APPENDIX H

REPORT OF THE SUBGROUP ON STATISTICS

(Cambridge, UK, 7 to 9 May 1996)

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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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Ichii, T., M. Naganobu and T. Ogishima. 1994. An assessment of the impact of the krill fishery on penguins in the South Shetlands. *CCAMLR Science*, 1: 107–128.

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Siegel, V. and V. Loeb. 1995. Recruitment of Antarctic krill *Euphausia superba* and possible causes for its variability. *Mar. Ecol. Prog. Ser.*, 123: 45–56.

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.

LIST OF PARTICIPANTS

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(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 $Z_{max} = \mathrm{Max}\{ Z_1, Z_2, ... Z_n \}$, 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.