subarea 48.3 and Adélie penguins in Subarea 48.1) from the 1980s to the 1990s;

(ii) that 1990/91 was a season of very poor reproductive performance by krill-dependent predators in Area 48; and

(iii) that some limited scope for switching from krill to other diets exists for some predators;

even all these together could not offset potential effects on the scale implied by a decrease in krill abundance within Area 48 directly proportional to the changes in density at Elephant Island. There remains, of course, the possibility that krill abundance is being substantially underestimated.

7.12 The Working Group had insufficient information to determine the degree to which the indices from the Elephant Island area are representative of abundance trends in the surrounding region (Subareas 48.1, 48.2 and 48.3). It agreed that the implications for the output from the krill yield model of the recruitment and density estimates reported in WG-EMM-96/45 should be investigated intersessionally. Detailed specifications of the work to be conducted are listed in Appendix G.

7.13 The Working Group agreed that these uncertainties reinforce the need for a new quasi-synoptic survey in Area 48.

7.14 The suggestion was made that the krill yield model be adjusted to take account of environmental determinants of krill recruitment success (note, for example, the correlation between such success and the extent of sea-ice cover reported in WG-EMM-96/24).

7.15 In response it was suggested that:

(i) environmental analyses be investigated to provide insight into both the temporal and areal scale (particularly whether local or regional) upon which measured krill recruitment fluctuations were likely to be correlated; and

(ii) rather than reformulate the yield model, analyses of environmental data be undertaken to provide information on the parameters of the statistical distribution to be expected for time series of krill recruitment on a regional scale (this is the key input to the krill yield model, and is at present inferred from the analysis of the length distribution data collected during scientific surveys).

7.16 It was noted that the functional relationship analysis for Antarctic fur seals (WG-EMM-96/67) suggests that the use of a value of the krill harvesting intensity parameter (γ) of slightly more than 0.1 would yield an estimated seal population level of some 50% of pre-exploitation abundance. Such a value for γ is compatible with that of 0.116 obtained from the krill yield model for maintaining median krill escapement at 75% of its pre-exploitation level. This value was previously adopted as an ad hoc means of taking account of the food requirements for krill predators in setting precautionary catch limits for the krill fishery.

7.17 It was noted that the krill predator functional relation model required an additional random variable (relating krill biomass to availability) in order to fit predator survival data (see paragraph 6.57 and WG-EMM-96/67, equation A4). This implies that additional care may be required when estimating precautionary catch limits until the relationship between krill biomass, krill availability and predator survival is better elucidated.

7.18 Previous meetings (e.g. SC-CAMLR-XIII, Annex 5, paragraph 4.56 and Annex 7, paragraphs 4.34 and 4.35) have noted that the estimate of γ provided by the krill yield model is sensitive to possible age-dependence in krill's natural mortality, specifically to larger values of this mortality at small ages.

7.19 WG-EMM-96/8 and 96/9 compared krill samples from contemporaneous net hauls with predator diet samples from Antarctic fur seals and six seabird species. A preponderance of gravid female krill in the predator diets was noted, probably reflecting some combination of selectivity by predators and superior escape responses of male krill.

7.20 In the light of these results, it was agreed that some tests should be conducted of the sensitivity of the krill yield model to a natural mortality schedule which increases at greater ages.

7.21 It was nevertheless noted that inferences from the observed distributions might be biased as a result of a preponderance of large krill in the population in the year of sampling. It was also pointed out that only land-breeding predators had been considered, and that the impact of other predators (e.g. fish) on small krill should not be overlooked.

7.22 The results presented also indicated that the effect of net selectivity on the procedure used to estimate M from krill length frequency distributions might require examination.

7.23 Results from a 1996 krill survey in Subarea 58.4 in the Indian Ocean were noted (WG-EMM-96/28). Estimates of R_2 were very similar to those used previously for inferring inputs to the krill yield model. Further the CV for the survey (0.27) was very close to that assumed (0.30) for previous calculations with this model. It was therefore agreed that there was no need to recompute γ from the model with input parameter values specific to the Indian Ocean, and that the current estimate of γ = 0.116 could be applied to compute a recommendation for a precautionary catch limit for this subarea.

Precautionary Catch Limits

7.24 The Working Group calculated the precautionary catch limit for Division 58.4.1 as 775 000 tonnes per year, based on the results of the Australian biomass survey (6.67 million tonnes) (WG-EMM-96/28) and the krill yield model (harvesting intensity 0.116).

7.25 At last year's meeting, the Working Group developed an intersessional work plan designed to enable the application of the method proposed by Everson and de la Mare (1996) for the calculation of precautionary catch limits based on predator consumption data (see SC-CAMLR-XIV, Annex 4, paragraph 8.2). This method uses estimates of krill consumption by predators, krill natural mortality and krill turnover times, and their variances, to calculate the biomass of krill which would be expected to be found in a given area if a synoptic survey were to be conducted there. Application of the method to Subarea 48.3 at this meeting would require a new estimate of predator krill consumption and an independent estimate of krill turnover based on oceanographic estimates of water mass turnover.

7.26 WG-EMM-96/66 presented new estimates of predator consumption in Subarea 48.3 based on the abundance and energetic requirements of fur seals and macaroni penguins at South Georgia. The estimates were derived from a generalised model of gross energy requirements of the predators in relation to age, breeding status, body mass and the stages of reproductive and life cycles (see also paragraph 6.46). Total krill requirements for the two predators combined was estimated to be 11.8 million tonnes per year, with an SD of approximately 1 million tonnes per year.

7.27 The Working Group welcomed this new analysis. The Working Group agreed with the points raised in the paper about future refinements to this model which would require predator diet data at finer temporal resolution, and the inclusion of spatial components such as dispersion in predator behaviour. Nonetheless, the Working Group also agreed that the estimates obtained with the current model were adequate for use in calculating precautionary catch limits based on predator consumption data.

7.28 Unfortunately, analyses aimed at obtaining an independent estimate of krill turnover could not be completed in time for this year's meeting. Dr Everson reported that estimates based on acoustic doppler current measurements were currently in progress, and should be ready for consideration at the Working Group's next meeting. Consequently, the Working Group was unable to calculate precautionary catch limits using this method at this meeting.

7.29 Dr V. Sushin (Russia) noted that, if calculations given in WG-EMM-96/66 are correct, krill fishing at current levels in Subarea 48.3 poses negligible or very little competition to predators. Even when maximum catches of about 250 000 tonnes of krill were taken in the past, these represented less than 2% of predators' food demand. Dr M. Naganobu (Japan) supported this view.

7.30 The Working Group, whilst noting these comments, considered it premature to draw conclusions about the impact of recent catch levels on dependent species until the analyses in paragraph 7.28 were completed.

Consideration of Possible Management Measures

7.31 The Working Group recommended a precautionary catch limit for Division 58.4.1 of 775 000 tonnes per year.

7.32 Noting the work still in progress for Area 48, and the additional tasks identified this year, the Working Group was unable to provide revised estimates of a precautionary catch limit for this area, or provide advice on the allocation of the limit to subareas. Pending the completion of this work, the Working Group recommended that existing management measures for Area 48 remain in force.

Extension of the Scope of CEMP

7.33 No extensions to the scope of CEMP were proposed at this meeting.

Strategic Modelling

7.34 Discussions on strategic modelling centred around the conceptual framework developed at the last meeting of WG-EMM. In particular, the Working Group reviewed Figure 4 in SC-CAMLR-XIV, Annex 4 with a view to identifying those areas where progress had been made in the past year.

It was agreed that in Figure 3 in that report, it was necessary to add an additional weak linkage from dependent species to the fishery, in order to take account of interference with fishing gear by seabirds and marine mammals (e.g. seabirds causing bait loss).

7.35 The Working Group noted that the work in the intersessional period has mainly concentrated on the strongest and most important of those processes and linkages in the conceptual model. These are designated by heavy arrows in the figures.

7.36 Tables 5 and 6 summarise where progress has been made on either the local-scale or regional-scale strategic models.

7.37 The Working Group was pleased to note that balanced progress had been made in enhancing understanding of each of the main linkages and processes at both local and regional scales.

7.38 The Working Group welcomed the carrying out of synoptic surveys by Italy (WG-EMM-96/63) and Australia (WG-EMM-96/29), during which data on a comprehensive suite of variables has been collected on dependent and harvested species and on the environment. Only preliminary analyses of results were available at this meeting, and the Working Group looked forward to subsequent presentation of integrated analyses of these data.

7.39 The work by the Subgroup on Statistics (Appendix H) and subsequently by the Secretariat on analysis of CEMP indices (WG-EMM-96/4) has greatly improved the ability of the Working Group to undertake quantitative, rather than qualitative, analyses of these indices. New methods have been developed for the identification of anomalies. The multivariate analysis in WG-EMM-96/27 gives an indication of the types of analyses that can now be conducted.

7.40 In addition to the considerable amounts of new data and analyses tabled at the meeting, a number of papers described new or improved models of processes underlying the linkages contained in the strategic model. These included models investigating the effects of fisheries on krill predators at the foraging trip level (WG-EMM-96/20), models of functional relationships between predators and prey (WG-EMM-96/67), models of growth dynamics of krill (WG-EMM-96/68), krill predator energetics models (WG-EMM-96/7, 96/66) and oceanographic circulation models (WG-EMM-96/61). While some of these models are in early stages of development, the Working Group was pleased that a wide variety of modelling approaches are now being attempted.

7.41 Revised indices of krill recruitment and biomass in the Elephant Island area were presented this year, along with plausible linkages with an environmentally driven variable (WG-EMM-96/45).

Although the extent to which these indices are representative of trends in the surrounding regions is as yet uncertain, the implications for the krill yield model of the variability observed in these indices is to be examined intersessionally (paragraphs 6.20, 6.21 and 7.6 to 7.15).

7.42 At present, most effort by the Working Group is devoted to improving the understanding of the processes and linkages between harvested species, dependent species, the environment and the fishery. The Working Group is very conscious, however, that the ultimate aim is to develop effective mechanisms for management of the ecosystem as envisaged in the CCAMLR Convention. It agreed that this aim must continue to be the overall focus for its work.

Ecosystem Implications of Proposed New Fisheries

7.43 CCAMLR-XV/8 to 11 gave notification of intent to initiate new fisheries by New Zealand, Australia, Norway and South Africa respectively. In each case, the principal target species was toothfish (*Dissostichus eleginoides*).

7.44 The Working Group agreed that a detailed review of these proposals, involving aspects of single-species fish stock assessment and of incidental mortality, would best be conducted by WG-FSA. It agreed, however, that there were several more general points raised by these proposals that warranted discussion within WG-EMM.

7.45 The first of these points was that there was virtually no information available about the target species in the widely separated areas proposed for the new fisheries. This highlighted the need to adopt a standard approach to the management of new fisheries and specification of the information required. It would also be helpful if a common format could be adopted both for proposals to initiate new fisheries and for submission of the information collected.

7.46 The second point was that each case involved initiation of a fishery on a trans-boundary stock that was able to move freely back and forth across the CCAMLR Convention boundary. Effective management of stocks that are part of an ecosystem that extends beyond CCAMLR boundaries requires close coordination between CCAMLR and other relevant organisations with responsibilities for waters near or adjacent to the Convention boundaries. The Working Group noted that this issue has been addressed in part by CCAMLR Resolution 10/XII.

7.47 Dr de la Mare noted that CCAMLR ecosystem boundaries are defined with respect to surface features. This is not appropriate for all species within the Antarctic ecosystem; a number of midwater and pelagic species, such as toothfish, myctophids and squid, have ranges extending beyond that Convention Area, as do flying birds such as albatrosses.

7.48 CCAMLR-XV/7 gave notification of the intention by the Republic of Korea and the United Kingdom to initiate a new fishery for the squid *Martialia hyadesi* in Subarea 48.3. While some aspects of the proposal would more appropriately be dealt with by WG-FSA, the Working Group agreed that it should discuss the wider ecosystem implications of harvesting this squid species.

7.49 This is the first proposal that has been received to initiate a fishery on this important group of marine organisms in the Convention Area. Though widely used outside the Convention Area, the fishing method proposed, jigging, is also a new method for CCAMLR. As with the other four proposals, the stock involved is a trans-boundary stock.

7.50 As noted briefly in CCAMLR-XV/7, dietary studies at South Georgia have shown that *M. hyadesi* is the major squid prey of a number of dependent species. Its main diet consists of myctophids and crustaceans, including krill, which means that it is also an important predator in the Antarctic ecosystem.

7.51 The Working Group agreed that, given the estimated annual consumption of *M. hyadesi* by predators in the Scotia Sea (400 000 tonnes), the proposed level of exploratory fishing (2 500 tonnes) is unlikely to have an impact on dependent species.

7.52 The Working Group agreed that important new knowledge could be gained from this new fishery given its important trophic links. It was important that further details be provided about the extent and format of data on catches of the target species, the by-catch and biological samples that would be collected. It was noted that a data form appropriate for squid fisheries has already been developed by the Scientific Committee. The Working Group recommended that an addendum to the proposal, detailing aspects of observation and data collection, should be prepared and submitted for consideration by WG-FSA at its next meeting.

7.53 Dr Miller suggested that precautionary catch limits for squid might be calculated in a manner similar to those developed by WG-FSA for the myctophid *E. carlsbergi*.

7.54 Dr Kock observed that it may be necessary to expand the scope of CEMP and WG-EMM to deal with fisheries for species such as myctophids and squid in view of their important role in the ecosystem.

7.55 In relation to any myctophid fishery that may recommence, the Working Group noted that procedures for resumption of a fishery were discussed in SC-CAMLR-XV/BG/11.

Future Work

7.56 The Working Group first reviewed the status of required work in relation to ecosystem assessment, as identified in section 8 of the report of the previous meeting of WG-EMM (SC-CAMLR-XIV, Annex 4).

Completed Tasks

7.57 The following tasks have been completed:

(i) Meeting of the Subgroup on Statistics. The Subgroup on Statistics had a very productive intersessional meeting and it produced a comprehensive report (Appendix H and paragraphs 4.56 to 4.65). The resulting quantitative presentation of CEMP indices (WG-EMM-96/4) has been widely referred to in discussions of the Working Group at this meeting. New tasks for the Subgroup on Statistics are discussed in paragraph 7.59.

(ii) Meeting of the Subgroup on Monitoring Methods. This subgroup met immediately before the current Working Group meeting. Its report is attached as Appendix I (see also paragraphs 4.12 to 4.55). A number of new standard methods were adopted (paragraph 4.26).

(iii) Consideration of the report of the Australian survey of Division 58.4.1. This survey has been successfully conducted and initial reports were considered by the Working Group (WG-EMM-96/28 and 96/29; paragraphs 3.31 to 3.36). The Working Group looks forward to submission of further papers describing analyses of this comprehensive dataset at future meetings.

(iv) Reporting of experience with gastric lavage and stomach sample techniques. Use of stomach lavage techniques is described in WG-EMM-Methods-96/6 and discussed in Appendix I, paragraphs 27 to 29 (see also paragraph 4.27).

(v) Methods for analysis of petrel diet samples and for petrel lavage. Standard methods have been agreed (WG-EMM-Methods-96/4, WG-EMM-96/53; paragraphs 4.26 and 4.27).

(vi) Instructions for the collection and preservation of samples to be taken in the event of disease outbreak. This has been completed subject to revision and a final circulation for comment (paragraphs 4.28 to 4.35).

(vii) Circulation for review of proposed changes to existing CEMP methods and proposals for new ones. This has been done and both existing and new methods were reviewed (paragraphs 4.13 to 4.26).

(viii) Acquisition of comprehensive SST data by the Secretariat. This has been done (WG-EMM-96/4; paragraphs 5.6 and 5.7). Information regarding the selection of data on SST is required.

(ix) CPD calculations. These have been presented in WG-EMM-96/4.

(x) Comparison of krill length frequency data from nets and predators, and examination of time series of krill length frequencies from predators for information on krill recruitment. This information is presented in WG-EMM-96/8 and 96/9 (see also paragraphs 7.19 to 7.22).

(xi) A correspondence subgroup should complete the analysis of recruitment estimates. The resulting paper is WG-EMM-96/45 (see also paragraphs 7.6 to 7.15).

(xii) A correspondence subgroup should consider Method A5. Preliminary discussions proposed minor alterations to Method A5 which have been adopted (WG-EMM-Methods-96/11, WG-EMM-Stats-96/5; paragraph 4.18).

Tasks Still Requiring Further Work

7.58 Some progress has been made on the following tasks, but they have not yet been completed:

(i) An effective mechanism for consideration of interactions between fish and their predators. The need to develop an effective mechanism was emphasised by the points raised in the discussion of the ecosystem implications of proposals to initiate new fisheries (see paragraphs 7.43 to 7.55).

(ii) Workshop on indices to monitor at-sea behaviour. The Working Group agreed that it would not be appropriate to hold such a workshop in the near future (paragraphs 4.41 to 4.44). Instead, it was agreed that the Subgroup on Statistics should be asked to consider analyses of sample datasets and to provide advice on the most appropriate indices and appropriate methods to derive them. This task was added to the terms of reference for the planned intersessional meeting of the subgroup (paragraph 7.59).

(iii) Further work on defining a strategic approach to ecosystem assessment and further development of methods appropriate for conducting an ecosystem assessment. Some progress has been made (paragraphs 7.34 to 7.42), but more work needs to be done.

(iv) Assessments should be developed from the current qualitative approach to a quantitative analysis. Considerable progress has been made on CEMP indices through the work of the Subgroup on Statistics and the Secretariat (WG-EMM-96/4), but further work is still needed.

(v) A new quasi-synoptic krill survey of Area 48 for krill. Plans for this were discussed at this meeting (paragraphs 3.72 to 3.75). This is considered to have high priority. Specific stratified random sampling designs need further examination.

(vi) Coordination of research in the Antarctic Peninsula. The ad hoc Subgroup on Coordination of International Research Activities in the Antarctic Peninsula also met during this WG-EMM meeting and a further meeting is planned (paragraph 2.13).

(vii) Further examination of uncertainty in acoustic surveys of krill. Several papers addressing this issue were discussed at this meeting (WG-EMM-96/28, 96/40, 96/41, 96/46, 96/71) and the immediate problems identified at the last meeting were resolved (paragraphs 3.6 to 3.10). It was agreed, however, that this topic should be kept open. Some aspects will be addressed at the Workshop on Acoustic Methods to be held immediately following the WG-EMM meeting.

(viii) The use of multifrequency acoustic techniques in surveying. This was discussed by an ad hoc Subgroup on Echo Classification (paragraph 3.11 and Appendix E).

Further work is needed before the issue of echo classification is fully resolved. Use of multifrequency acoustic techniques also needs further development.

(ix) Standard methods for Antarctic fur seal demography and diet studies should be prepared. Papers containing descriptions of appropriate methods have been published (Boyd et al., 1995; Reid, 1995; Reid and Arnould, 1995), but CEMP standard methods have not yet been developed. Some further intersessional work is needed. Further standard methods for fulmarine petrels have also been requested (paragraph 4.54).

(x) More extensive studies on the occurrence of fish in krill catches. WG-EMM-96/52 provided further information on by-catches in the Japanese krill fishery. It was agreed that additional studies covering the entire span of a fishing season are needed (paragraphs 6.1 to 6.3).

(xi) A table of existing spatio-temporal scales should be circulated for revision. It was originally intended that this would be discussed by the Subgroup on Statistics. Some progress was made at this meeting in defining relevant spatial and temporal scales (paragraph 3.66 and Table 2). Additional work is required on the realised overlap index has also been identified (paragraph 6.65).

(xii) All appropriate data on CEMP indicator species currently held by Members and which have not yet been submitted, including historical datasets, should be compiled and submitted in CCAMLR formats. This is a continuing request.

(xiii) A bibliography of publications on diets, energy budgets and foraging ranges of dependent species should be maintained by CCAMLR. The Secretariat maintains a full bibliography of papers tabled before CCAMLR. Additional literature is available as part of CEMP. It is beyond the resources of the Secretariat to actively seek out additional literature on this topic, however, it was agreed that, if sent by Members, modest amounts of key literature could be held and catalogued by the Secretariat. This could include literature not directly on Southern Ocean species if appropriate. The Working Group noted that WG-EMM-96/19 contained a particularly valuable and comprehensive bibliography on this topic.

(xiv) The acquisition of comprehensive bathymetric data should be pursued by the Secretariat. This remains to be done. Adjustments and improvements to the definition of areas from which SST indices are derived are also needed (paragraph 5.10).

(xv) Final calculations of the krill/dependent species model for black-browed albatrosses and Antarctic fur seals should be completed and presented, together with initial requests for a revised version of the Adélie penguin model. WG-EMM-96/67 contained calculations for Antarctic fur seals and black-browed albatrosses. Additional information is needed before calculations can be completed for black-browed albatrosses and Adélie penguins (see paragraphs 6.58 and 6.59 and Appendix F).

(xvi) The relationship between overall krill abundance and actual krill availability to predators within a CPD requires investigation. This is a continuing topic for study, though WG-EMM-96/49 and 96/55 addressed this issue (paragraphs 6.43 and 6.44).

(xvii) Further work on the submodels within the conceptual framework of Figures 3 and 4 in SC-CAMLR-XIV, Annex 4 is encouraged. Useful progress has been made on the specification of submodels. WG-EMM-96/20, 96/61, 96/67 and 96/68 each contain relevant models. There is an encouraging degree of potential or actual interrelationship between some of the models (e.g. the functional relationship models of WG-EMM-96/20 and 96/67). Further work on the krill yield model is outlined and discussed in paragraphs 7.14 to 7.23.

(xviii) A correspondence subgroup should consider the development of appropriate sea-ice indices and the formulation of specific hypotheses on the potential effects of sea-ice on components of the ecosystem. A start has been made on this, but more needs to be done (paragraphs 5.14 to 5.22).

(xix) A subgroup will carry out further work on the incorporation of information on predator demand in the calculation of precautionary catch limits and their allocation to subareas. The work on the energy budget calculations has been completed (WG-EMM-96/56) but further estimates of krill flux are needed to complete the precautionary catch limit calculations (paragraphs 7.25 to 7.30).

Additional Work Arising from Discussions at this Meeting

7.59 The need for the following tasks relating to ecosystem assessment to be completed arose from discussions at this meeting:

(i) Further intersessional meeting of the Subgroup on Statistics. There is a need for an intersessional meeting of the Subgroup on Statistics to address the following topics:

   (a) development of indices of at-sea behaviour and methods of deriving them via analysis of sample datasets (paragraph 4.44);

   (b) further review of identification of anomalies in CEMP indices (paragraph 4.60);

   (c) methods for coping with missing values in multiple datasets (paragraph 4.63); and

   (d) critical evaluation of the assumptions and parameter values of the Agnew and Phegan (1995) model of realised overlap (paragraph 6.81).

ADVICE TO THE SCIENTIFIC COMMITTEE

Management Advice

8.1 The Working Group recommended that the precautionary catch limit for krill in Division 58.4.1 should be set at 775 000 tonnes (paragraphs 7.24 and 7.31).

8.2 As relevant work is still in progress, the Working Group was unable to provide revised estimates of the precautionary limit for krill in Area 48 and could not offer further advice on the allocation of precautionary catch limits to subareas (paragraph 7.32).

8.3 Given the number of new fisheries developing in various parts of the Convention Area, the Working Group highlighted the need for a coordinated approach to managing these fisheries. The development of such an approach is seen as critical for species being harvested and species being monitored under CEMP which cross the Convention's boundaries (paragraphs 7.45 and 7.46).

General Advice with Budgetary/Organisational Implications

Cooperation with Other Groups

8.4 (i) Maintenance of close links with APIS (paragraphs 4.46 to 4.52 and 4.54).

(ii) An international krill symposium will be held in 1998 or 1999 (paragraphs 9.1 to 9.4).

Publications

8.5 (i) The updated *Scientific Observers Manual* along with logbooks for krill and finfish fisheries should be published in 1997 as a matter of urgency (paragraph 2.12).

(ii) The *CEMP Standard Methods* should be revised and distributed as soon as possible (paragraphs 4.15, 4.16, 4.18, 4.19, 4.21, 4.24, 4.26, 4.28, 4.32 and 4.33).

Meetings

8.6 (i) The workshop on indices to monitor at-sea behaviour will not now be held (paragraph 4.43).

(ii) The Subgroup on Statistics should meet in 1997. The Convener is to be announced (see paragraph 7.57).

(iii) A workshop on linkages between monitoring sites within Area 48 and the interrelationships between Subareas in Area 48 is planned for the 1997 intersessional period (local organiser, Dr Holt) (paragraph 6.94).

Future Work for WG-EMM

Development of an Ecosystem Assessment

8.7 Approaches to improve on current ecosystem assessments and to develop new initiatives should be encouraged. The details of relevant work are contained in paragraphs 7.34 to 7.42.

Surveys

8.8 (i) The carrying out of a quasi-synoptic krill survey of Subareas 48.1, 48.2 and 48.3 is recommended as a matter of priority. Detailed plans for this survey should be prepared for the next meeting of WG-EMM (paragraphs 3.72 to 3.75).

(ii) Given the difficulties experienced in surveying large statistical subareas and divisions, further consideration should be given to subdividing such areas to make them more manageable (paragraph 3.41).

Data Collection/Analysis Methods

8.9 (i) The continued collection/analysis of time budget data from the krill fishery is encouraged (paragraph 2.11).

(ii) Because of their utility, the submission of haul-by-haul data from the krill fishery should continue to be encouraged (paragraphs 3.28 and 3.29).

(iii) Studies on the occurrence of fish in krill catches should continue in accordance with the recommended methods (paragraph 6.1).

Data Submission/Acquisition/Access

8.10 (i) The adaptations to and expansions of the standard methods should be included in the revised version of the *CEMP Standard Methods* (see 'Publications' above) (paragraphs 4.24 to 4.26 and 4.28 to 4.32).

(ii) The Secretariat should request relevant CPD index data during the next year (paragraph 6.81).

Modelling/Analysis

8.11 Although there is insufficient interest to justify holding the at-sea behaviour workshop (see above), the need to develop analytical methods for at-sea behaviour is re-affirmed along with the requirement to ensure that data are reduced into a format compatible with the CEMP database (paragraph 4.43). The Subgroup on Statistics should place the issue on the agenda of its next meeting (paragraph 4.44).

Correspondence Groups

8.12 (i) The Secretariat should contact the Polish authorities in order to ascertain that nation's plans for future krill fishing (paragraph 2.6).

(ii) The group led by Dr Kim should continue to coordinate research activities in Area 48 by intersessional correspondence and meetings whenever possible (paragraph 2.13).

(iii) An e-mail correspondence group should be set up to improve the dissemination of literature on the physical aspects of the Antarctic marine environment (paragraph 5.37).

(iv) The Subgroup on Statistics should correspond towards the development of a proposal for its meeting in 1997.

OTHER BUSINESS

9.1 The Scientific Committee has proposed to set aside a sum of A$7 000 in its 1997 forecast budget in support of the proposed International Symposium on Euphausiid Biology and Ecology discussed by WG-EMM at its 1995 meeting (SC-CAMLR-XIV, Annex 4, paragraphs 9.1 to 9.5).

9.2 Subsequent developments and discussions during WG-EMM's 1996 meeting explored further the format and timing of such a symposium.

9.3 It is now proposed that the symposium should comprise a series of working sessions aimed at promoting dialogue and information exchange between scientists working in the field of euphausiid biology and ecology.

9.4 It is therefore proposed that a new proposal for the symposium will be prepared by Dr Mangel who has offered to host the symposium in 1998 or 1999. This proposal will be presented to the 1997 meeting of the Scientific Committee. It is anticipated therefore that SC-CAMLR's budgetary commitment is only likely to fall due in the 1998 or 1999 budget.

ADOPTION OF THE REPORT

10.1 The report of the second meeting of WG-EMM was adopted.

CLOSE OF THE MEETING

11.1 In closing the meeting, the Convener, Dr Everson, expressed the sincere thanks of the Working Group to Dr Øritsland and his colleagues in Bergen for the substantial amount of work they had done to ensure that the meeting ran smoothly. He also thanked the rapporteurs and the Secretariat for their work.

11.2 The Working Group expressed its thanks to the Convener for conducting the meeting in an efficient and productive fashion.

11.3 Dr Kock thanked Dr Agnew for his work with the Secretariat during his term as CCAMLR Data Manager and the Secretariat staff presented him with a Norwegian drinking horn on behalf of his friends in the Scientific Committee.

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Table 1: Results of krill biomass surveys.

Statistical Area and Year of Survey	Conducted By	Area Surveyed (km^2)	$\bar{X}$ Density g m^{-2}	Biomass (millions of tonnes)	CV (%)	Reference
48.2 (1996)	Russia	68 562	38.3	2.6	9.6	WG-EMM-96/36
48.1 (1996)	USA	41 673	76.26	3.37	11	WG-EMM-96/23
(two surveys)		"	69.37	2.92	23	"
48.3 (1992)	UK	36 267	94.96 (day)	3.4		WG-EMM-96/42
48.3 (1992)	UK	36 267	22.71 (night)	3.4		"
48.3 (1996)	UK	8 000	40.57		13.37	WG-EMM-96/18
(two survey boxes)		8 000	26.48		54.30	
58.4.1 (1996)	Australia	873 000	7.65	6.67	27	WG-EMM-96/28
88.1 (1994)	Italy	170 814	132.48	5.14	-	WG-EMM-96/63
(two surveys)		156 408	75.6	3.37	-	"

Note that these figures are not comparable between surveys because the methods used to allocate echos to krill and other targets were not consistent. Appendix E gives a full explanation of these problems.

Table 2: Estimates of average temporal and spatial scales at which information relevant to indices of local prey distributions is collected for predator species.

Variable	Scale: Temporal/Spatial (Horizontal)				
	Gentoo Penguin	Adélie Penguin*	Macaroni Penguin	Antarctic Fur Seal	Black-browed Albatross
Dive	1–3 min/<0.1 km	1–3 min/< 0.1 km	1–3 min/< 0.1 km	1–3 min/< 0.1 km	<0.1 min/< 0.001 km
Dive bout	1–5 hr/1–5 km	?/?	1–3 hr/1–10 km	0.1–5 hr/0.1–10 km	0.5 hr/0.1–10 km
Foraging trip	0.3 days/1–10 km	1–3 days/100–200 km	1–2 days/10–50 km	4–6 days/50–200 km	2-3 days/50–300 km
Incubation shift	1 day/10 km	5–18 days/100–300 km	15–30 days/100 km	-	10–20 days/100–500 km
Hatching success (diet)	80 days/10 km	55 days/100–120 km	50 days/10–50 km	-	120 days/50–300 km
Breeding success	120 days/10 km	90 days/120–300 km	90 days/100 km	120 days/50–200 km	190 days/100–500 km

* There may be substantial differences between birds at breeding sites on Antarctic Peninsula and eastern Antarctica. Values given here are mainly from the latter area.

Table 3: Levels of overlap between fisheries and dependent species.

	Index	Description	Sensitive to
1	Catch of krill in the CPD	Tonnage of krill taken within 100 km of predator colonies from December to March.	Catch size and distribution
2	Percentage of krill catch taken in CPD	Percentage of the total catch in a subarea taken within 100 km of predator colonies from December to March.	Catch distribution
3	Realised overlap (Agnew and Phegan)	Product of the expected consumption of krill by penguins in a fine-scale square and the catch in that square.	Catch size and distribution
4	Realised potential overlap (Modified Agnew and Phegan)	Realised overlap divided by the maximum possible realised overlap, calculated by assuming the areas of maximum catch coincide with the areas of maximum krill consumption by penguins.	Catch distribution

Table 4: Categorised standardised normal deviate of an index.

The standardised normal deviate of an index is calculated as the deviation from the mean over all years, expressed in units of standard deviation. Where the distribution of the index over all years is known not to approximate a normal distribution, it is transformed according to the table below, and the normal deviates of the transformed index are presented here.

The size of the deviate is represented by the following symbols:

deviate > 1.5	*
1.5 > = deviate > 0.5	+
0.5 > = deviate > -0.5	o
-0.5 > = deviate > -1.5	-
-1.5 > = deviate	=

If the deviate is identified as 'anomalous' using the methodology described in the Subgroup on Statistics report (Appendix H), it is represented by ** or == depending on whether it is in the upper 2.5% or lower 2.5% of the time series distribution of indices.

Note: data from each time series of less than three years are not shown since it is not possible to calculate valid anomalies, e.g. South African data.

According to discussions and hypotheses presented in this report, not all indices may be expected to behave in the same way in response to similar changes in conditions. For instance, when krill is more abundant, one would expect sea-ice extent to be greater, breeding success to be greater, foraging duration to be lower, and SST to be lower. This table presents the indices simply as they are recorded in the CCAMLR databases, which means that even when all the indices are responding to the same phenomenon, one may expect a mixture of positive and negative responses in the table. It is not appropriate to modify the

Table 4 (continued)

indices themselves, because their interpretation is based on hypotheses put forward in this report, which may change. However, it is appropriate to indicate how the Working Group expects the standard normal deviates to behave in response to similar phenomena. The table below specifies whether the standardised normal deviate is EXPECTED to be positive (+, * or **) or negative (-, = or ==) in 'good' years, where 'good' is understood to mean years of high krill abundance (see previous sections of the report for hypotheses on the relationships between parameters, especially for the expected responses of sea-ice and foraging duration).

Index Name	Transformation	Response
A1 arrival weight (g)	No transformation	+ (heavier birds = more food)
A2 first incubation shift (days)	Ln transform	- (longer shift = less food)
A2 second incubation shift (days)	Ln transform	- (longer shift = less food)
A3 number of pairs	Delta ln; difference between logs of adjacent years	+ (more birds = more food)
A5 foraging during brood (hr)	Ln transform	- (longer foraging = less food)
A5 foraging during creche (hr)	Ln transform	- (longer foraging = less food)
A6a % breeding success A (potential chicks)	Log Odds transform [ln(p/(1-p))]	+ (greater success = more food)
A6c % breeding success C (potential chicks)	Log Odds transform [ln(p/(1-p))]	+ (greater success = more food)
A7 fledging weight (g)	No transformation	+ (heavier chicks = more food)
A8 mean ration weight (g)	No transformation	+ (heavier stomachs = more food)
A8 proportion fish in diet	Log Odds transform [ln(p/(1-p))]	- (more fish = less krill)
A8 proportion stomachs containing krill	Log Odds transform [ln(p/(1-p))]	+ (more krill = more krill)
B1a albatross population, n. nests (colony H)	Delta ln; difference between logs of adjacent years	+ (more birds = more food)
B1b albatross % breeding success (colony H)	Log Odds transform [ln(p/(1-p))]	+ (greater success = more food)
C1 cow foraging (hr)	Ln transform	- (longer foraging = less food)
C2 pup growth (kg/month)	Ln transform	+ (faster growth = more food)
F2a September ice % cover	Log Odds transform [ln(p/(1-p))]	+ (greater sea-ice = more krill)
F2b proportion of the year free of ice	Log Odds transform [ln(p/(1-p))]	- (greater proportion = less krill)
F2c weeks sea-ice within 100km	No transformation	- (increasing weeks = less krill)
F5 summer sea-surface temperature	No transformation	- (higher temperature = less sea-ice = less krill)
H1a Japanese CPUE (tonnes/hr)	Ln transform	+ (higher CPUE = more krill)
H1b Japanese CPUE (tonnes/day)	No transformation	+ (higher CPUE = more krill)
H2 krill catch in CPD (tonnes)	No transformation	+ (higher catch = more krill)
H3a standardised realised overlap	Log Odds transform [ln(p/(1-p))]	unknown
H3b realised potential overlap	Log Odds transform [ln(p/(1-p))]	unknown

Table 4 (continued)

Group	Series	ASD Code	Site Code	Species Code	Sex	Index Name	58	73	74	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
A	1	481	_	_	_	F2a September ice % cover								o	**	+	+	-	=	-	+	+	o	-	o	o	-	o	o	
A	2	481	_	_	_	H1a Japanese CPUE (tonnes/hr)									+	+		o	==		o	o	o	-	o	+	o	o	o	
A	3	481	_	_	_	H1b Japanese CPUE (tonnes/day)									-	-		-	=		o	o	+	o	o	*	+	+	+	
A	4	481	_	_	_	H2 krill catch in CPD (tonnes)												-	-	o	+	+	**	o	o	+	-	-	-	
A	5	481	_	_	_	H3a standardised realised overlap									*	o		o	-	o	o	o	**	o	o	o	-	-	-	
A	6	481	_	_	_	H3b realised potential overlap									+	+		**	o	+	o	o	o	o	o	-	-	=	-	
B	1	481	AIP	_	_	F2b proportion of the year free of ice								-	-	-	o	o	o	o	-	-	o	**	+	-	o	o	o	
B	2	481	AIP	_	_	F2c weeks sea-ice within 100km								o	=	o	o	+	+	+	=	o	+	*	-	-	+	o	o	
B	3	481	AIP	_	_	F5 summer sea-surface temperature										+	o	+	+	+	=	+	o	+	-	-	-	o	o	-
B	4	481	CSS	_	_	F5 summer sea-surface temperature										+	-	o	+	o	==	+	o	+	-	-	o	o	o	-
B	5	481	EIS	_	_	F5 summer sea-surface temperature										+	-	o	+	o	=	o	-	+	-	o	o	o	+	-
B	6	481	ESP	_	_	F5 summer sea-surface temperature										*	-	+	*	+	-	o	-	+	-	o	-	-	o	-
C	1	481	SES	_	_	F2b proportion of the year free of ice								-	-	-	+	*	+	o	-	-	+	+	-	-	o	o	-	
C	2	481	SES	_	_	F2c weeks sea-ice within 100km								o	-	-	+	+	+	o	=	o	+	+	-	-	+	o	-	
C	3	481	SES	_	_	F5 summer sea-surface temperature										+	-	o	+	o	=	o	-	+	-	o	o	o	+	-
C	4	481	SPS	_	_	F2b proportion of the year free of ice								-	-	o	o	*	+	o	-	-	o	o	-	-	+	**	o	
C	5	481	SPS	_	_	F2c weeks sea-ice within 100km								-	-	o	+	+	+	o	=	o	+	+	-	-	+	o	o	
C	6	481	SPS	_	_	F5 summer sea-surface temperature										*	-	+	*	+	-	o	-	+	-	o	-	-	o	-
D	1	481	AIP	PYD	U	A3 number of pairs																				=	o	+	-	+
D	2	481	AIP	PYD	U	A5 foraging during brood (hr)																		+	+	-	o	-	o	
D	3	481	AIP	PYD	U	A5 foraging during creche (hr)																		-	*	+	o	o	-	
D	4	481	AIP	PYD	U	A6c % breeding success C (potential																		-	-	o	+	o	+	+
D	5	481	AIP	PYD	U	A7 fledging weight (g)																		-	+	+	+	-	-	-
D	6	481	AIP	PYD	U	A8 mean ration weight (g)																		-	-	+	o	o	+	-
D	7	481	AIP	PYD	U	A8 proportion fish in diet																		+	-	o	+	-	o	+
D	8	481	AIP	PYD	U	A8 proportion stomachs containing krill																		o	o	o	==	o	o	o
G	1	481	ESP	PYD	U	A1 arrival weight (g)																						+	=-	o
G	2	481	ESP	PYD	U	A2 first incubation shift (days)																						-	+	o
G	3	481	ESP	PYD	U	A2 second incubation shift (days)																						-	+	o
G	4	481	ESP	PYD	U	A6a % breeding success A (potential																						+	o	-
G	5	481	ESP	PYD	U	A3 number of pairs																						=	-	+
H	1	481	SES	EUC	U	A6c % breeding success C (potential																+		*	o	o	-	o	-	
H	2	481	SES	PYN	U	A5 foraging during brood (hr)																-	+	+	o	o	-	+		

Table 4 (continued)

Group	Series	ASD Code	Site Code	Species Code	Sex	Index Name	58	73	74	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
H	3	481	SES	PYN	U	A5 foraging during creche (hr)																	+		o	o	-	o		
H	4	481	SES	PYN	U	A6c % breeding success C (potential																+	+	-	-	o	o	-	o	
H	5	481	SES	PYN	U	A7 fledging weight (g)																*	+	-	==	o	o	-	o	o
H	6	481	SES	PYN	U	A8 mean ration weight (g)																-	o	**	-			o		
H	7	481	SES	PYN	U	A8 proportion fish in diet																-	o	o	=			+		
H	8	481	SES	PYN	U	A8 proportion stomachs containing krill																o	==	o	o			o		
I	1	481	SES	SEA	F	C2 pup growth (kg/month)																-	**	-	+	-	o	o	o	
I	2	481	SES	SEA	M	C2 pup growth (kg/month)																+	+	==	+	-	o	o	-	
I	3	481	SES	SEA	U	C1 cow foraging (hr)																-		-	*	o	+	o	-	
I	4	481	CSS	SEA	M	C2 pup growth (kg/month)																						-	o	+
I	5	481	CSS	SEA	F	C2 pup growth (kg/month)																						-	+	o
J	1	482	_	_	_	F2a September ice % cover								o	**	o	o	o	-	-	o	*	+	-	o	o	o	o	o	
J	2	482	_	_	_	H1a Japanese CPUE (tonnes/hr)										-	-	+	+	-	*	o	+		-	o	+	o		
J	3	482	_	_	_	H1b Japanese CPUE (tonnes/day)										==	-	o	+	o	+	o	+		o	=	o	+		
J	4	482	_	_	_	H2 krill catch in CPD (tonnes)															o	+	-	o	**	+	-	-	-	
J	5	482	LAO	_	_	F5 summer sea-surface temperature										*	o	o	+	o	-	+	-	+	o	-	+	o	o	==
J	6	482	SIO	_	_	F2b proportion of the year free of ice								-	-	o	-	o	o	o	-	-	o	+	-	-	+	**	o	
J	7	482	SIO	_	_	F2c weeks sea-ice within 100km								-	=	o	o	o	+	+	-	-	-	*	-	-	*	o	o	
J	8	482	SIO	_	_	F5 summer sea-surface temperature										*	o	o	+	o	-	+	-	+	o	-	+	o	o	==
K	1	482	SIO	PYD	U	A3 number of pairs																		=	-	+	o	o	-	+
K	2	482	SIO	PYD	U	A6a % breeding success A (potential																		o	o	o	*	-	o	
K	3	482	SIO	PYN	U	A3 number of pairs																		=	-	+	o	+	-	o
K	4	482	SIO	PYN	U	A6a % breeding success A (potential																		==	+	+	+	-	o	o
K	5	482	SIO	PYP	U	A3 number of pairs																		=	==	+	o	o	o	o
K	6	482	SIO	PYP	U	A6a % breeding success A (potential																		-	+	+	o	-	o	o
K	7	482	LAO	PYD	U	A1 arrival weight (g)																-	o	+						
L	1	483	_	_	_	F2a September ice % cover								-	**	o	-	-	o	-	o	**	o	-	-	+	o	+	o	
L	2	483	_	_	_	H1a Japanese CPUE (tonnes/hr)																			o	-	o	*	-	
L	3	483	_	_	_	H1b Japanese CPUE (tonnes/day)																			o	-	o	**	o	
L	4	483	_	_	_	H2 krill catch in CPD (tonnes)																-	*+	o	-					
L	5	483	BIG	_	_	F5 summer sea-surface temperature										**	o	+	o	o	-	-	o	+	o	-	+	o	o	==
M	1	483	BIG	DIM	U	B1a albatross population, n. nests (colony				=	o	o	o	o	o	o	o	o	o	o	o	=	*	o	o	o	o	o	==	**
M	2	483	BIG	DIM	U	B1b albatross % breeding success (colony				+	+	o	+	==	o	+	+	o	+	o	o	-	o	+	==	o	+	-	==	+

Table 4 (continued)

Group	Series	ASD Code	Site Code	Species Code	Sex	Index Name	58	73	74	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
N	1	483	BIG	EUC	F	A1 arrival weight (g)																	+	+	+	-	o	o	o	-
N	2	483	BIG	EUC	M	A1 arrival weight (g)																	+	o	==	+	o	o	-	o
N	3	483	BIG	EUC	U	A3 number of pairs	=				=	**	-	o	o	+	o	+	o	o	-	-	+	-	o	o	o	o	==	o
N	4	483	BIG	EUC	U	A6a % breeding success A (potential					o	-	o	+	o	o	o	==	o	o	-	-	+	+	+	o	+	o	o	o
N	5	483	BIG	EUC	U	A7 fledging weight (g)																	+	o	-	+	o	-	-	o
N	6	483	BIG	EUC	U	A8 mean ration weight (g)																		o	-	**	+	o	-	-
N	7	483	BIG	EUC	U	A8 proportion fish in diet																		-	-	-	+	+	+	-
N	8	483	BIG	EUC	U	A8 proportion stomachs containing krill																		+	-	+	o	-	-	+
O	1	483	BIG	PYP	U	A3 number of pairs		=			=	o	==	*		=	o	-	o	+	o	o	+	o	=	+	o	o	o	o
O	2	483	BIG	PYP	U	A6a % breeding success A (potential					+	==	o	+		-	o	o	o	o	o	o	o	o	==	+	*	-	+	+
O	3	483	BIG	PYP	U	A7 fledging weight (g)																	o	+	-	+	o	-	-	o
O	4	483	BIG	PYP	U	A8 mean ration weight (g)																		o	-	+	o	==	+	+
O	5	483	BIG	PYP	U	A8 proportion fish in diet																		o	+	o	==	+	o	+
O	6	483	BIG	PYP	U	A8 proportion stomachs containing krill																		o	-	+	+	-	o	-
P	1	483	BIG	SEA	F	C2 pup growth (kg/month)																		-	+	-	+	+	-	o
P	2	483	BIG	SEA	M	C2 pup growth (kg/month)																		-	+	-	+	-	+	o
P	3	483	BIG	SEA	U	C1 cow foraging (hr)																		-	+	-	o	**	o	-
P	4	5841	_	_	_	H1a Japanese CPUE (tonnes/hr)				-	-								o	+	o				-		+	+	-	
P	5	5841	_	_	_	H1b Japanese CPUE (tonnes/day)				=	o								o	+	+				o		**	o	o	
Q	1	5842	SYO	PYD	U	A3 number of pairs										=	+	-	+	-	+	o	*	==	+	-	o	o	-	=
Q	2	881	EDP	_	_	F5 summer sea-surface temperature										-	*	*	+	+	o	-	+	o	-	o	o	-	o	=
Q	3	881	ROS	PYD	U	A3 number of pairs																	=	+	-	o	+		=	
Q	4	pbis	_	_	_	F2a September ice % cover								=	+	+	o	+	o	+	o	o	o	*	o	-	-	-	=	
R	1	5842	_	_	_	H1a Japanese CPUE (tonnes/hr)			=	o	+	o			o		o													
R	2	5842	_	_	_	H1b Japanese CPUE (tonnes/day)			==	o	+	o			o		+													
R	3	5842	_	_	_	H2 krill catch in CPD (tonnes)			-		+	+	+	o	-	-	-					o								
R	4	5842	BEE	_	_	F2c weeks sea-ice within 100km								o	+	o	o	o	+	+	+	o	==	o	o	o	-	+	==	
R	5	5842	BEE	_	_	F5 summer sea-surface temperature										+	+	+	+	-	o	-	-	-	-	+	+	+	-	==
R	6	5842	MAD	_	_	F5 summer sea-surface temperature										**	+	+	o	o	o	-	-	-	-	o	o	+	o	==
R	7	5842	SYO	_	_	F5 summer sea-surface temperature										o	+	o	*	o	+	+	-	-	-	+	o	o	o	==
S	1	5842	BEE	PYD	F	A1 arrival weight (g)																				-	-	+	+	o
S	2	5842	BEE	PYD	M	A1 arrival weight (g)																				-	o	+	o	-
S	3	5842	BEE	PYD	U	A1 arrival weight (g)																				+	o		-	

Table 4 (continued)

Group	Series	ASD Code	Site Code	Species Code	Sex	Index Name	58	73	74	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
S	4	5842	BEE	PYD	U	A2 first incubation shift (days)																			o	o	-	=	+	o
S	5	5842	BEE	PYD	U	A2 second incubation shift (days)																			+	+	-	=	+	o
S	6	5842	BEE	PYD	U	A3 number of pairs																				=	-	+	+	o
T	1	5842	BEE	PYD	U	A6a % breeding success A (potential																				o	+	=	=-	+
T	2	5842	BEE	PYD	U	A6c % breeding success C (potential																				o	o	+	==	o
T	3	5842	BEE	PYD	U	A7 fledging weight (g)																				o	o	+	==	+
T	4	5842	BEE	PYD	U	A8 mean ration weight (g)																			-	o	o	+	-	
T	5	5842	BEE	PYD	U	A8 proportion fish in diet																			o	+	o	o	-	
T	6	5842	BEE	PYD	U	A8 proportion stomachs containing krill																			o	-	o	+	o	

Table 5: Local-scale strategic model.

Linkage or Process	New Information Available
Fishery-harvested species	Changes in timing and distribution of Japanese fishery in Subarea 48.1 (WG-EMM-96/64).
Harvested-dependent species	Chinstrap penguin foraging and prey distribution, Seal Island (WG-EMM-96/49, 96/55; paragraphs 6.43 and 6.44). Predator foraging ranges (paragraph 6.42). Predator energy budgets, South Georgia (WG-EMM-96/7, 96/66; paragraphs 6.45 and 6.46). Predator foraging model (WG-EMM-96/20; paragraphs 6.47 to 6.54). Standardised CEMP indices (WG-EMM-96/4).
Environment-dependent species	Effect of sea-ice on penguins (WG-EMM-96/10, 96/27, 96/58; paragraphs 6.31 to 6.34). Oceanographic models (WG-EMM-96/61). Standardised CEMP indices (WG-EMM-96/4).
Environment-harvested species	Krill recruitment, biomass and environmental indices, Subarea 48.1 (WG-EMM-96/21 to 96/23, 96/27) and Subarea 48.3 (WG-EMM-96/18) (see also paragraphs 6.5 to 6.22). Standardised CEMP indices (WG-EMM-96/4).

Table 6: Regional-scale strategic model.

Linkage or Process	New Information Available
Fishery-harvested species	Fine-scale krill catch and effort data (WG-EMM-96/25; paragraphs 2.2 to 2.9). Distribution of krill catches in Area 48 (WG-EMM-96/64; paragraph 6.25)
Harvested-dependent species	Predator energy budgets (WG-EMM-96/7, 96/10, 96/66; paragraphs 6.40 and 6.41). Models of functional relationships (WG-EMM-96/67; paragraphs 6.56 to 6.60) Standardised CEMP indices (WG-EMM-96/4).
Environment-dependent species	Effect of sea-ice on penguins (WG-EMM-96/10, 96/58; paragraphs 6.31 to 6.34). Oceanographic models (WG-EMM-96/61). Standardised CEMP indices (WG-EMM-96/4). Krill flux in Subarea 48.2 (WG-EMM-96/37).
Environment-harvested species	Krill recruitment, biomass and environmental data, Subarea 58.4 (WG-EMM-96/28, 96/29), Ross Sea (WG-EMM-96/63). Standardised CEMP indices (WG-EMM-96/4).

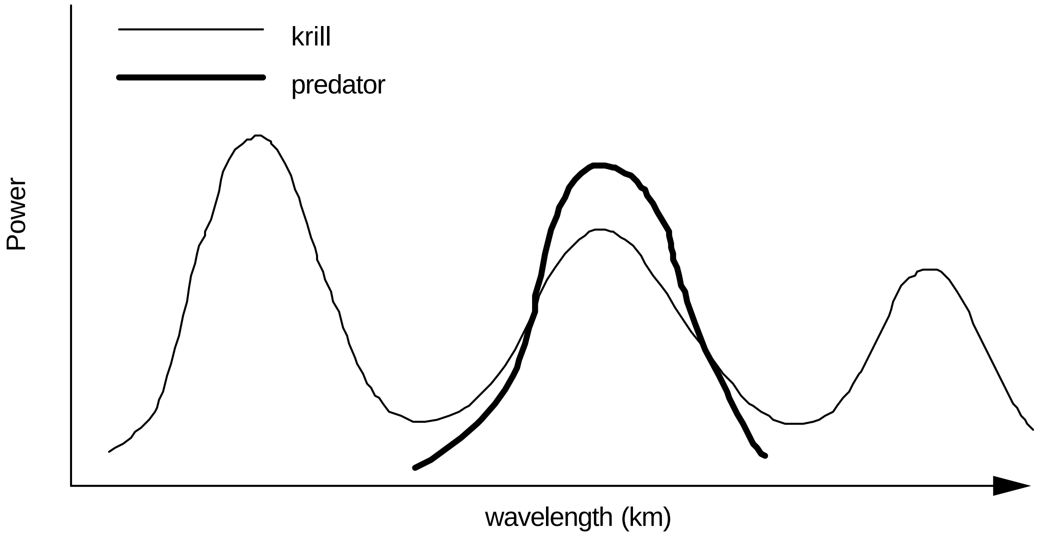

Figure 1: Hypothetical illustration of the congruence of top-down and bottom-up approaches. In this example the spectrum of the krill pattern has three peaks, showing three levels of spatial organisation of krill. The spectrum of predator behaviour has a single peak that overlaps with one of the krill peaks, indicating that this is the relevant local index.

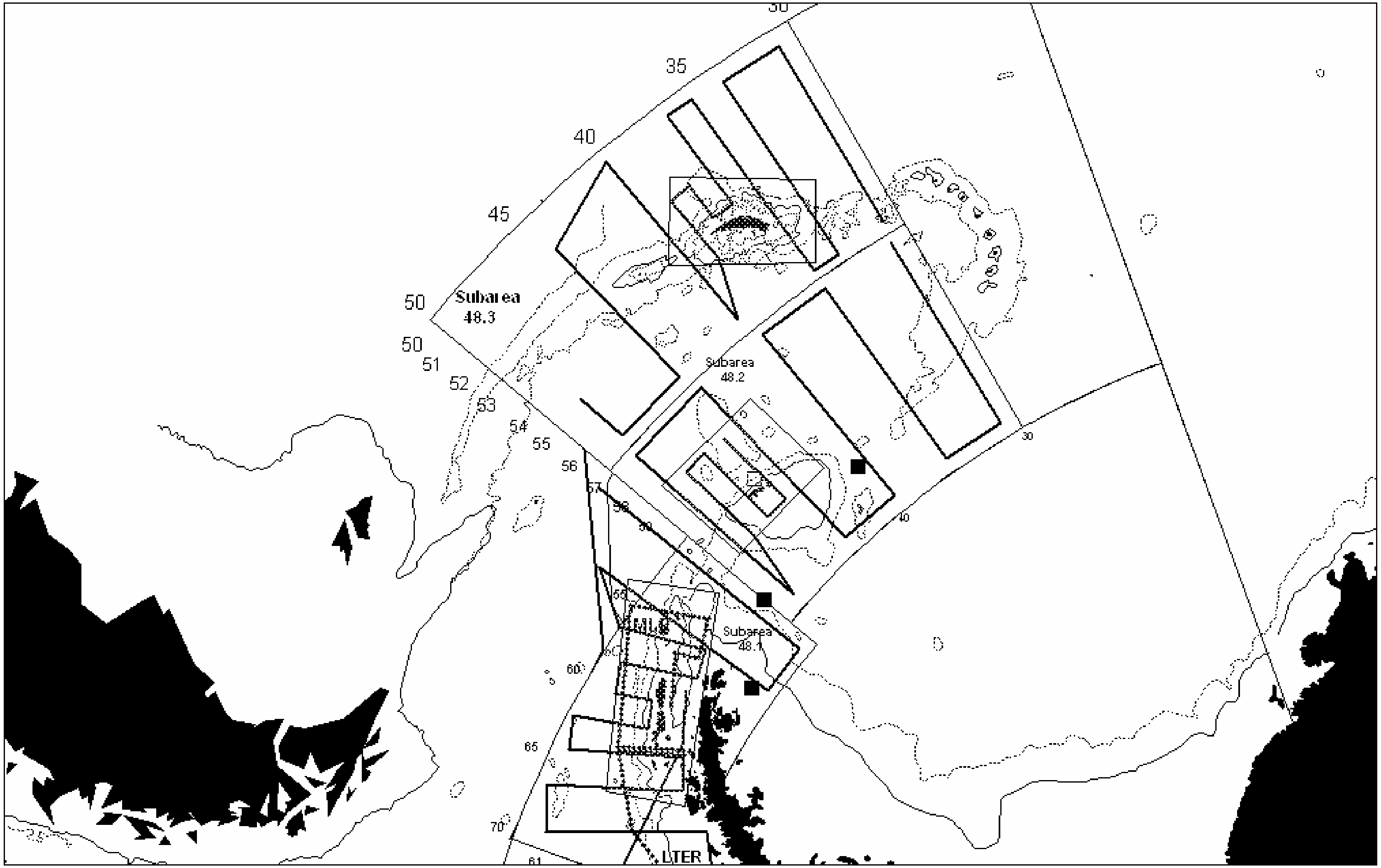

Figure 2: Map showing a possible synoptic survey in Subareas 48.1, 48.2 and 48.3 using three months of ship time. Trackline lengths and placement are illustrative only and do not represent any statistical scheme. Dotted lines in Subarea 48.1 delineate the US LTER and AMLR study regions. Filled squares represent mean ice position in January. Large boxes around islands represent areas of historically high krill density and are the basis for survey stratification.

APPENDIX A

AGENDA

Working Group on Ecosystem Monitoring and Management
(Bergen, Norway, 12 to 22 August 1996)

1. Introduction
   (i) Opening of the Meeting
   (ii) Organisation of the Meeting and Adoption of the Agenda

2. Data
   (i) Fisheries
      (a) Catches, Status and Trends
      (b) Harvesting strategies
      (c) Observer Scheme
      (d) Other Information
   (ii) Surveys on Harvested Species
   (iii) Dependent Species
   (iv) Environment
   (v) Biology and Ecology of Harvested and Dependent Species of Particular Relevance to Fisheries Management and CEMP

3. Harvested Species
   (i) Methods for Estimating Distribution, Standing Stock, Recruitment and Production of Harvested Species
   (ii) Analysis and Results of Studies on Distribution and Standing Stock
   (iii) Analysis and Results of Studies on Recruitment and Production of Harvested Species
   (iv) Indices of Harvested Species Abundance, Distribution and Recruitment
   (v) Future Work
      (a) Synoptic Krill Survey in Area 48
      (b) Other Work

4. Dependent Species
   (i) Sites
   (ii) Species
   (iii) Monitoring Methods

(a) Report of the Subgroup on Monitoring Methods
(b) Revisions
(c) New Methods
(d) At-sea Behaviour
(e) Marking Birds
(f) Crabeater Seals

(iv) Analytical Methods
(a) Report of the Subgroup on Statistics
(b) Calculation of Indices
(c) Extension of Indices

(v) Data Submission

(vi) Future Work

5. Environment

(i) Methods for Monitoring Environmental Variables of Direct Importance in Ecosystem Assessment
(ii) Consideration of Studies on Key Environmental Variables
(iii) Indices of Key Environmental Variables

6. Ecosystem Analysis

(i) By-catch of Fish in the Krill Fishery
(ii) Interactions between Ecosystem Components
(a) Harvested Species and the Environment
(b) Harvested Species and the Krill Fishery
(c) Dependent Species and the Environment
(d) Dependent Species and Harvested Species
(i) Diet
(ii) Food Consumption/Energy Budgets
(iii) Predator/Prey Models
(e) Fishery and Dependent Species Overlap
(iii) Analysis of Data from CEMP Indices

7. Ecosystem Assessment

(i) Assessments Based on CEMP indices
(ii) Estimation of Potential Yield
(iii) Precautionary Catch limits
(iv) Consideration of Possible Management Measures
(v) Extension of the Scope of CEMP

(vi) Strategic Modelling
(vii) Ecosystem Implications of Proposed New Fisheries
(viii) Future Work

8. Advice to the Scientific Committee
    (i) General Advice
    (ii) Management Advice
    (iii) Future Work

9. Other Business

10. Adoption of the Report

11. Close of the Meeting.

LIST OF PARTICIPANTS

Working Group on Ecosystem Monitoring and Management
(Bergen, Norway, 12 to 22 August 1996)

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LIST OF DOCUMENTS

Working Group on Ecosystem Monitoring and Management
(Bergen, Norway, 12 to 22 August 1996)

WG-EMM-96/1 Rev. 1	PROVISIONAL AGENDA AND PROVISIONAL ANNOTATED AGENDA FOR THE SECOND MEETING OF THE WORKING GROUP ON ECOSYSTEM MONITORING AND MANAGEMENT (WG-EMM)
WG-EMM-96/2	LIST OF PARTICIPANTS
WG-EMM-96/3	LIST OF DOCUMENTS
WG-EMM-96/4	CEMP INDICES 1996: SECTIONS 1 TO 3 Secretariat
WG-EMM-96/4 Errata	CEMP INDICES 1996: SECTIONS 1 TO 3 Secretariat
WG-EMM-96/5	GEOGRAPHICAL ASPECTS OF UTILISING RESOURCES OF KRILL (*EUPHAUSIA SUPERBA*) R.R. Makarov (Russia)
WG-EMM-96/6	REPORT OF THE MEETING OF THE SUBGROUP ON STATISTICS (Cambridge, UK, 7 to 9 May 1996) (Attached to WG-EMM this report as Appendix H)
WG-EMM-96/7	THE RELATIONSHIP BETWEEN FORAGING BEHAVIOUR AND ENERGY EXPENDITURE IN ANTARCTIC FUR SEALS (*J. Zool., Lond.* (1996), 239) J.P.Y. Arnould, I.L. Boyd and J.R. Speakman (UK)
WG-EMM-96/8	A COMPARISON OF ANTARCTIC KRILL (*EUPHAUSIA SUPERBA* DANA) CAUGHT BY NETS AND TAKEN BY MACARONI PENGUINS (*EUDYPTES CHRYSOLOPHUS* BRANDT): EVIDENCE FOR SELECTION? H.J. Hill, P.N. Trathan, J.P. Croxall and J.L. Watkins (UK)
WG-EMM-96/9	KRILL CAUGHT BY PREDATORS AND NETS: DIFFERENCES BETWEEN SPECIES AND TECHNIQUES K. Reid, P.N. Trathan, J.P. Croxall and H.J. Hill (UK)

WG-EMM-96/10	DYNAMICS OF ANTARCTIC PENGUIN POPULATIONS IN RELATION TO INTER-ANNUAL VARIABILITY IN SEA-ICE DISTRIBUTION (*Polar Biol.* (1996), 16: 321–330) P.N. Trathan, J.P. Croxall and E.J. Murphy (UK)
WG-EMM-96/11	THE FISH DIET OF BLACK-BROWED ALBATROSS *DIOMEDEA MELANOPHRYS* AND GREY-HEADED ALBATROSS *D. CHRYSOSTOMA* AT SOUTH GEORGIA (*Polar Biol.* (1996), 16) K. Reid, J.P. Croxall and P.A. Prince (UK)
WG-EMM-96/12	CEPHALOPODS AND MESOSCALE OCEANOGRAPHY AT THE ANTARCTIC POLAR FRONT: SATELLITE TRACKED PREDATORS LOCATE PELAGIC TROPHIC INTERACTIONS (*Mar. Ecol. Prog. Ser.* (1996), 136: 37–50) P.G. Rodhouse, P.A. Prince, P.N. Trathan, E.M.C. Hatfield, J.L. Watkins, D.G. Bone, E.J. Murphy and M.G. White (UK)
WG-EMM-96/13	DEVELOPMENTS IN THE CEMP INDICES 1996 Secretariat
WG-EMM-96/14	TESTING FOR NORMALITY IN COLONY COUNTS Secretariat
WG-EMM-96/15	A HISTORY OF THE ACQUISITION AND ANALYSIS OF SEA-ICE DATA BY CCAMLR D.J. Agnew (Secretariat)
WG-EMM-96/16	WG-EMM WORKSHOP ON AT-SEA BEHAVIOUR I.L. Boyd (UK)
WG-EMM-96/17	DIET OF THE CAPE PETREL *DAPTION CAPENSE* DURING THE CHICK-REARING PERIOD AT FILDES PENINSULA AND HARMONY POINT, SOUTH SHETLAND ISLANDS, ANTARCTICA G.E. Soave, N.R. Coria, P. Silva, D. Montalti and M. Favero (Argentina)
WG-EMM-96/18	KRILL BIOMASS ESTIMATES FOR TWO SURVEY BOXES TO THE NORTH-EAST AND NORTH-WEST OF SOUTH GEORGIA IN JANUARY 1996: THE BEGINNING OF A FIVE-YEAR MONITORING PROGRAM A.S. Brierley, J.L. Watkins and A.W.A. Murray (UK)
WG-EMM-96/19	A SYNOPTIC REVIEW OF ENERGETIC REQUIREMENTS OF SOUTHERN OCEAN KRILL PREDATORS A.M. Stansfield (USA)

WG-EMM-96/20	A MODEL AT THE LEVEL OF THE FORAGING TRIP FOR THE INDIRECT EFFECTS OF KRILL (*EUPHAUSIA SUPERBA*) FISHERIES ON KRILL PREDATORS P.V. Switzer and M. Mangel (USA)
WG-EMM-96/21	CLIMATE CHANGE AND ZOOPLANKTON DOMINANCE IN THE ANTARCTIC MARINE ECOSYSTEM: IMPLICATIONS FOR THE FOOD WEB V. Loeb (USA), V. Siegel (Germany), O. Holm-Hansen, R. Hewitt, W. Fraser, W. Trivelpiece and S. Trivelpiece (USA)
WG-EMM-96/22	INDICES OF PREY AVAILABILITY NEAR THE SEAL ISLAND CEMP SITE: 1990 THROUGH 1996 R.P. Hewitt, G. Watters and D.A. Demer (USA)
WG-EMM-96/23	DISTRIBUTION, BIOMASS AND ABUNDANCE OF ANTARCTIC KRILL IN THE VICINITY OF ELEPHANT ISLAND DURING THE 1996 AUSTRAL SUMMER R.P. Hewitt, D.A. Demer and V. Loeb (USA)
WG-EMM-96/24	AREAL AND SEASONAL EXTENT OF SEA-ICE COVER OFF THE NORTHWESTERN SIDE OF THE ANTARCTIC PENINSULA: 1979 THROUGH 1995 R.P. Hewitt (USA)
WG-EMM-96/25	REPORTING OF FINE-SCALE KRILL DATA IN THE 1994/95 SEASON Secretariat
WG-EMM-96/26	OBSERVATIONS OF FISHING VESSEL ACTIVITY, RKTS *GENERAL PETROV*, MARCH TO JULY 1995 Submitted by Ukraine (with additional notes by the Secretariat)
WG-EMM-96/27	A WAY FORWARD IN THE MULTIVARIATE ANALYSIS OF ANTARCTIC PREDATOR, PREY AND ENVIRONMENT INDICES: PREDATOR-ENVIRONMENT INTERACTIONS AT SEAL ISLAND D.J. Agnew (Secretariat), G. Watters and R. Hewitt (USA)
WG-EMM-96/28	RESULTS OF A HYDROACOUSTIC SURVEY OF ANTARCTIC KRILL POPULATIONS IN CCAMLR DIVISION 58.4.1 CARRIED OUT IN JANUARY TO APRIL 1996 T. Pauly, I. Higginbottom, S. Nicol and W. de la Mare (Australia)
WG-EMM-96/29	AN OVERVIEW AND SOME PRELIMINARY RESULTS OF A BIOLOGICAL/OCEANOGRAPHIC SURVEY OFF THE COAST OF EAST ANTARCTICA (80-150°E) CARRIED OUT IN JANUARY TO MARCH 1996 S. Nicol, N. Bindoff, W. de la Mare, D. Gillespie, T. Pauly, D. Thiele, E. Woehler and S. Wright (Australia)

WG-EMM-96/30	VACANT
WG-EMM-96/31	FISH IN THE DIET OF THE BLUE-EYED SHAG *PHALACROCORAX ATRICEPS* AT THE SOUTH SHETLAND ISLANDS: SIX YEARS OF MONITORING STUDIES R. Casaux and E. Barrera-Oro (Argentina)
WG-EMM-96/32	THE IMPORTANCE OF FISH IN THE DIET OF THE SOUTH POLAR SKUA *CATHARACTA MACCORMICKI* AT THE SOUTH SHETLAND ISLANDS, ANTARCTICA D. Montalti, R. Casaux, N. Coria and G. Soave (Argentina)
WG-EMM-96/33	MONITORING OF SEAL POPULATIONS ON KING GEORGE ISLAND, 1995–1996 (VNIRO, Russia)
WG-EMM-96/34	ON SELECTIVITY OF COMMERCIAL AND RESEARCH TRAWLS WHEN KRILL CATCHING S.M. Kasatkina (Russia)
WG-EMM-96/35	HYDROMETEOROLOGICAL CONDITION FEATURES IN SOUTH ORKNEYS SUBAREA IN FEBRUARY–MARCH 1996 M.I. Polischuk and V.N. Shnar (Russia)
WG-EMM-96/36	RESULTS OF ACOUSTIC ASSESSMENT OF KRILL BIOMASS IN SUBAREA 48.2 DURING SUMMER 1996 S.M. Kasatkina, V.A. Sushin, V.M. Abramov, V.I. Sunkovich, M.I. Polischuk and V.N. Shnar (Russia)
WG-EMM-96/37	EVALUATION OF KRILL TRANSPORT FACTOR RESULTS IN SUBAREA 48.2 IN SUMMER PERIOD OF 1996 S.M. Kasatkina, V.N. Shnar, M.I. Polischuk V.M. Abramov and V.A. Sushin (Russia)
WG-EMM-96/38	TRENDS IN SIZE AND SUCCESS OF BREEDING COLONIES OF MACARONI AND ROCKHOPPER PENGUINS AT MARION ISLAND, 1979/80-1995/96 J. Cooper, A. Wolfaardt and R.J.M. Crawford (South Africa)
WG-EMM-96/39	SUMMARY OF CEMP ACTIVITIES AT CAPE SHIRREFF D. Torres (Chile)
WG-EMM-96/40	UNCERTAINTY IN ECHOSOUNDER CALIBRATIONS D.A. Demer and M.A. Soule (USA)
WG-EMM-96/41	MEASUREMENTS OF FISH SCHOOL VELOCITIES WITH AN ACOUSTIC DOPPLER CURRENT PROFILER D.A. Demer (USA)

WG-EMM-96/42 AN ACOUSTIC SURVEY OF ANTARCTIC KRILL ON THE SOUTH GEORGIA SHELF, CCAMLR SUBAREA 48.3, IN JANUARY 1992
C. Goss and I. Everson (United Kingdom)

WG-EMM-96/43 INTER-ANNUAL VARIATION IN CONDITION INDEX OF THE MACKEREL ICEFISH *CHAMPSOCEPHALUS GUNNARI*
I. Everson (United Kingdom), K.-H. Kock (Germany) and G. Parkes (United Kingdom)

WG-EMM-96/44 DIET OF THE CAPE PETREL *DAPTION CAPENSE* DURING THE POST-HATCHING PERIOD AT IAURIE ISLAND, SOUTH ORKNEY ISLANDS, ANTARCTICA
N.R. Coria, G.E. Soave and D. Montalti (Argentina)

WG-EMM-96/45 LONGTERM MONITORING OF KRILL RECRUITMENT AND ABUNDANCE INDICES IN THE ELEPHANT ISLAND AREA (ANTARCTIC PENINSULA
V. Siegel (Germany), W. de la Mare (Australia) and V. Loeb (USA)

WG-EMM-96/46 EFFECT OF MISSING MODES ON CALIBRATION SPHERE TARGET STRENGTHS (ICES CM 1996/B: 37, Fish Capture Committee)
K.G. Foote (Norway)

WG-EMM-96/47 CPUES AND BODY LENGTH OF ANTARCTIC KRILL DURING 1994/95 SEASON IN THE FISHING GROUNDS AROUND THE SOUTH SHETLAND ISLANDS
S. Kawaguchi, T. Ichii and M. Naganobu (Japan)

WG-EMM-96/48 REPORT OF THE 1995/96 JAPANESE WHALE RESEA RCH PROGRAMME UNDER SPECIAL PERMIT IN THE ANTARCTIC (JARPA) IN AREA IV AND EASTERN PART OF AREA III
S. Nishiwaki, H. Ishikawa, D. Tohyama, M. Kawasaki, K. Shimamoto, S. Yuzu, T. Tamura, T. Mogoe, T. Hishii, T. Yoshida, H. Hidaka, H. Nibe, K. Yamashiro, K. Ono and F. Taguchi (Japan)

WG-EMM-96/49 COMPARISONS IN PREY DISTRIBUTION BETWEEN INSHORE AND OFFSHORE FORAGING AREAS OF CHINSTRAP PENGUINS AND ANTARCTIC FUR SEALS AT SEAL ISLAND
T. Ichii (Japan), J.L. Bengtson (USA), T. Takao (Japan), P. Boveng, J.K. Jansen, M.F. Cameron, L.M. Hiruki, W.R. Meyer (USA), M. Naganobu and S. Kawaguchi (Japan)

WG-EMM-96/50 CPUE AND RECRUITMENT INDICES CALCULATED FROM LOG BOOK DATA OF JAPANESE KRILL FISHERIES
S. Kawaguchi, T. Ichii and M. Naganobu (Japan)

WG-EMM-96/51 CPUE, NET TOWING DEPTH AND BODY LENGTH OF KRILL DURING THE WINTER OPERATION OF JAPANESE KRILL FISHERY AROUND SOUTH GEORGIA
S. Kawaguchi, T. Ichii and M. Naganobu (Japan)

WG-EMM-96/52 PRELIMINARY RESULTS ON BY-CATCH OF FISHES CAUGHT BY THE FISHERY VESSEL *CHIYO MARU NO. 3* TO THE NORTH OF THE SOUTH SHETLAND ISLANDS (FEBRUARY TO MARCH, 1996)
S. Kawaguchi, T. Ichii and M. Naganobu (Japan)

WG-EMM-96/53 DRAFT METHODS RECOMMENDED TO WG-EMM FOR APPROVAL BY THE SUBGROUP ON MONITORING METHODS

WG-EMM-96/54 Rev. 1 REPORT OF THE SUBGROUP ON MONITORING METHODS
(Bergen, Norway, 8 to 10 August 1996)
(Attached to this report as Appendix I)

WG-EMM-96/55 COMPARISONS IN DIET BETWEEN DIURNAL AND OVERNIGHT FORAGING CHINSTRAP PENGUINS AT SEAL ISLAND
T. Ichii, T. Hayashi (Japan), J.L. Bengtson, P. Boveng, J.K. Jansen, M. F. Cameron (USA) and A. Miura (Japan)

WG-EMM-96/56 CALCULATING PRECAUTIONARY CATCH LIMITS BASED ON MASS OF KRILL CONSUMED BY PREDATORS
I. Everson (UK) and W. de la Mare (Australia)

WG-EMM-96/57 COOPERATIVE PROJECT BELGIUM – ARGENTINA INTO EMM: 'GERLACHE – SOBRAL'
D. Vergani (Argentina), L. Holsbeek (Belgium), Z. Stanganelli (Argentina) and C. Joiris (Belgium)

WG-EMM-96/58 THE BREEDING BIOLOGY AND DISTRIBUTION OF ADELIE PENGUINS: ADAPTATIONS TO ENVIRONMENTAL VARIABILITY
(In: Ross, R., E. Hofmann and L. Quetin (Eds). *Foundations for Ecological Research West of the Antarctic Peninsula*. American Geophysical Union, Washington, DC, 1996)
W.Z. Trivelpiece and W.R. Fraser (USA)

WG-EMM-96/59 USE OF AT-SEA DISTRIBUTION DATA TO DERIVE POTENTIAL FORAGING RANGES OF MACARONI PENGUINS DURING THE BREEDING SEASON
P. Trathan, E. Murphy, J. Croxall and I. Everson (UK)

WG-EMM-96/60 A CONCEPTUAL FRAMEWORK FOR MODELING ANTARCTIC KRILL
E.E. Hofmann (USA)

WG-EMM-96/61	OCEANOGRAPHIC CIRCULATION MODELS FOR THE WESTERN ANTARCTIC CONTINENTAL SHELF AND DRAKE PASSAGE J.M. Klinck, E.E. Hofmann (USA) and E. Murphy (UK)
WG-EMM-96/62 Rev. 1	EXECUTIVE SUMMARY OF SCAR/COMNAP WORKSHOPS ON 'MONITORING OF ENVIRONMENTAL IMPACTS FROM SCIENCE AND OPERATIONS IN ANTARCTICA' (Oslo, Norway 17-20 October 1995 and College Station, Texas, US, 25-29 March 1996)
WG-EMM-96/63	ESTIMATION OF BIOMASS OF KRILL *EUPHAUSIA SUPERBA* AND BIRDS AND MAMMALS CENSUS DURING THE XTH ITALIAN EXPEDITION TO ROSS SEA, NOVEMBER/DECEMBER 1994 M. Azzali, J. Kalinowski and N. Saino (Italy)
WG-EMM-96/64	DETAILED DISTRIBUTION OF KRILL FISHING AROUND SOUTH GEORGIA E.J. Murphy, P.N. Trathan, I. Everson and G. Parkes (UK)
WG-EMM-96/65	HATCHING SEASON AND GROWTH OF *PLEURAGRAMMA ANTARCTICUM* LARVAE NEAR THE ANTARCTIC PENINSULA IN AUSTRAL SUMMER 1993/94 Tae won Lee, Suam Kim and Seong Sik Cha (Republic of Korea)
WG-EMM-96/66	PRELIMINARY ESTIMATES OF KRILL CONSUMPTIONS BY ANTARCTIC FUR SEALS AND MACARONI PENGUINS AT SOUTH GEORGIA I.L. Boyd and J.P. Croxall (UK)
WG-EMM-96/67	EXTENSION TO THE KRILL-PREDATOR MODELLING EXERCISE R.B. Thomson and D.S. Butterworth (South Africa)
WG-EMM-96/68	MODELING THE GROWTH DYNAMICS OF ANTARCTIC KRILL C.M. Lascara and E.E. Hofmann (USA)
WG-EMM-96/69	THE FORAGING RANGE OF ADELIE PENGUINS – IMPLICATIONS FOR CEMP AND INTERACTIONS WITH THE KRILL FISHERY K.R. Kerry, J.R. Clarke (Australia), S. Corsolini (Italy), S. Eberhard, H. Gardner, R. Lawless (Australia), D. Rodary (France), R. Thomson (South Africa), R. Tremont and B. Wieneke (Australia)
WG-EMM-96/70	EVALUATION OF THE KRILL STOCK IN SUBAREA 48.3, JUNE–AUGUST 1995 V.A. Bibik (Ukraine)
WG-EMM-96/71	ICES WORKING GROUP ON FISHERIES ACOUSTICS SCIENCE AND TECHNOLOGY (FAST); SUMMARY OF TOPICS DISCUSSED AT THE 1996 MEETING I. Everson (UK)

WG-EMM-96/72	VACANT
WG-EMM-96/73	AMLR 1995/96 FIELD SEASON REPORT – OBJECTIVES, ACCOMPLISHMENTS AND TENTATIVE CONCLUSIONS Delegation of USA

OTHER DOCUMENTS

CCAMLR-XV/7	NOTIFICATION OF THE INTENTION OF KOREA AND THE UNITED KINGDOM TO INITIATE A NEW FISHERY Delegations of Korea and the United Kingdom
CCAMLR-XV/8	NOTIFICATION OF NEW ZEALAND'S INTENTION TO INITIATE NEW FISHERIES Delegation of New Zealand
CCAMLR-XV/9	NOTIFICATION OF AUSTRALIA'S INTENTION TO INITIATE NEW FISHERIES Delegation of Australia
CCAMLR-XV/10	NOTIFICATION OF NORWAY'S INTENTION TO INITIATE A NEW FISHERY Delegation of Norway
CCAMLR-XV/11	NOTIFICATION OF SOUTH AFRICA'S INTENTION TO INITIATE NEW FISHERIES Delegation of South Africa
SC-CAMLR-XIV/BG/20	REPORT OF BIOLOGIST-OBSERVER ON FISHING VESSEL RKTS *GENERAL PETROV*, MARCH TO AUGUST 1994 Delegation of Ukraine
SC-CAMLR-XV/BG/2	DRAFT CEMP TABLES 1 TO 3 Secretariat
SC-CAMLR-XV/BG/7	POPULATION CHANGES IN ALBATROSSES AT SOUTH GEORGIA Delegation of the United Kingdom
SC-CAMLR-XV/BG/10 Rev. 1	EXCERPTS FROM THE REPORT OF THE MEETING OF THE SCAR GROUP OF SPECIALISTS ON SEALS (Cambridge, UK, 1–2 August 1996)
SC-CAMLR-XV/BG/11	NEED FOR PROCEDURES TO GOVERN THE RESUMPTION OF FISHERIES TARGETING SPECIES NOT PRESENTLY HARVESTED BUT FOR WHICH A FISHERY PREVIOUSLY EXISTED Delegation of USA

DETAILS THAT SHOULD BE INCLUDED IN REPORTS OF ACOUSTIC SURVEYS OF KRILL BIOMASS AND/OR DISTRIBUTION

Recommended details to be added to reports of acoustic surveys of krill biomass and/or distribution. These details are additional to those given in SC-CAMLR-XI, Annex 4, Appendix H, points 2 and 3.

Description of echosounder and associated systems:

Echosounder
- make
- model
- software version

Data logging
- software description
- data types logged (e.g. ping or integration interval)

Data processing
- software description
- noise removal techniques
- background noise thresholding methods

Calibration description:

General
- date
- location

Methods
- technique (e.g. sphere)
- sphere type
- ship mooring type (eg. 1, 2, 4 anchors etc.)

Environmental conditions

water temperature*

salinity*

sound velocity*

bottom depth

sphere depth

qualitative descriptions of sea state, swell, wind, currents etc.

(* profiles of these as a function of depth would be ideal)

Transducer description for each channel logged

frequency

manufacture

model

type (single, dual- or split-beam)

mounting method (flush or sea chest; window material etc.)

location (hull, keel, pole or towed body)

orientation (downward, upward looking etc.)

depth (or depth range of towed body)

Transceiver settings

power

bandwidth

pulse length

absorption coefficient

time varied gain (TVG)

noise rejection level

noise margin

S_v threshold

Calibration results

e.g.	or	or
peak S_v transducer gain	source level	source level
two-way beam angle	receiver sensitivity	beam width
beam width	narrow beam factor	echosounder constant
along ship		
athwart ship		
narrow		
wide		

(Note: the parameters required from a calibration vary from one echosounder type to another and also for different transducer types. We have listed here only indicative parameters determined in calibrations.)

Survey operating and processing conditions:

nominal ship speed
integration interval type (distance, time etc.)
integration interval value (in n miles, seconds etc.)
integration depth layers
pulse repetition rate

REPORT OF THE SUBGROUP ON ECHO CLASSIFICATION

A total of seven papers (WG-EMM-96/18, 96/23, 96/28, 96/36, 96/42, 96/49 and 96/63) discussed the use of acoustic methods to estimate krill biomass. The Working Group noted that there was considerable variation in the amount of detail given in the description of methods used to classify the acoustic signal. As a result, a subgroup comprising Drs J. Watkins (UK), D. Demer (USA), T. Pauly (Australia), M. Naganobu (Japan), M. Azzali (Italy), V. Sushin (Russia), R. Hewitt (USA), K. Foote (Norway) and D. Miller (South Africa) was formed to:

(i) describe the different echo classification techniques;
(ii) assess how comparable the results were; and
(iii) recommend common criteria to be used for comparative purposes.

2. Detailed information was obtained from the authors of all the above-mentioned papers during the meeting.

3. In WG-EMM-96/23 and 96/28 signals thought to be non-biological, including background noise, were removed. The remaining acoustic backscatter was considered to be due to krill. If other scatterers are also present in the water column, then such a technique is likely to overestimate krill density.

4. In WG-EMM-96/18, 96/42 and 96/63 the biological signal remaining after noise removal was classified on the basis of a dB difference (dB difference = 120 kHz S_V - 38 kHz S_V). The effectiveness of such a classification is yet to be consistently determined.

5. WG-EMM-96/18 classified the acoustic backscatter into three classes: nekton (dB difference < 2 dB), krill (2 dB < dB difference < 12 dB) macrozooplankton (dB difference > 12 dB).

6. WG-EMM-96/42 classified acoustic backscatter into two classes: nekton (dB difference < 2 dB), krill and zooplankton (dB difference > 2 dB).

7. WG-EMM-96/63 classified acoustic backscatter first into two classes: fish (dB difference < 0 dB) and krill plus zooplankton (dB difference > 0 dB). The krill was then separated from the zooplankton on the basis of TS of individual scatterers (-73 dB < krill TS < -68 dB).

8. WG-EMM-96/36 used a method based on *in situ* TS to separate krill from other scatterers. Minimum and maximum TS values were derived from net catches using the size of krill and TS to length relationship described in SC-CAMLR-X. Acoustic backscatter with *in situ* TS values estimated by the echosounder as falling within the minimum and maximum values calculated from the net catch was then classified as krill.

9. WG-EMM-96/49 used a classification system based on net hauls and a video camera deployed on nets, CTDs and ROVs.

10. In addition, WG-EMM-96/28 and 96/63 used net hauls to identify the dominant euphausiid in the area and so determine which areas to exclude from biomass estimates.

11. Given the differing techniques used to classify acoustic backscatter mean that krill biomass estimates are not directly comparable. At present there is no universally agreed method for classifying the acoustic backscatter to separate krill from other targets.

12. The subgroup recommended that all papers on echo classification should contain a full description of the echo classification procedures used.

13. Each paper should also contain average mean volume backscattering strength (S_v) and average mean area backscattering coefficient (S_A) for each transect before any biological classification is undertaken. Furthermore, estimates of krill volumetric density and krill areal density can be computed from the above S_V and S_A using the methods described in Hewitt and Demer, 1993 and Demer and Hewitt, 1995. Although this may lead to overestimates of krill density, it will provide baseline values suitable for comparative purposes. Authors are encouraged to present results classified into krill and other scatterers.

14. Finally, the subgroup recognised that both multifrequency and single-frequency echo classification techniques were being developed and encouraged most strongly the further development, validation and description of such techniques.

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NOTES REGARDING FURTHER WORK ON KRILL-PREDATOR MODELLING STUDIES

Note: Comments pertain to the Thomson-Butterworth approach (e.g. WG-EMM-96/67) to analysis except where indicated otherwise.

(i) Antarctic fur seal

(a) Sensitivity of results to density dependence with adult survival rate, and to alternative functional forms (i.e. alternative to linear functional forms) for the density dependence remains to be investigated.

(b) The assumption made in recent analyses that the estimated population growth rate reflects the maximum possible (i.e. corresponds to an absence of density dependent effects) is considered reasonable for the population viewed as a whole (although there are indications that the population has reached, and perhaps even exceeded, pre-exploitation levels in localised areas).

(c) A further year's data which has now become available should be incorporated into analyses.

(ii) Black-browed albatross

(a) Further analyses should assume that the estimated survival rates include a component related to fishery-induced mortality from the year 1989 when longlining commenced in the vicinity of South Georgia, and should incorporate the survival rate estimates subsequent to 1990/91 which are now available. The analyses need to take account of differences in population trend before and after 1989.

(b) Data suggest that the population size was high and stable during the 1970s, but dropped to a lower but still stable level in the 1980s. Such behaviour is not immediately compatible with the structure of the present krill-predator and krill yield models, and modifications to these which permit reconciliation with these data should be investigated.

(c) There are no series of population size estimates which would allow estimates to be made of maximum population growth rate from periods of population increase – an analysis in any case rendered the more problematic because of the long lag from fledging to recruitment to the breeding population. Instead, maximum growth rate estimates based on plausible maxima for values of demographic parameters for survival and reproduction need to be considered.

(iii) Adélie penguin

(a) Dr M. Mangel (USA) will liaise directly with Dr W. Trivelpiece (USA) to obtain local-scale data pertinent to the further development of the Switzer-Mangel krill-Adélie penguin functional response model (WG-EMM-96/20).

(b) Dr Mangel will liaise with Dr D. Butterworth and Miss R. Thomson (South Africa) to effect input of results from a refined Switzer-Mangel model into computations allowing estimation of the effect of different krill fishing intensities (measured by γ) on the size of the Adélie penguin population.

(c) Further work to amend the Thomson-Butterworth Adélie penguin model as per Appendix F of SC-CAMLR-XIV, Annex 4 is unlikely to commence before 1997. Dr Trivelpiece will, if possible, extract the requisite data (annual estimates of the number of colony birds and fledging success rates) for these analyses by early 1997.

(d) The population in question appears to have changed from a stable level in the 1980s via a sudden drop in 1988/89 to a subsequent near stable but lower level. The latter period shows much lower levels of cumulative survival from fledging to recruitment to the breeding population. This combination of events implies that other demographic parameters must also have changed, and available data on age at first laying and adult survival rate should be examined for evidence of this.

(e) The present approach assumes that only the juvenile (first year) survival rate depends on krill availability. This approach should be extended to allow sub-adult survival rates to depend upon this as well. Data available on cumulative survival to first breeding could be used to attempt the estimation required.

(iv) Crabeater seals

(a) As survival rate data do not exist, indices of relative cohort strength (inferred from investigations of teeth and ovaries) would need to be used as a substitute for juvenile survival rate in any analysis.

(b) Information on maximum possible population increase rates would need to be inferred by analogy from other species. As results for resilience to krill harvesting seem likely to be very sensitive to this value, and given the questionable reliability of such arguments by analogy, analysis for this species should be accorded a lesser priority.

(v) Gentoo penguins

(a) Dr Trivelpiece has data for this species similar to those he has collected for Adélie penguins. Investigation would be of interest because this species has a different life history to Adélie penguins (including, in particular, a much lower age at first laying).

(b) Extraction of the data required for a modelling exercise will, however, be time-consuming. Thus work on this species should first await progress with the analyses for Adélie penguins.

CALCULATIONS FOR SENSITIVITY TESTS OF THE KRILL YIELD MODEL

1. Use the R_1 and R_2 estimates from Table 3 of WG-EMM-96/45 in the recruitment model (de la Mare, 1994). These will probably not be suitable for use in the beta distribution model, in which case they should be incorporated using a re-sampling method. The consequent estimates of the recruitment distribution and natural mortality provide a distribution for the pre-exploitation biomass, which is to be compared with the distribution of densities given in Table 4 of WG-EMM-96/45 to see whether the recruitment proportion and density data are consistent with an absence of trend in median recruitment (as assumed by the recruitment model). The relative frequency of model trajectories which closely match the observed density series is to be assessed.

2. Re-calculate the values of γ pertinent to Subareas 48.1, 48.2 and 48.3 taking account of:

   (i) the revised joint distribution for M and krill recruitment distribution parameters from 1 above; and

   (ii) an estimate of the biomass level at the time of the FIBEX survey relative to the median pre-exploitation biomass.

3. Use the R_1 and R_2 estimates in conjunction with density estimates to calculate an index of absolute recruitment. Re-sample from these to calculate yield and a distribution of population trajectories. Again use the distributions and relative frequency of similar trajectories as comparative measures. Examine the stock recruitment relationship indicated by these estimates.

4. Investigate the robustness of the precautionary limits calculated from the yield model by using recruitment data generated from two types of models. The first model is to include the effects of serial correlation in recruitment. The serial correlation used is to be based on serial correlation estimated from the observed recruitment series. The second model is to generate recruitment from a model in which krill recruitment switches from time to time from a higher level to a lower level. The amplitude and period of the level shifts are to be based on those required to emulate the abundance indices given in Table 4 of WG-EMM-96/45. The precautionary yield from the usual krill model is then to be compared with the known yield from the simulation models used to generate the data.

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REPORT OF THE SUBGROUP ON STATISTICS

(Cambridge, UK, 7 to 9 May 1996)

REPORT OF THE SUBGROUP ON STATISTICS

(Cambridge, UK, 7 to 9 May 1996)

INTRODUCTION

The Subgroup on Statistics, convened by Dr D. Agnew (Secretariat), met from 7 to 9 May 1996 in Cambridge, UK, to consider a number of items referred to it by the meeting of WG-EMM in 1995. These items are identified in the agenda, which is given in Attachment A. The lists of participants and documents are given in Attachments B and C respectively. The report was prepared by the Secretariat.

CALCULATIONS OF INDICES OF DEPENDENT SPECIES PARAMETERS

2. The methods of calculating indices from the data collected by CEMP have been described in WG-EMM-95/10 to 95/14. In brief, data collected by each standard method are analysed to calculate one or more indices for each combination of site/species/sex and year. Each combination of index/site/species/sex is thus a time series. In addition to the documents listed in Attachment C, the subgroup had available to it a version of WG-EMM-95/14 which had been revised by the Secretariat in accordance with requests by WG-EMM-95 (SC-CAMLR-XIV, Annex 4, paragraphs 5.69 to 5.73). The subgroup examined these indices and discussed a number of desirable modifications.

3. There are two fundamentally different types of variance included in the standard presentation of indices produced by the Secretariat: within- and between-year variances.

4. Included in the presentations in WG-EMM-95/13 are the within-year variance of an index for each year in a time series, the value of the index itself and the statistical significance of the difference between that index and the previous year's value. In general, these statistics are being appropriately applied and are of some value.

5. The between-year variance has been used in these presentations to calculate confidence limits of the mean (over years) index; years with values outside these confidence bounds have been identified as apparently anomalous.

6. The subgroup recognised that both the anomalies and trends, within an index series, are of interest. The identification of anomalous values should continue to be carried out using the mean and variance of the series when the value of the index between years is expected to be normally

distributed. However, when normality cannot be assumed, identification of anomalous values should be carried out either using quantiles of the empirical distribution of the values, or by transformation to normality (for instance the log-odds transformation $log(p/(1 - p))$ for proportional data).

7. Where anomalies are identified from normal distributions (either naturally normal or transformed to normality) the length of the time series is critical in determining the level at which values are to be considered anomalous. An empirical analysis described in Attachment D was used to derive the values of z_c in Table 1, to be used in the identification of anomalies; a value is considered anomalous where $value < mean - z_c\ sd$ or $value > mean + z_c\ sd$.

Table 1: Values of z_c to be used in the identification of anomalies.

Series Length (no. of years)	Critical Value z_c	Series Length (no. of years)	Critical Value z_c	Series Length (no. of years)	Critical Value z_c	Series Length (no. of years)	Critical Value z_c
		11	2.36	21	2.72	31	2.92
		12	2.41	22	2.75	32	2.94
3	1.15	13	2.46	23	2.77	33	2.95
4	1.49	14	2.51	24	2.80	34	2.96
5	1.72	15	2.55	25	2.82	35	2.98
6	1.89	16	2.58	26	2.84	36	2.99
7	2.02	17	2.61	27	2.86	37	3.00
8	2.13	18	2.64	28	2.87	38	3.02
9	2.22	19	2.67	29	2.89	39	3.03
10	2.29	20	2.70	30	2.91	40+	3.04

8. Identification of anomalous values should in all cases only be performed when a series is composed of three or more years of data. Indices where normality may be assumed were identified as A1, A7, A8a and C2. The proportion indices (A6, A8b, B2) should be investigated for normality, and subject to the log-odds transformation and subsequent treatment as normal distributions if necessary. Indices where normality was unlikely were those involving foraging duration (A2, A5 and C1), and these may be transformed using logs if this gives approximate normality. The population size indices (A3 and B1) might be best studied by log-transforming them and investigating the year-to-year differences as changes in logs. Detection of anomalies and trend in any indices which cannot be treated in this way should be carried out using quantiles.

9. All indices should be examined for evidence of trends although, until recently, time series have been too short to analyse using standard trend statistics (such as Mann-Kendal statistics). In the cases where trends can be identified, consideration should be given to ways to de-trend the data to assist the identification of anomalous years. However, the methodologies for de-trending these data, and the appropriate z_c values to use on de-trended series, require further investigation.

10. It was recognised that as the demand for identification of anomalies and trends becomes greater, the computational challenges involved in performing these analyses using database software will increase. It is highly desirable to retain the present software design, which is linked directly to the CCAMLR database and enables additional data to be rapidly incorporated into the analysis, although this necessitates the employment of standardised, general methodologies. For this reason, the presentations of the indices should clearly state that the identification in these presentations of significant between-year changes, anomalous years and trends should be treated simply as guidelines to assist examination of the data. Formal statistical analysis will continue to require the detailed examination of individual series on a case-by-case basis.

11. A number of points were made concerning specific indices.

A3 – Breeding Population Size

12. The addition of year-to-year percentage change would be helpful in identifying trends for this index.

13. The problem of ensuring data continuity for indices of population size was discussed in some detail. A good example of the problem is given by the data on Adélie penguins from Syowa station (Table 2).

14. Situations such as that at Syowa are most likely to arise where logistic or operational reasons prohibit the monitoring of a colony in a particular year. They may also arise if the colony count was zero but was erroneously reported as a null, or where colonies have coalesced. In the latter case, the problem may be overcome by creating a new colony code to cover both the coalesced colony and its previous parent colonies.

15. Where there are cells missing from the matrix of colonies by year, the situation is currently treated by including only those colonies which have time series of similar lengths in the final index calculation. For Syowa, only the Ongul colony was included in the calculation of the index. The subgroup agreed that although the current method omits several colonies which may contribute useful data, the alternative method, that of omitting all years where there are data missing for one or more colonies, was not appropriate. As a better solution, methods of interpolating missing data for years when at least one colony out of a group has been counted should be investigated.

16. As an interim measure, the subgroup requested that a table similar to Table 2 should be presented whenever missing data are identified in Method A3.

Table 2: Colony counts from Syowa site.

Site Code	Species Code	Split-year	Colonies				
			Huku	Mame	Mizu	Ongul	Rumpa
SYO	PYD	1966			39	103	
SYO	PYD	1967			134		960
SYO	PYD	1968			180		1000
SYO	PYD	1971				113	
SYO	PYD	1972				88	
SYO	PYD	1974				73	
SYO	PYD	1975	140	21		50	533
SYO	PYD	1977				55	
SYO	PYD	1978				46	
SYO	PYD	1980		24		43	473
SYO	PYD	1981		70		102	1145
SYO	PYD	1982	480	60		122	1500
SYO	PYD	1983	310	53		59	1200
SYO	PYD	1984	500	53		77	1550
SYO	PYD	1985	670	53		83	1224
SYO	PYD	1986	520	68		158	1450
SYO	PYD	1987	434	72	247	82	1437
SYO	PYD	1988	750		493	59	2270
SYO	PYD	1989	439		258	78	1338
SYO	PYD	1990	398	115	416	124	1893
SYO	PYD	1991	352	139	318	91	1498
SYO	PYD	1992	290	180	413		1485

A5 – Foraging Duration

17. Some evidence was presented at the 1995 meeting of WG-EMM that male and female Adélie penguins showed different foraging behaviour (SC-CAMLR-XIV, Annex 4, paragraph 5.17). Currently, few datasets submitted to CCAMLR enable separation of this index by sex (WG-EMM-Stats-96/5) to be carried out, and the subgroup, while feeling unable to comment on the significance of inter-sex differences in foraging duration, noted that the collection and reporting of data by sex would enable separation to be carried out in the future should this be deemed necessary. Sex should also be identified when reporting data under Method A2 (incubation shift).

18. The subgroup endorsed the current method of calculating foraging duration during the brood and creche stages separately, but requested that the tables of mean foraging duration by five-day period presented in WG-EMM-Stats-96/5 should be routinely produced along with the A5 indices to aid interpretation.

19. It was noted that a t-test was currently being employed for pair-wise interannual comparisons of foraging duration. The within-year normal distribution assumed by this test was unlikely to hold for the foraging data, but given the large sample sizes currently employed it is most

likely that the means would be approximately normally distributed, leading to results which were probably not misleading. The current methodology should therefore be retained.

A6 (A6a – Chicks Fledged per Eggs Laid;
A6c – Chicks Fledged per Chicks Hatched)

20. The subgroup agreed that the current method of calculating binomial standard error of breeding success was appropriate. The unit of sampling is the nest rather than the egg, leading to: *se(p)* = v*(p(l-p)/n)* for one-egged species; and *se(p)* being somewhere between v*(p(l-p)/n)* and v*(p(*1*p)/*2*n)* for two-egged species, the largest of these *(v(p(l-p)/n))* being taken to provide the most conservative estimate of *se*. This approach is also adopted in the comparison of pair-wise year differences, where the chi-squared is divided by 2 for two-egged species. To avoid confusion in the future, the rationale for using these tests should be explained more fully in the text of the indices. Several other editorial changes were suggested, including an explanation of the result of coalescing of colonies between and within years (see paragraph 14).

A8a – Ration Size

21. WG-EMM noted that at Béchervaise Island some cases of known breeding birds returning to the CEMP site with empty stomachs had been reported (WG-EMM-95/32). It requested the Subgroup on Monitoring Methods to consider how data on empty stomachs should be incorporated into the calculation of indices. Because the question also has relevance to the Subgroup on Statistics, it was also considered by this group.

22. The subgroup recognised that it was essential that birds found to have empty stomachs were known to be breeding birds with living chicks, and that empty stomachs be clearly defined and separated from stomachs with very few contents. Given this assurance, two options for incorporation of empty stomach data were considered. Firstly, a non-normal distribution could be fitted to describe within-year variation. However, this requires further investigation and is not suggested as a solution at the moment.

23. Secondly, the present (assumed normal distribution) calculation of the index could be enforced for non-zero stomachs only, with the additional presentation of the proportion of empty stomachs. If necessary, comparative and trend statistics on the proportion of empty stomachs could be calculated, for instance using the log-odds ratio transformation. The indices produced using this method would probably be the easiest to interpret, and would also be simplest to compute.

24. The easiest way to report this information would be as a single figure for the number of empty stomachs on form A8.

A8b – Prey Categories

25. New categories for specific prey items of particular importance at some sites should be recorded in the database (e.g. *Themisto* at South Georgia). These should not necessarily be presented in the indices document. However, under the indices of 'mean proportion by weight' an 'others' column should be introduced to complement the current categories of squid, fish and krill and demonstrate that the total proportions sum to approximately 1.

26. It was noted that the proportion given was calculated as the mean proportion of diet component in individual stomachs, and not the proportion of that component in all stomachs (i.e. $mean(p(x)_i)$ not $p(sum(x_i))$ where x_i is the weight of diet component x in bird i and $p(x)_i$ is the proportion of diet component x in bird i). The former calculation is considered to reflect the population condition more accurately because it takes the sampling unit to be the individual animal rather than the group of animals. Both methods, however, are vulnerable to biases due to weighting problems where birds have particularly variable stomach content masses.

27. Mr T. Ichii (Japan) reported that some recent data (Jansen, unpublished) had indicated that there were both diurnal and overnight foragers within the chinstrap penguin population, which resulted in chicks being fed twice per day during the early rearing period, and that the prey composition found in penguins foraging at these different times of day was distinct. For instance, both fish and krill were taken at night and only krill was taken during the day. Previously, it had been assumed that these penguins undertook only one, daytime, foraging trip.

28. If sampling of diet was confined to a single time of day, then this could lead to biases in the monitoring results. However, it was recognised that this did not affect the method of calculation of the indices or their statistics, but should be referred to the Subgroup on Monitoring Methods to examine the problem in more detail and determine ways to ensure consistency of sampling.

C1 – Fur Seal Female Foraging Duration

29. This method involves placing transmitters on seals to record the duration of foraging for their first six perinatal trips. Failure of animals to complete six trips usually results in the transmitter being

recovered and placed on another female, but failures are currently not reported. It was suggested that the number of failures be reported in addition to the foraging details of seals which successfully complete a full six foraging trips; this suggestion should be referred to the Subgroup on Monitoring Methods.

30. The text of the indices should be amended to reflect changes in the method of calculating the index determined at the 1994 meeting of the Subgroup on Statistics.

C2 – Fur Seal Pup Growth

31. The three data series being compiled for this parameter (Cape Shirreff, Seal Island and Bird Island) all use procedure A where a number of pups are weighed at intervals throughout the growing season. The indices calculated from these data may be biased because it is impossible to identify (and thus eliminate from the analysis) pups weighed early in the season which will not survive to weaning. These pups are often smaller than average, and are most likely to die in the first month, thereby depressing the regression near the origin. Further, in poor seasons when more pups are likely to die, the biasing effect on the calculated regression is likely to be greater, leading to greater apparent growth rates in poor seasons than good seasons.

32. To examine this problem further, growth rates calculated using data from early and late parts of the season should be compared in an attempt to identify consistent biases. This would best be done by Members using original data rather than the data submitted to CCAMLR.

Environmentally Unusual Years

33. WG-EMM requested that the Subgroup on Statistics develop methods of highlighting anomalous years where the reason for the anomaly is known and, if necessary, excluding them from trend analyses (SC-CAMLR-XIV, Annex 4, paragraph 5.83). This report will refer to these years as ‘unusual’ to distinguish them from the statistical description of ‘anomalous’ years given in paragraphs 6 to 8.

34. An example of the problem was discussed with reference to black-browed albatrosses at South Georgia. Occasionally heavy snow and ice conditions at Bird Island prevent many albatrosses from nesting. In these years breeding success for birds that do lay is often zero or near-zero. Although snow, ice and local weather conditions are considered by monitoring methods F3 and F4,

these land-ice conditions at Bird Island are not monitored regularly so as to form a continuous series which would serve as an environmental index.

35. The subgroup agreed that where significant environmental events occur which are noted by researchers as affecting monitored parameters but which are not part of a continuous environmental monitoring regime, they should be recorded and reported to CCAMLR on the data submission forms for CEMP methods. They will then be entered as presence/absence data into the database, presented alongside the indices, and can be incorporated as binomial variables in any multivariate analysis of the indices. Accordingly, all forms need to be amended to include an entry for 'unusual environmental conditions'.

EXTENSION OF INDICES TO COVER HARVESTED SPECIES AND ENVIRONMENTAL PARAMETERS

CPD Index

36. The subgroup has been asked to provide a critical re-examination of the concept of the CPD index (SC-CAMLR-XIV, Annex 4, paragraphs 5.92 to 5.96). This index is currently calculated as the krill catch within 100 km of predator colonies during the period December to March. It is not a measure of competition between predators and the fishery, but is a simple expression of potential niche overlap. This index is intended to be used to assist in understanding some of the predator-fishery interactions identified in the schematic representation of the ecosystem described by WG-EMM (SC-CAMLR-XIV, Annex 4, Figure 3). The concept has been developed in some depth by Ichii et al. (1994), and Agnew and Phegan (1995), who attempted to further refine the calculation of realised niche overlap.

37. The four general levels at which analysis of this niche overlap may be viewed are shown in Table 3.

Table 3: Levels of analysis of niche overlap.

Name	Scale/Operation	Description	Example
Precautionary overlap	Subarea or Southern Ocean.	Covers whole area of krill distribution and all krill predators.	Potential yield model.
Potential overlap	Broad-scale spatial (100-km radius) and temporal resolution.	Very broad scale. Local overlaps or separations between predators and the fishery may be missed or misrepresented, but flux can be ignored.	Current CPD calculations (WG-EMM-95/41).
Realised overlap	Fine-scale horizontal distributions of predators and the fishery (30 n mile x 30 n mile) combined with estimates of predator consumption rates.	Fine-scale overlap is measured, but the major problem of flux between fine-scale areas is not addressed.	Modelling approach suggested by Agnew and Phegan (1995).
Dynamic overlap	Very fine-scale vertical and horizontal distributions of predators and the fishery, together with modelling of flux effects and the common availability of prey to both resource users.	This would be the best descriptor of the functional link between predators and the fishery, but would require a much larger knowledge base than is available at the moment.	Some discussion in Ichii et al. (1994).

38. The subgroup agreed that all levels of analysis of niche overlap should be developed. It was felt that worthwhile progress could be made with the potential and realised overlap indices using available data and current knowledge, but that substantial progress with the dynamic overlap index would require additional data and new biological knowledge. Development of the potential and realised indices should proceed in parallel – the latter being perceived as a refinement of the former.

39. A dynamic overlap index will require detailed data at a fine spatial and temporal scale appropriate to the scale of predator-prey-fishery interactions. Members should be encouraged to develop research programs to collect data and generate analyses.

40. The subgroup noted the reservations about the spatial and temporal scales of the existing CPD calculations expressed in SC-CAMLR-XIV, Annex 4, paragraphs 5.92 to 5.95, but felt that it did not have the expertise to determine adequately the values of parameters necessary for these models. Accordingly, it requested WG-EMM to provide information for known colonies on monthly estimates of:

(i) typical diet composition (along the lines of index A8b); and
(ii) maximum and modal foraging range.

Where data are not available for a colony, values should be inferred from the closest or most similar colony.

41. These data can then be aggregated on the most appropriate spatial and temporal scales to calculate indices of potential overlap with the fishery. It was suggested that the largest scale on which such aggregation would be useful was annually for a statistical subarea. Within this scale, the data aggregation should be set at a level appropriate to the predator species in question. It was clear that it would be unlikely that any one spatial or temporal scale would be suitable for all species or areas, but the subgroup felt that it did not have sufficient data or expertise to determine these scales and requested advice from WG-EMM accordingly.

42. In order to make progress with the realised overlap approach of Agnew and Phegan (1995), data on the density of predators as a function of distance and bearing to colonies will be required. There are two methods of acquiring this information: through satellite tracking of known breeding animals and through standardised shipboard surveys. Research data on the distribution of predators at sea, obtained via satellite tagging and through aerial and shipboard observation, are becoming increasingly available, and Members who have such data are encouraged to analyse them in such a way as to provide the necessary input for the calculation of a realised overlap index. However, using data on predator distribution and density at sea requires that such data be collected in a standardised fashion using recommended procedures (e.g. taking account of biases caused by moving animals, species-specific detectability, etc.) and that they be analysed taking account of biases due to local aggregation effects, travelling as opposed to foraging or feeding, temporal patterns of foraging/diving, etc.

43. For the time being, the CPD index (describing potential overlap) should continue to be calculated according to the methods described in WG-EMM-95/41, and the approach of Agnew and Phegan (1995) towards the calculation of a realised overlap index should be re-assessed for presentation to WG-EMM. Modifications of these calculations will be undertaken when the requested data are available and the appropriate spatial and temporal scales have been determined.

Harvested Species Indices

44. Indices of harvested species are essential for both the interpretation of predator indices and the development of WG-EMM's conceptual model of the Antarctic ecosystem. The group identified a number of indices which could be calculated from existing datasets or data which will become available in the near future (Table 4).

45. It is essential that this part of the ecosystem monitoring system be developed as soon as possible to complement the existing indices of predators and the development of environmental indices. It is strongly suggested that investigations of the feasibility of calculating these indices, the availability of data, and the applicability of the indices to the objectives of WG-EMM be initiated as soon as possible, and that interim results be presented to WG-EMM in 1996.

46. It was recognised that krill flux could potentially complicate the interpretation of many of these indices. The spatial scale of an index should be set sufficiently large that, assuming the turnover rates calculated by the Workshop on Evaluating Krill Flux Factors (SC-CAMLR-XIII, Annex 5, Appendix D), the biomass of krill subject to flux across the boundaries of an area should be negligible, compared with the total stock within the area, over the time scale over which the data are collected.

Environmental Parameters Influencing Harvested Species

47. A number of indices of sea-ice distribution are currently being calculated by the Secretariat (WG-EMM-95/41), and a correspondence group convened by Dr D. Miller (South Africa) is studying the indices and other aspects of the interaction of sea-ice with other components of the Antarctic ecosystem. The subgroup made no further comment about this parameter.

48. Data are currently available for a number of additional environmental parameters which may be important in determining the state of the marine environment, and which could influence harvested species distribution and abundance. These are:

(i) the presence/position of frontal zones;
(ii) sea-surface temperature (SST); and
(iii) shelf surface water flow (ADCP measurements).

Table 4: Suggested harvested species indices.

Aim: To Determine...	Index	Data Source and Availability	Scale	Description
Large-scale harvested species population trends	CPUE by area	Commercial [Statlant B data (subarea resolution) is available now]	Subarea Season (summer only)	Calculate catch/hour and catch/day at the subarea level by fleet, or for a standardised fleet/vessel established by GLM analysis. Different CPUE indices are likely to respond differently depending on area/fleet. For instance, catch/day is likely to be appropriate for the Japanese fleet in the Indian Ocean sector where a considerable searching effort is required, but catch per hour is more likely to reflect swarm density in the Atlantic Ocean sector where searching is not usually necessary. However, in view of the lack of confluence between fishing areas and CEMP sites in the Indian Ocean sector, it is suggested that effort be put into developing this index for the Atlantic Ocean sector for the time being.
Large-scale harvested species distribution	Relative catch or CPUE distribution between defined areas	Commercial [fine-scale catch data available now. Fine-scale CPUE data present for some fleets now]	Subarea Season	Within a subarea, assume that fleets operate as a single unit. Assume also that within subareas, favoured fishing areas identified through experience are preferentially targetted, but that the fleets will move between favoured areas depending on catch rates in those areas. For instance, in Subarea 48.1 the Japanese fleet preferentially targets the Livingston Island fishing area, unless it finds that the Elephant Island area is particularly profitable. The fleet is then acting as a selective predator and its distribution will reflect the distribution of harvested species. An index of this distribution might be calculated by choosing two or more known fishing areas and calculating the ratio of catches between these areas over the season being considered.
Local abundance	Mean krill density from a number of surveys	Research [local acoustic surveys]	100 x 100 n mile scale areas, for specific months	Local krill surveys have shown that krill distribution and abundance may be highly variable in space and time. A number of surveys of a restricted area are therefore required in a restricted time interval, for instance six weeks in January/February each year.
Local distribution	Local krill density relative to colonies	“	“	A number of measures of krill distribution could be used: for instance, the distance between predator colonies and the centroid of krill density; minimum and maximum distances from a site to krill densities of a defined size; changes in krill density spectral analyses. This index needs considerable research.
Local vertical distribution	Depth of krill swarms	“	“	Calculate maximum and minimum depth of high densities of krill, or the proportion of krill within depth strata (for example the depth of the mixed layer) and by time of day.
Population abundance	Krill density by subarea/region	Research [synoptic acoustic surveys]	Subarea or other large region	A synoptic survey every year is clearly impractical. However, a survey at intervals of several years is essential for calibrating other indices of population density, and for determining long-term trends in krill abundance.
Demography	Recruitment proportion	Research [net hauls]	Subarea or other large region	Methods for estimating recruitment proportion (R_1) are being developed by a number of researchers (see for instance de la Mare (1994) and Siegel and Loeb (1995)).
Demography	Commercial length composition	Commercial [net hauls]	Regional	Kawaguchi and Satake (1994) have previously shown that trends in the length composition of the commercial catch can be correlated with environmental parameters. Commercial length composition data should be separated by region where major biogeographical differences are known to exist – for instance, in Subarea 48.1 small animals are found inshore and large animals offshore, so separation into inshore and offshore components is necessary.

Wind stress, sea-surface roughness and geopotential anomaly are other variables for which information is available from satellites, but these are considered to be of secondary importance for the present exercise.

49. From these data one could construct two indices:

(i) SST anomaly, measured at positions of relevance to CEMP sites, for each month of the breeding season; and

(ii) water flux (transport), measured in January/February, in a number of fine-scale squares close to CEMP sites.

50. The former of these can be calculated using freely available data, and should be attempted by the Secretariat prior to WG-EMM in 1996. The latter will only be available through the design of standard monitoring areas by research organisations. Members are encouraged to investigate the development of standard methods for monitoring this parameter.

Environmental Parameters Influencing Dependent Species

51. A number of methods for monitoring sea-ice as viewed from the CEMP site, as well as local weather conditions and snow cover at a CEMP site have already been defined by CCAMLR (Methods F1, F3 and F4). Although data are being collected by Members, none are currently submitted and this precludes the calculation of indices for these parameters. It was strongly recommended that standard formats for submitting these data be developed by WG-EMM and that Members be encouraged to submit the data in time series that are comparable to the predator data already available. Recording extraordinary environmental conditions should also be encouraged as noted in paragraphs 33 to 35.

52. It is recommended that attempts be made to develop methods for calculating the complete suite of environmental indices which have now been defined, that is:

(i) sea-ice indices
  (a) number of ice-free days
  (b) distance from CEMP site to sea-ice edge;

(ii) marine indices
  (a) SST anomaly

(b) water flux; and

(iii) terrestrial indices
   (a) sea-ice viewed from the CEMP site
   (b) local weather (e.g. temperature, wind-speed anomalies by month)
   (c) snow cover.

PRESENTATION

53. WG-EMM had requested the Secretariat to develop a mechanism for representing index status and trend data quantitatively to replace the current qualitative tabulations in SC-CAMLR-XIV, Annex 4, Table 3. WG-EMM-Stats-96/7 suggested a method for these displays in which a standardised normal variate ($z = (x - \bar{x})/sd$) was calculated for each index. Additional tabulations were made of a qualitative presentation of these data and the original indices.

54. The subgroup considered this to be a useful first step in the transition from a qualitative to a quantitative analysis of the indices. However, concerns were expressed that the dimensionless standardised series masked important information contained in the indices, both because the indices were not necessarily normally distributed (see paragraph 8) and because the magnitude of the indices themselves may be important. There was also some concern that the standardised series would change each year as the time series from which the means and standard deviations were calculated increased in length.

55. The first of these concerns would be addressed by the following transformations prior to calculation of the standardised normal variate:

(i) normally distributed data: no transformation;

(ii) proportions: log-odds transformation;

(iii) foraging distribution: log transformation (pending further investigation); and

(iv) population size: yearly changes, expressed as differences between logs of the colony counts in adjacent years, may be normally distributed, but this should be investigated further.

These transformations should be displayed along with each index in the Secretariat's report of CEMP indices.

56. The second and third points of concern would be addressed if the standardised series was presented graphically, as a guide to the interpretation of anomalies and trends in the indices, rather than as numbers which could be used for further analysis. It would then be understood that further investigative analysis should use the original indices and not the standardised series.

57. The subgroup also considered the problem of the presentation of trends by WG-EMM in its report. It is clear from the analyses presented in WG-EMM-Stats-96/7 that the subjective, qualitative display currently employed (SC-CAMLR-XIV, Annex 4, Table 3) can be misleading. The current display, by site, species, method and year is also rather complex to interpret. A more useful output from WG-EMM might be a summary of the anomalies and trends by site, species and year (i.e. an ecosystem assessment following quantitative analysis of all indices for a particular site and species).

58. The following suggestion is made for a structured approach by which WG-EMM might analyse the indices:

(i) examination of a document presenting anomalies and trends by site and species, to be prepared by the Secretariat;

(ii) perform a systematic analysis of the indices, by area, site and species. This should proceed by iterations of:

(a) examination of a graphical display of standardised series (as in WG-EMM-Stats-96/7) to identify general trends and associations between parameters and species. An associated qualitative display of these anomalies, and table of index values will be provided for reference;

(b) further detailed analysis of features indicated by the standardised series, through examination of the actual indices and figures given in presentations similar to those in WG-EMM-95/13 and 95/14; and

(iii) modification, as necessary, of the document described in (i) above presenting anomalies and trends by site and species. This document should then act as the basis for presentation within the report of WG-EMM.

59. It was recognised that step (ii) would require a considerable amount of analysis by the working group. This would be facilitated if the data and software necessary for the calculation of the indices was made available to Members in the intersessional period. It was recognised that data would be available under the normal CCAMLR data access rules, but that only software written in the software package being used by the Secretariat could be provided. This is currently MS Access.

60. The mechanism described above would act to assist the transfer of information from the Secretariat to WG-EMM and from WG-EMM to the Scientific Committee. However, it will require a considerable amount of work by the Secretariat, and may take several years to develop. The three levels of analysis required of the Secretariat are: indices and figures as in WG-EMM-95/13 and 95/14; standardised series figures, qualitative change and tabulations of source indices as in WG-EMM-Stats-96/7; and a summary of significant anomalies and trends.

CLOSE OF THE MEETING

61. The report was adopted. In closing the meeting the Convener thanked the British Antarctic Survey for hosting the meeting. He also thanked all participants for their enthusiasm and contributions to a meeting whose results should significantly advance the work of CCAMLR, and WG-EMM, towards a quantitative ecosystem assessment.

REFERENCES

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ATTACHMENT A

AGENDA

Subgroup on Statistics
(Cambridge, UK, 7 to 9 May 1996)

1. Introduction
   (i) Opening of the Meeting
   (ii) Organisation of the Meeting and Adoption of the Agenda

2. Calculations of Indices of Dependent Species Parameters
   (i) Review progress with all tasks assigned to the Secretariat at WG-EMM (SC-CAMLR-XIV, Annex 4, paragraphs 5.69 to 5.76)
   (ii) Develop methods for the incorporation of empty stomach data in diet indices (This task was allocated to the Subgroup on Monitoring Methods (SC-CAMLR-XIV, Annex 4, paragraph 5.27) but it more appropriately fits within the expertise of the Subgroup on Statistics)
   (iii) Develop methods of highlighting anomalous years, where the reason for the anomaly is known and, if necessary, excluding them from trend analyses (SC-CAMLR-XIV, Annex 4, paragraph 5.83)

3. Extension of Indices to Cover Harvested Species and Environmental Parameters
   (i) Provide a critical re-examination of the concept of the CPD index (SC-CAMLR-XIV, Annex 4, paragraphs 5.92 to 5.96)
   (ii) Develop satisfactory indices for harvested species and environmental data (SC-CAMLR-XIV, Annex 4, paragraphs 7.89 and 7.95)

4. Presentation
   (i) Develop a mechanism for representing index status and trend data quantitatively to replace Table 3 (by, for instance, deviations, in SD units, from a short- or long-term mean). This needs to be addressed for predator, harvested species and environmental indices (SC-CAMLR-XIV, Annex 4, section 8)

5. Advice to WG-EMM

6. Close of the Meeting.

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Subgroup on Statistics
(Cambridge, UK, 7 to 9 May 1996)

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ATTACHMENT C

LIST OF DOCUMENTS

Subgroup on Statistics
(Cambridge, UK, 7 to 9 May 1996)

WG-EMM-Stats-96/1	PRELIMINARY AGENDA FOR THE 1996 MEETING OF THE WG-EMM SUBGROUP ON STATISTICS
WG-EMM-Stats-96/2	LIST OF PARTICIPANTS
WG-EMM-Stats-96/3	LIST OF DOCUMENTS
WG-EMM-Stats-96/4	BACKGROUND INFORMATION FOR THE SUBGROUP ON STATISTICS MEETING, CAMBRIDGE, 7–9 MAY 1996 Secretariat
WG-EMM-Stats-96/5	DATA REQUIREMENTS FOR METHOD A5 D.J. Agnew (Secretariat)
WG-EMM-Stats-96/6	A FINE-SCALE MODEL OF THE OVERLAP BETWEEN PENGUIN FORAGING DEMANDS AND THE KRILL FISHERY IN THE SOUTH SHETLAND ISLANDS AND ANTARCTIC PENINSULA D.J. Agnew and G. Phegan (Secretariat)
WG-EMM-Stats-96/7	CALCULATION OF A STANDARDISED INDEX ANOMALY D.J. Agnew (Secretariat)

OTHER DOCUMENTS

WG-EMM-95/10	DEVELOPMENTS IN THE CALCULATION OF CEMP INDICES 1995 Data Manager
WG-EMM-95/11	CALCULATION OF INDICES OF SEA-ICE CONCENTRATION USING DIGITAL IMAGES FROM THE NATIONAL SNOW AND ICE DATA CENTRE D.J. Agnew (Secretariat)
WG-EMM-95/12 Rev. 1	INDEX PART 1: INTRODUCTION TO THE CEMP INDICES 1995 Data Manager

WG-EMM-95/13 Rev. 1	INDEX PART 2: CEMP INDICES: TABLES OF RESULTS 1995 Data Manager
WG-EMM-95/14 Rev. 1	INDEX PART 3: CEMP INDICES: FIGURES 1995 Data Manager
WG-EMM-95/32	STOMACH FLUSHING OF ADELIE PENGUINS (CEMP METHOD A8) Judy Clarke (Australia)
WG-EMM-95/41	KRILL CATCH WITHIN 100 KM OF PREDATOR COLONIES FROM DECEMBER TO MARCH (THE CRITICAL PERIOD-DISTANCE) Data Manager
WG-EMM-95/46	DRAFT: DIFFERENCES IN THE FORAGING STRATEGIES OF MALE AND FEMALE ADELIE PENGUINS Judy Clarke and Knowles Kerry (Australia) and Enrica Franchi (Italy)

ATTACHMENT D

CRITICAL VALUES FOR RANDOM NORMAL TIME SERIES

Suppose that a yearly time series consists of random independent values X_1, X_2, ..., X_n from a normal distribution with mean μ, standard deviation σ. Let the mean and variance of the observations be denoted by $M = X_i/n$ and $s^2 = (X_i - M)^2/(n - 1)$. Then the statistics

$$Z_i = (X_i - M)/s, \qquad (1)$$

$i = 1, 2, ..., n$ will have the same distribution for all values of μ and σ, but this distribution will depend upon the series length n.

To detect unusual years it is possible to compute the absolute values Z_i, $i = 1, 2, ... n$, and see which of these, if any, is 'significantly' large. To determine whether Z_i is significantly large it can be compared with the value that is only exceeded for (say) 5% of time series by chance. This allows one or more of the years in a series to be defined as being unusual.

A procedure for determining the critical value for Z_i is as follows for a series of length n:

(a) simulate n values X_1, X_2, ..., X_n from a standard normal distribution with $\mu = 0$ and $\sigma = 1$.

(b) convert the X_i values to Z_i values using equation (1).

(c) find $Z_{max} = \text{Max}\{ Z_1, Z_2, ... Z_n \}$, the maximum of the absolute Z values.

(d) repeat (a) to (c) many times to determine the distribution of Z_{max}.

(e) choose the critical value for Z to be the value that is exceeded for 5% of the series.

The critical value obtained in this way controls for the multiple testing that is inherent in considering n values of Z for each series because if the time series being considered does consist of random values from a normal distribution then the probability of declaring one or more years to be significant is only 0.05. The critical values for this procedure are shown in Table 1 of the main text.

REPORT OF THE SUBGROUP ON MONITORING METHODS

(Bergen, Norway, 8 to 10 August 1996)

REPORT OF THE SUBGROUP ON MONITORING METHODS

(Bergen, Norway, 8 to 10 August 1996)

INTRODUCTION

The Subgroup on Monitoring Methods held its meeting from 8 to 10 August 1996 in Bergen, Norway, immediately before the meeting of WG-EMM. The meeting was convened by Dr K. Kerry (Australia).

2. The agenda of the meeting comprised all the tasks referred to the subgroup by WG-EMM in 1995 (SC-CAMLR-XIV, Annex 4, paragraphs 5.19, 5.24, 5.26, 5.27, 5.29 to 5.32, 5.39, 5.41, 5.42, 5.44, 5.48, 5.51 and 5.53). The agenda adopted by the subgroup, the list of participants and the list of papers considered at the meeting are appended to this report as Attachments A, B and C respectively.

3. Dr E. Sabourenkov (Secretariat) was rapporteur. Additional sections were prepared by Drs D. Miller (South Africa) and W. Trivelpiece (USA).

REVIEW OF NEW METHODS AND TECHNIQUES

4. Drafts of several new methods (WG-EMM-Methods-96/4 to 96/7, 96/13 and 96/14) as well as sampling techniques were developed during the intersessional period and submitted for examination by the subgroup. These drafts were also submitted to SCAR for consideration by SCAR-BBS (WG-EMM-Methods-96/12). The subgroup noted with thanks the comments of SCAR-BBS. It was noted that the SCAR-BBS received the drafts late in July and had not had sufficient time to circulate them among its members. However, the Subcommittee's comments were taken into account, as appropriate, throughout the subgroup's discussions. Matters raised in the report of the intersessional meeting of WG-EMM's Subgroup on Statistics (Appendix H) and excerpts from the report of the meeting of SCAR-GSS (SC-CAMLR-XV/BG/10) were also taken into consideration by the subgroup.

5. It was agreed that when only minor amendments and editorial changes were required to draft standard methods, these drafts would be revised accordingly and recommended for publication in *CEMP Standard Methods*. In cases where drafts required an extensive revision, the subgroup identified those points which needed to be taken into account in the revision as well as scientists whose assistance would be required for revision(s) during the forthcoming intersessional period.

6. In its review of methods, the subgroup considered the development of procedures to examine the suitability of monitoring methods to meet CEMP objectives. Where appropriate these deliberations are incorporated into the relevant sections of this report. However, the subgroup was unable to establish a framework for a comprehensive review of existing methods and reiterated WG-EMM's call to develop this framework as a matter of urgency (SC-CAMLR-XIV, Annex 4, paragraph 4.42).

7. The comments and recommendations of the subgroup in respect of standard methods and techniques given in this report should be read in conjunction with original papers tabled at the meeting.

New Standard Methods

Attachment of Instruments

8. A technique for attaching external instruments, including TDRs and satellite tracking devices, to penguins and Antarctic fur seals was prepared by Dr I. Boyd (UK) at the request of WG-CEMP. It was agreed that this technique (WG-EMM-Methods-96/5) was practical, comprehensive and, with minor amendments, including those suggested by SCAR-BBS, should now be included as an appendix to the *CEMP Standard Methods*.

9. The subgroup recalled that a Workshop on Researcher-Seabird Interactions had been held in 1993 in Minnesota, USA, and noted that much useful information was contained in the subsequent report. Similarly, it was noted that the work of Dr R. Bannasch (1995) provided important information. Both reports contained theoretical and practical information to be considered when attaching instruments to birds and seals.

10. It was noted that the wrapping of instruments in electrical tape before they were glued onto an animal allowed subsequent removal with minimal damage to fur, hair or feathers. Where larger instruments are used, or where longer deployments (a month or more) are required, it may be necessary to glue unwrapped instruments directly onto an animal. The instruments are then removed by carefully cutting the feathers or pelage close to the instruments. Instruments not recovered in this way will fall off during moult. It was noted that some Members have carried out over 100 platform transmitter terminal (PTT) deployments of Adélie penguins using this method without any demonstrable adverse effects on the survival of the birds.

11. The subgroup noted that some of the fast-setting epoxy glues (e.g. Loctite 401) are exothermic when setting and that the structural strength of the feathers and thus their ability to hold the instrument may be compromised if too much heat is generated. Care should be exercised, therefore, to delay the attachment of the instrument to the feathers by a few seconds to allow some of the initial heat to dissipate.

12. The subgroup reiterated the requirement that instruments attached to penguins should be neutrally buoyant and that their total weight in air should be less that 5% of the bird's weight.

13. The subgroup noted that many scientists are tracking flighted birds, including CEMP-designated species. However, the techniques used for attaching instruments to flighted birds are different to those used on penguins and include the use of harnesses. The subgroup recommended that scientists with experience in attaching instruments to flying birds be asked to provide details of methods they have used and to develop recommendations for a CEMP standard method.

Data Collection Using TDRs

14. A detailed method for the collection of at-sea behaviour data using TDRs had been prepared by Dr Boyd (WG-EMM-Methods-96/5). It was noted that the deployment of these instruments was straightforward and that the method as presented was appropriate and in a form suitable for immediate use. In some instances, and for penguins in particular, where the duration of foraging trips is less than one day, it may be necessary to set the sampling rate for depth intervals at one second. This will use available electronic memory much faster and may require shorter deployment times or instruments (TDRs) with expanded memory. It was agreed that, with this addition, the standard method be adopted.

15. At its 1994 meeting, WG-CEMP began the process of developing indices of predator foraging performance based on at-sea behaviour for inclusion in the monitoring program (SC-CAMLR-XII, Annex 6, paragraphs 4.15 to 4.23). At its first meeting, WG-EMM approved the proposal to hold a workshop on the measurement of at-sea behaviour of krill predators (SC-CAMLR-XIV, Annex 4, paragraphs 5.29 to 5.32).

16. The subgroup strongly supported the proposal for the workshop to examine the methods for analysis and interpretation of TDR data and the development of indices of predator foraging performance and requested WG-EMM to support the holding of such a workshop in the first half of 1997.

Methods for Monitoring Petrels

17. The subgroup considered the proposed methods for dietary studies of the Cape petrel (WG-EMM-Methods-96/4), for monitoring the population size and breeding success of the Antarctic petrel (WG-EMM-Methods-96/14) and describing a lavage technique for sampling diets of Procellariiformes (WG-EMM-Methods-96/6).

Chick Diet – Cape and Antarctic Petrel

18. The subgroup welcomed the draft method developed by Drs N. Coria, G. Soave and D. Montalti (Argentina) for dietary studies of the Cape petrel (WG-EMM-Methods-96/4). It was noted that the method was based largely on Method A8, which had been developed for penguins. Because of similarities between the Cape petrel and the Antarctic petrel, it was agreed that both species could be investigated using the same procedure.

19. It was agreed that the monitoring method should be based on the collection of food from parent birds and not from chick regurgitations. Adults should be caught beside their nest to ensure that they are, in fact, breeding.

20. The question of whether seawater, fresh water or water of intermediate salinity should be used for flushing petrels (and also penguins) was discussed. Although both fresh and seawater have been used, there are insufficient data to determine the relative value or effect of either. It was agreed that until appropriate investigations have been carried out, scientists could use either, but they must note which had been used when reporting the data to CCAMLR. It was emphasised that water used for stomach flushing should be warmed. Where possible, the recovery of birds after flushing should be monitored.

21. Several problems have been encountered in preserving and analysing food items. These problems were generic and concerned samples obtained from all bird species. They were therefore considered along with a more detailed examination of parameter A8 (paragraphs 62, 63 and 66 to 69).

22. The method was revised in light of the above discussions and it was agreed that it is suitable for publication as a CEMP standard method. The revised text is given in WG-EMM-96/53.

Antarctic Petrel

23. Draft methods prepared by Dr F. Mehlum (Norway) and Dr J. van Franeker (Netherlands) for the determination of breeding population size and adult survival rate were presented in WG-EMM-95/86 and WG-EMM-Methods-96/14. The latter paper included the comments received from SCAR-BBS (WG-EMM-Methods-96/12). The subgroup expressed its thanks to the authors for the considerable effort in preparing the documents.

Breeding Population Size

24. It was agreed that the proposed method was appropriate but that further drafting was required to take account of the following points before finalisation as a standard method.

(i) Following courtship, Antarctic petrels undertake a pre-laying exodus and are away from the colony for a few days. The recording of nests and eggs should commence immediately the birds return to lay.

(ii) Colonies of Antarctic petrels vary enormously in size from a few nests to colonies in excess of 100 000. Different methods of counting birds (including photographic surveys) are therefore required.

(iii) The list of 'Mandatory Data' should include only those data which are to be used in the calculation of CEMP indices. All supplementary data recorded during observation should be included in the data recording forms developed for this purpose.

(iv) If observations do not take place at a standard time each day, then they should be made each day at a random time over the 24-hour period, and the time of these observations recorded. Later analysis will show whether any bias is introduced by sampling at a particular time of day.

(v) Consideration should be given to determining the applicability of this method to Cape petrels.

Adult Survival Rate

25. This method was drafted originally to monitor both annual survival and recruitment (WG-EMM-Methods-96/14). The subgroup, however, felt that for large and dense colonies it would be

difficult to determine recruitment because it would be virtually impossible to find all the banded birds and also because birds often do not return to breed in their natal colony. Once adults commence breeding, they apparently return each season to the same nest. It was agreed, therefore, that a new parameter of 'adult annual survival' be adopted and that the text of the method be rewritten accordingly.

26. A detailed procedure for the establishment of sampling plots for large colonies was prepared by Dr S.-H. Lorentsen (Norway). This procedure was adopted for inclusion as an appendix to the *CEMP Standard Methods*.

Stomach Lavage for Procellariiformes

27. A paper on the use of stomach lavage techniques to sample diets of Procellariiformes was prepared by Dr R. Veit (USA) (WG-EMM-Methods-96/6) at the request of WG-CEMP. The subgroup welcomed this paper, which gives a useful background for the use of this sampling technique. The paper primarily addressed the sampling of birds caught at sea and did not relate directly to the determination of chick diet. The information contained in the paper was considered in the development of methods for the collection of food samples from petrels (paragraphs 18 to 22).

28. The subgroup noted that for species of birds which are of special conservation concern, stomach lavage would be the most appropriate procedure because it does not involve killing birds.

29. It was emphasised that in sampling stomach contents multiple flushing is necessary unless no food items were obtained in the first flush.

Breeding Chronology – Antarctic and Cape Petrels

30. The subgroup recommended that a method for breeding chronology similar to Method A9 should be developed for petrels.

Effects of Diseases and Pollutants

31. At last year's meeting of WG-EMM, it was noted that the outbreak of disease or presence of pollutants may mask the effects on monitored parameters of food availability or changes in the environment. Therefore, it was agreed that protocols should be developed for the collection and

preservation of samples taken from birds in the field for later pathological and/or toxicological analysis (SC-CAMLR-XIV, Annex 4, paragraphs 5.46 to 5.51).

32. Papers submitted to the subgroup dealt with protocols for collecting samples for both toxicological (WG-EMM-Methods-96/7) and pathological analysis (WG-EMM-Methods-96/13). The latter document was submitted as an extension of WG-EMM-Methods-95/44.

33. The subgroup made some editorial changes to the protocol for collecting samples for toxicological analysis and recommended that the protocol should be published as an annex to *CEMP Standard Methods*. Note was taken that samples could only be analysed in specialised laboratories and that such analyses were very expensive. Contamination of collected samples is possible if the wrong sort of containers are used and so care should be taken to have the correct containers on hand in the field.

34. The subgroup noted that the instructions for the collection of diagnostic samples if and when an outbreak of disease or a parasite infestation is observed in a seabird colony (WG-EMM-95/44) had been available to Members and that comments were to be forwarded to Dr Kerry for inclusion in a revised document (SC-CAMLR-XIV, Annex 4, paragraphs 5.46 to 5.48). No comments were received, so the document was revised by Dr H. Gardner (Australia) in the light of experience gained by a number of veterinarians and other scientists working on the Australian CEMP program. The revised document was tabled as part of WG-EMM-Methods-96/13. The subgroup thanked Dr Gardner for its preparation.

35. The subgroup agreed that the revised instructions provided an excellent approach to the examination of birds for disease and the collection of samples for diagnostic investigations. They could be used immediately if required. The subgroup felt, however, that it did not have sufficient expertise to thoroughly evaluate the content of the protocol and recommended that time be given for examination by other veterinarians. Due to the important nature of the document and the fact that scientists may need to collect specimens in the field this season, it is requested that Members forward comments to the Secretariat before the 1996 meeting of the Scientific Committee. Dr Gardner will then be asked to revise the text, which in turn should be forwarded to those undertaking field programs. Inclusion as an appendix to the *CEMP Standard Methods* would then follow.

36. The subgroup requested that diagrams or colour photographs should be included in the protocol to aid dissection and identification of organs and tissues to be sampled. Dr Kerry agreed to consult with Dr Gardner on the provision of such illustrative material.

37. The recommendation of WG-EMM was reiterated that upon publication of the protocol, scientists conducting field studies should consult with a veterinary pathologist before going into the field, to ensure that, if needed, urgent analysis of samples is possible and any specialised sampling requirements can be accommodated (SC-CAMLR-XIV, Annex 4, paragraph 5.49). It was recommended that scientists make contact with appropriate laboratories before going into the field to ensure analyses can be undertaken if necessary and that collection techniques appropriate to that laboratory are used.

Other Methods

Marking of Birds for Long-term Studies

38. Many of the CEMP parameters require that penguins be permanently marked for identification. Banding has been generally used to do this. There is, however, increasing evidence that flipper bands may be lost or that they may injure individuals of some penguin species (see for example WG-EMM-Methods-96/8). Alternative methods are now being sought. It was noted that a workshop on alternative marking techniques had been held recently in conjunction with the meeting of SCAR-BBS, but unfortunately the report of this workshop was not available to the subgroup.

39. The use of implanted electronic tags is increasing as an alternative to bands. These tags have the advantage of permitting automated identification and monitoring. A study on the use of implanted identification tags in penguins was submitted for consideration at the meeting (WG-EMM-Methods-96/8). The paper had been sent earlier to SCAR-BBS as a contribution to its workshop (see paragraph 38 above).

40. The subgroup agreed that for some applications the use of implanted tags makes monitoring easier and helps avoid the multiple handling of birds. Currently, tags are implanted in Adélie penguins under the skin of the neck and care should be taken not to implant into muscle tissue. Introduction of bacteria during tag implantations has the potential to lead to chronic localised infections and the development of recurrent acute infections or disseminated foci of persistent infection, following detachment, of bacteria from the initial site and dispersion via the bloodstream. Detailed information is contained in WG-EMM-Methods-96/8.

41. It was also noted that implanted tags may migrate away from the original injection site. The subgroup recommended that studies be conducted as soon as possible on the prevalence of tag

migration. The use of X-ray examination for such studies is preferable to killing the bird for dissection.

42. The subgroup recommended that since the use of implanted tags is increasing in CEMP monitoring studies, protocols for their use should be developed and published in *CEMP Standard Methods*. Dr Kerry agreed to draft these methods in conjunction with Dr J. Clarke (Australia).

Crabeater Seals

43. The subgroup reviewed an extract from the report of the August 1996 meeting of SCAR-GSS (SC-CAMLR-XV/BG/10) presented by Dr T. Øritsland (Norway) on behalf of SCAR-GSS. It was noted that SC-CAMLR had requested the assistance of SCAR-GSS in the drafting of standard methods for the monitoring of crabeater seals.

44. SCAR-GSS had advised that its APIS program should provide much new information on circumpolar population numbers and that standard methods for surveying crabeater seals should become available in 1997. Further, ancillary information on the ecology of crabeater seals is also likely to arise from APIS fieldwork. The subgroup noted that SC-CAMLR had supported the development of APIS (SC-CAMLR-XIII, paragraphs 9.2 to 9.9).

45. The subgroup drew WG-EMM's attention to the advice of SCAR-GSS that, given the difficulties of working in the pack-ice and the general paucity of knowledge on crabeater seals, it is too soon to determine which, if any, data are relevant for CEMP purposes. SCAR-GSS also advised that the development of appropriate monitoring methods and indices for crabeater seals is only likely to be possible when APIS is completed in 2000.

46. The subgroup, therefore, recommended that members with experience in working on crabeater seals should continue towards developing monitoring indices for this species. Furthermore, WG-EMM should encourage the maintenance of close contact with, and support for, APIS in the interests of developing monitoring methods and indices for crabeater seals.

REVIEW OF EXISTING METHODS AND TECHNIQUES

47. The subgroup discussed the existing standard methods and suggested the following changes, additions and/or comments.

Method A1 – Adult Weight on Arrival at Breeding Colony

48. There were no suggested changes to this method.

49. The subgroup noted that very few scientists were able to be in the field in time to observe the first arrival of birds at the breeding colony. Last year, a possible new method was suggested which may help to assess the variability in early-season breeding condition among Adélie penguins (SC-CAMLR-XIV, Annex 4, paragraph 5.16). This method involves comparing interannual variability in weights of adults and first eggs at peak egg laying, using nests with two adults present but at the stage at which only the first egg had been laid.

50. Dr Trivelpiece reported that this method looks promising, although additional years of data are needed before a judgment can be made. There were significant differences between years in the weights of male and female Adélie penguins and in the weights of the eggs. However, not all of these years also had data on the length of time between arrival and egg laying, making it impossible to determine whether these differences reflected differences in actual arrival condition or in the length of the courtship fasting period. This study is continuing and results will be presented when available.

Method A2 – Duration of First Incubation Shift

51. The subgroup suggested the following changes to the data collection and analysis methods of this parameter:

Data Collection: General Procedure

1. Select 100 pairs prior to the beginning of the egg-laying period. Note: these can be the same birds as used to determine breeding success by Procedure B.

2. Band or mark (with dye) both pair members, capturing (marking) them close to egg laying to minimise the possibility of the birds deserting.

3. Check nests daily, note dates of relief. When both birds are present at the nest during a nest check, each receives a half-day credit for that day.

4. Continue monitoring nests daily until the chicks hatch <u>and</u> both members of the pair are seen, indicating they are both still alive.

Analytical Methods

1. For analysis purposes, use only pairs which laid two eggs and successfully hatched both chicks (note: this will minimise differences in age/experience among the sample nests between years).

2. For each nest, day 0 equals the date of clutch completion.

3. Calculate the duration of the first incubation shift for males and females.

4. Calculate total number of days spent by males and females on the nest throughout the incubation period.

5. Determine the total number of reliefs at the nest during the incubation period.

6. Note the dates and causes of nest failures.

Interpretation of Results

Add paragraph 2:
Analysis of incubation shift durations within and among sites indicates that incubation shifts at specific sites are fairly constant year-to-year while significant differences exist between different sites (Trivelpiece, ms in prep.). Adélie penguins may be returning to areas of known productivity during their first long incubation shifts (WG–EMM-96/58), hence the fairly consistent, year-to-year, duration of shifts at each site. Differences between sites may reflect differences in travel time needed to reach productive areas in the early spring from different breeding locations.

Method A5 – Duration of Foraging Trips

52. Highly Desirable Data

Add paragraph 2:
The number of chicks a pair is feeding should be recorded as it may influence the foraging behaviour (and diet) of the adults.

Interpretation of Results

Add paragraph 3:

Interannual differences in foraging trip durations from sites adjacent to broad-shelf regions may reflect differences in krill distribution, not availability or biomass *per se*. For example, long trips by Adélie penguins at Anvers Island occur in conjunction with the dominance of large size classes in the krill population, short foraging trips correlate with the dominance of juvenile krill. Large krill are distributed at the shelf break where spawning occurs, small krill are found inshore. For sites such as Anvers Island where the shelf break is 120+ km distant, large interannual variability in foraging durations reflects differences in krill distribution and the distances Adélie penguins must travel to obtain food.

Additional Comments on Method A5

53. At the 1995 meeting of WG-EMM, evidence was presented that male and female Adélie penguins showed differences in foraging behaviour (SC-CAMLR-XIV, Annex 4, paragraph 5.17). These differences, as determined for Béchervaise Island and Edmonson Point, are set out in WG-EMM-Methods-96/11. Based on the above considerations, the subgroup agreed that it was essential that the foraging trip durations be recorded and analysed separately for males and females. Further, because Adélie penguins alternate variously short and long trips, it may be necessary to examine the foraging behaviour of individual birds; scientists undertaking CEMP studies should report the sequential foraging trips of individual birds. With this in mind, the subgroup noted the suggestions of the Secretariat contained in WG-EMM-Stats-95/6.

54. The subgroup noted that, in addition to radio frequency telemetry, there are now a number of methods available for determining foraging trip duration, including Automated Penguin Monitoring Systems, as used by Australia, and satellite tracking. It would be preferable to include descriptions of such automated means as an appendix to the *CEMP Standard Methods* and update them regularly.

Method A6 – Breeding Success

55. Last year, WG-EMM suggested that Procedure C does not reflect breeding success but rather fledging success (chicks fledged per chick hatched) (SC-CAMLR-XIV, Annex 4, paragraph 5.20). In fact, Procedure C explicitly does include hatching, fledging and overall breeding success.

56. The subgroup noted that Procedure A was considerably less rigorous (and therefore potentially less useful) than Procedures B and C. It was therefore recommended that for new studies it should be mandatory to use either Procedure B or Procedure C. Editorial changes to the standard method should be made as necessary. This would be undertaken by the Secretariat prior to the forthcoming meeting of the Scientific Committee.

Method A7 – Chick Weight at Fledging

57. The subgroup suggested that the comments in Procedure A, paragraph 2, relating to banded birds would be more appropriate if included in a separate procedure. Therefore, the last sentence of paragraph 2 in the standard method should be deleted.

An outline of an additional procedure relating to obtaining chick weight at fledging for banded birds was proposed:

General Procedure – Procedure C:

Procedure C involves weighing chicks that are banded as part of ongoing demographic studies (Method A4).

1. Capture banded chicks which are on the beach and about to fledge. Weigh each chick (to nearest 10 to 50 g) and record its band number.

2. Make regular (1 to 2 times daily) visits to all beaches throughout the fledging period, continuing to capture and weigh banded chicks.

3. Attempt to capture 200 to 300 individuals per year.

Comments

Procedure C will provide a chronology of fledging dates each year and will allow later examination of the relationship between chick fledging weights and survival. See also comments in paragraph 69.

Method A8 – Chick Diet

58. The subgroup considered the SCAR proposal that General Procedure A of Method A8 should be redrafted as suggested in WG-EMM-Methods-96/12. In considering this proposal, the subgroup decided that the stomach flushing procedure represents a sample collection technique and as such it should be published as an appendix to the *CEMP Standard Methods*. The proposed text of the stomach flushing procedure was compared with the existing procedure contained in Appendix 7 in the *CEMP Standard Methods*. It was found that the SCAR and CEMP versions were very similar, and it was recommended that Appendix 7 be retained in its present form.

59. As a precautionary measure, it was recommended that the tube used for flushing the stomach should not be inserted deep into the stomach and generally should be stopped when it reaches the bird's oesophagus.

60. The subgroup suggested that if the procedure of taking the diet sample resulted in the bird's death, the bird should be retained for post mortem analysis. An example of the value of this was shown by the post mortem investigation of a little penguin (*Eudyptula minor*) described in WG-EMM-Methods-96/10.

61. It was noted that eyeball measurements could provide good estimates of the length of euphausiids and that some regression equations for this had already been published (e.g. Nemoto et al., 1984).

62. The subgroup recommended that diet samples comprising krill which may require long storage times should be first fixed in formalin (4–10%, 12 h) prior to being preserved in 70% alcohol.

63. WG-EMM had requested the Subgroup on Statistics to consider how data on empty stomachs should be incorporated into the calculation of indices (SC-CAMLR-XIV, Annex 4). WG-EMM noted that it was essential to determine if birds found with empty stomachs were breeders and suggested that the easiest way to report this information would be as a single figure on form A8 for the number of empty stomachs (Appendix H, paragraphs 21 and 22). The subgroup also recommended that whether or not birds with empty stomachs were found, the total number of birds sampled with food in their stomachs should still be five for each five-day period as required by General Procedure A.

64. The subgroup recommended that the following additional data should be recorded as part of Method A8 (chick diet):

(i) the sex of the sampled birds (see *CEMP Standard Methods*, Appendix 2); and

(ii) the number of chicks of each bird at the time of sampling.

The latter data could be obtained by either capturing the bird at its nest site instead of on the beach or by marking the bird following sampling and following it to the nest.

65. The subgroup noted the comments of the Scientific Committee (SC-CAMLR-XIV, Annex 4, paragraph 5.25) concerning the differences between the first and subsequent vomits (noted in WG-EMM-95/32). The subgroup recommended separating the fresh food fraction of the stomach content from the more digested fraction during collection by switching trays while lavaging the bird. This would make the subsequent analysis of the stomach content easier.

66. Differences in foraging patterns of males and females had recently been documented for Adélie penguins at Edmonson Point and Béchervaise Island (WG-EMM-Methods-96/11). It was recommended that diet samples collected in accordance with Method A8 should also be separately analysed by sex.

67. The subgroup recommended that comments relating to possible bias for species with individuals whose foraging trips may or may not include overnight periods at sea (WG-EMM-96/49 and 96/55) be added to the 'Problems to be Considered' section of the standard method.

68. The need to develop a standardised procedure for Method A8 which would enable a quantitative evaluation of the stomach content was discussed. Several approaches were considered, including evaluation: of the sample wet weight versus displacement volume, methods of removing excess water from the sample, and using a standard volume of water for each sample. The subgroup felt that the best way of dealing with the issue would be to convene a special workshop with participation of experts in sampling zooplankton.

Method A9 – Breeding Chronology

69. The proposed procedure for selecting a sample of nests (see also Method A6, Procedure B, 1) appears to be too restrictive. The procedure should be made more flexible to allow for differences in site conditions and colony size while maintaining the required sample size. The subgroup called for the preparation of modified text for consideration at the next meeting of WG-EMM.

Methods B1, B2 and B3 – Flying Birds

70. No expertise on the subject was available among the subgroup members present, therefore no comments were made with regard to these methods.

Method C1 – Duration of Cow Foraging/Attendance Cycles

71. The recommendation of the Subgroup on Statistics that the method should be amended to allow for reporting failures of animals with transmitters to complete their first six post-natal trips was adopted (Appendix H, paragraph 29).

Method C2 – Pup Growth

72. The subgroup felt that observations carried out in accordance with Procedure A might also be also used to collect information on mortality of pups, i.e. information on the survival of marked pups. However, it was noted that at many sites this would be very difficult, if not impossible, to achieve.

73. The comment of the Subgroup on Statistics that there might be a bias in Procedure B indices because it is impossible to identify pups weighed early in the season which will not survive to weaning, has raised an important point, also relevant to Method A7 (see Williams and Croxall, 1990). This might be also pertinent for penguin chicks (Method A7) and the matter should be investigated.

MONITORING OF ENVIRONMENTAL PARAMETERS

74. Standard methods for the monitoring of environmental parameters were adopted by WG-CEMP in 1990 (SC-CAMLR-IX, Annex 4, paragraph 120). Since these methods have not been developed to the same degree of detail as the predator methods, they are currently appended to the *CEMP Standard Methods*.

75. The above methods are preliminary and submission of the relevant data to CCAMLR is not yet required. The methods are allocated codes in accordance with the proposed CCAMLR nomenclature for CEMP standard methods and include:

F1 Sea-ice cover as viewed from the colony
F2 Sea-ice within the study region
F3 Local weather
F4 Snow cover in the colony.

76. The subgroup noted the comments by the Subgroup on Statistics dealing with the monitoring of environmental parameters influencing harvested species (Appendix H, paragraphs 47 to 50) and dependent species (Appendix H, paragraphs 51 and 52). In particular, the subgroup noted that significant environmental events (i.e. those which fall outside a continuous monitoring regime) are encountered and that these may directly affect monitored parameters. The subgroup agreed that these should be noted and reported to CCAMLR on the predator reporting forms. Accordingly, all forms should be amended to include an entry for 'unusual environmental conditions'.

77. The subgroup noted that the identification and recording of environmental parameters for monitoring purposes requires further development as a matter of priority. Such development needs to be encouraged through a series of workshops to identify essential parameters and to develop decision rules which may be used to select 'critical' parameters which exert demonstrable influences on monitored indices.

OTHER BUSINESS

78. The subgroup noted the discussions of the Subgroup on Statistics on the CPD index. This index is currently calculated as the krill catch within 100 km of predator colonies during the period December to March and is intended to indicate the degree of spatial overlap between the foraging area of the birds and the fishery. The subgroup agreed that this was a useful index, but noted that in some instances Adélie penguins regularly forage farther afield. The foraging range of the Adélie penguin varies with the stage in the breeding cycle and the sex of the bird. There is also increasing evidence to suggest that birds regularly travel to specific areas to forage and in any event to the edge of the continental shelf. With this in mind, the subgroup endorsed the recommendations of the Subgroup on Statistics (Appendix H, paragraphs 38 to 40).

79. The subgroup noted that the book *CEMP Standard Methods* would be improved by the addition of an introductory section which described the development of CEMP, its objectives and structure and explained the choice of monitored species and parameters. Such an introduction would be of particular value to scientists who are planning to commence field programs and to field staff.

80. Electronic submission (on disc, e-mail or other internet systems) is now being encouraged by the Secretariat, provided that the data conform to the structure of the CCAMLR databases. Members wishing to submit data electronically should contact the Secretariat to obtain a description of the format in which their data should be submitted.

SUMMARY ADVICE TO WG-EMM

81. (i) Drafts of standard methods recommended for inclusion in *CEMP Standard Methods* (paragraphs 8, 14, 22, 26, 33 and 34) and those which have been prepared but require further revision (paragraphs 24 and 25) are presented in WG-EMM-96/53.

(ii) The following new methods were recommended for development:

(a) breeding chronology of Antarctic and Cape petrels (paragraph 30);
(b) attachment of instruments to flying birds (paragraph 13); and
(c) marking of birds for long-term studies (paragraph 42).

(iii) Several amendments were proposed for existing standard methods (paragraphs 48 to 77).

(iv) An investigation should be carried out on the effect on birds of fresh- and sea-water used for stomach flushing (paragraph 20).

(v) The workshop on the analysis of TDR data and the development of indices of predator foraging performance should be held in the first half of 1997 (paragraph 16).

(vi) Close contact with and support of APIS should be continued in the interests of developing monitoring methods and indices for crabeater seals (paragraph 46).

(vii) A special workshop should be convened to develop a standardised procedure for a quantitative evaluation of the stomach content used for dietary studies (paragraph 68).

CLOSE OF THE MEETING

82. The report was adopted. In closing the meeting the Convener thanked the Institute of Marine Research in Bergen and Dr Øritsland for hosting the meeting. He also thanked all participants.

REFERENCES

Bannasch, R. 1995. Hydrodynamics of penguins: an experimental approach. In: Dann P., F.I. Norman and P.N. Reilly (Eds). *The Penguins: Ecology and Management*. Surrey-Beatty, Sydney: 141–176.

Nemoto, T., M. Okiyama and M. Takahashi. 1984. Squid in food chains of the Antarctic marine ecosystem. *Memoirs of the National Institute of Polar Research*, Tokyo, Special Issue 32: 89–92.

Williams, T.D. and J.P. Croxall. 1990. Is chick fledging weight a good index of food availability in seabird populations? *Oikos*, 59: 414–416.

ATTACHMENT A

AGENDA

Subgroup on Monitoring Methods
(Bergen, Norway, 8 to 10 August 1996)

1. Introduction

2. Review of New Methods
   (i) Attachment of Instruments
   (ii) Petrels
   (iii) Diseases and Pollutants
   (iv) Other Methods

3. Amendments to Old Methods

4. Comprehensive Review of Methods

5. Advice to WG-EMM and Future Work

6. Close of Meeting.

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(Bergen, Norway, 8 to 10 August 1996)

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LIST OF DOCUMENTS

Subgroup on Monitoring Methods
(Bergen, Norway, 8 to 10 August 1996)

WG-EMM-Methods-96/1	PROVISIONAL AGENDA FOR THE 1996 MEETING OF THE WG-EMM SUBGROUP ON METHODS
WG-EMM-Methods-96/2	LIST OF PARTICIPANTS
WG-EMM-Methods-96/3	LIST OF DOCUMENTS
WG-EMM-Methods-96/4	A METHODOLOGICAL PROPOSAL TO DIET STUDIES OF THE CAPE PETREL, *DAPTION CAPENSE* N.R. Coria, G.E. Soave and D. Montalti (Argentina)
WG-EMM-Methods-96/5	DRAFT STANDARD METHODS FOR ATTACHMENT OF INSTRUMENTS AND THE COLLECTION OF DATA ABOUT AT-SEA BEHAVIOUR I.L. Boyd (UK)
WG-EMM-Methods-96/6	USING STOMACH LAVAGE TO SAMPLE DIETS OF PROCELLARIIFORMES R. Veit (USA)
WG-EMM-Methods-96/7 Rev. 1	PROTOCOLS FOR COLLECTING SAMPLES FOR TOXICOLOGICAL ANALYSIS S. Focardi, S. Corsolini and E. Franchi (Italy)
WG-EMM-Methods-96/8	IMPLANTED IDENTIFICATION TAGS IN PENGUINS: IMPLANTATION METHODS, TAG RELIABILITY AND LONG-TERM EFFECTS (DRAFT VERSION) J. Clarke and K. Kerry (Australia)
WG-EMM-Methods-96/9	CCAMLR STANDARD METHOD A8: PROCEDURE A J. Clarke (Australia)
WG-EMM-Methods-96/10	POST MORTEM REPORT ON A LITTLE PENGUIN J. Clarke (Australia)
WG-EMM-Methods-96/11	GENDER DIFFERENCES IN ADELIE PENGUIN FORAGING TRIPS (CCAMLR STANDARD METHOD A5: DURATION OF FORAGING TRIPS) J. Clarke and K. Kerry (Australia)

WG-EMM-Methods-96/12	CEMP MONITORING METHODS: REPORT FROM THE SCAR BIRD BIOLOGY SUBCOMMITTEE TO THE CCAMLR WORKING GROUP ON ECOSYSTEM MONITORING AND MANAGEMENT (WG-EMM) SUBGROUP ON MONITORING METHODS SCAR Bird Biology Subcommittee
WG-EMM-Methods-96/13	PROTOCOLS FOR TAKING SAMPLES FOR PATHOLOGICAL ANALYSIS IN THE EVENT OF DISEASE BEING SUSPECTED AMONG MONITORING SPECIES K. Kerry (Australia)
WG-EMM-Methods-96/14	DRAFT STANDARD METHODS FOR FULMARINE PETRELS: A) ANTARCTIC PETREL *THALASSOICA ANTARCTICA* F. Mehlum (Norway) and J.A. van Franeker (Netherlands)

OTHER DOCUMENTS

WG-EMM-95/44	PROTOCOLS FOR TAKING SAMPLES FOR PATHOLOGICAL ANALYSIS IN THE EVENT OF DISEASE BEING SUSPECTED AMONG MONITORED SPECIES K.R. Kerry, J. Clarke, D. Opendorf (Australia) and J. Cooper (South Africa)
WG-EMM-95/46	DRAFT: DIFFERENCES IN THE FORAGING STRATEGIES OF MALE AND FEMALE ADELIE PENGUINS J. Clarke and K. Kerry (Australia) and E. Franchi (Italy)
WG-EMM-95/86	DRAFT STANDARD METHODS FOR FULMARINE PETRELS: A) ANTARCTIC PETREL F. Mehlum (Norway) and J. A. van Franeker (The Netherlands)
WG-EMM-STATS-96/5	DATA REQUIREMENTS FOR METHOD A5 D.J. Agnew (Secretariat)
WG-EMM-96/6	REPORT OF THE MEETING OF THE SUBGROUP ON STATISTICS (Cambridge, UK, 7 to 9 May 1996) (Attached to WG-EMM report as Appendix H)
SC-CAMLR-XV/BG/10	EXCERPTS FROM THE REPORT OF THE MEETING OF THE SCAR GROUP OF SPECIALISTS ON SEALS (CAMBRIDGE, UK, 1–2 AUGUST 1996)