ANNEX 4

REPORT OF THE WORKING GROUP ON ECOSYSTEM MONITORING AND MANAGEMENT

(Big Sky, Montana, USA, 5 to 16 August 2002)

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INTRODUCTION

Opening of the Meeting

1.1 The eighth meeting of WG-EMM was held at Big Sky, Montana, USA, from 5 to 16 August 2002. The meeting was convened by Dr R. Hewitt (USA).

1.2 Dr Hewitt welcomed participants and outlined the program for the meeting. This was the second meeting with a hybrid agenda consisting of plenary and subgroup sessions to discuss core topics, and a workshop (Workshop on Small-scale Management Units, such as Predator Units, hereafter called the SSMU Workshop).

1.3 This year's electronic submission of meeting papers had worked successfully and 60 meeting documents were submitted by the deadline of 19 July 2002 (two weeks prior to the start of the meeting). WG-EMM thanked the Secretariat, particularly Mrs R. Marazas (Website and Information Services Officer), for promptly processing all the papers. The complete set of meeting documents was available through the CCAMLR website from 21 July 2002. WG-EMM also congratulated the Secretariat for revising the CCAMLR website. The new format allowed rapid and easy access to meeting information and documents.

1.4 WG-EMM considered five papers which had been submitted after the deadline. It was agreed that two papers analysing fishery data of direct relevance to the workshop (WG-EMM-02/62 and 02/63) would be accepted. WG-EMM agreed that the acceptance of these two papers after the deadline would not set a precedent. The remaining three papers were not accepted.

1.5 WG-EMM reaffirmed that only papers accompanied by a completed one-page synopsis and submitted electronically by the deadline would be considered at future meetings (see also paragraph 6.32). The deadline is the Friday closest to two weeks prior to the meeting based on Eastern Australia standard time ('Hobart' time). It was agreed that the exact date of the deadline for the next meeting of WG-EMM would be contingent on the date agreed by the Scientific Committee for the commencement of the Working Group's meeting. Papers submitted after the deadline would not be considered.

1.6 WG-EMM welcomed the informal presentation of a poster brought by Dr B. Bergström (Sweden). The poster was displayed in the coffee break area. WG-EMM encouraged participants to use this medium if they wished to provide further information on activities which were of relevance to the work of WG-EMM.

Adoption of the Agenda and Organisation of the Meeting

1.7 The Provisional Agenda was discussed and it was agreed to include 'Review of procedures for the electronic submission of meeting documents' under Item 6. With this addition, the agenda was adopted (Appendix A).

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

1.9 The report was prepared by Dr A. Constable (Australia), Prof. J. Croxall (UK), Dr D. Demer (USA), Mr M. Goebel (USA) and Drs S. Nicol (Australia), P. Penhale (USA), D. Ramm (Data Manager), K. Reid (UK), E. Sabourenkov (Science Officer), V. Siegel (Germany), C. Southwell (Australia), P. Trathan (UK) and G. Watters (USA).

STATUS AND TRENDS IN THE KRILL FISHERY

Fishing Activity

2000/01 Season

2.1 The preliminary estimate of total reported catch from the krill fishery during the 2000/01 fishing season was 103 335 tonnes (Table 1). All krill fishing occurred in Area 48. Krill was taken by nine trawlers flagged to five Member countries: Japan (3 vessels), Republic of Korea (1 vessel), Poland (3 vessels), Ukraine (1 vessel) and the USA (1 vessel) (WG-EMM-02/6).

2.2 All Members fishing for krill submitted monthly catch and effort reports; however, some Members have only reported accumulated catch and effort for Area 48 as a whole. Available fine-scale data (67% of reported catches) indicate that most krill fishing during the 2000/01 season occurred in Subareas 48.1 (68% of reported catches) and 48.3 (24%).

2001/02 Season and Future Plans

2.3 Monthly catch and effort reports submitted so far for the 2001/02 fishing season indicate that krill fishing has only occurred in Area 48, with 77 085 tonnes of krill taken between January and June 2002 (Table 2). Fine-scale haul-by-haul data have been submitted by the USA (WG-EMM-02/6).

2.4 In 2001/02, nine trawlers fished for krill, and these were flagged to five Members: Japan (2 vessels), Republic of Korea (1 vessel), Poland (2 vessels), Ukraine (3 vessels) and the USA (1 vessel). These are the same countries and the same number of vessels that fished in the 2000/01 season.

2.5 The estimated catch for 2001/02, projected from the current catch level and previous catch history, is approximately 115 000 tonnes. This would represent an increase on the 2000/01 catch and be similar to the 1999/2000 level. This increase is largely due to higher catches by Ukraine and the USA.

2.6 It was noted that Ukraine had indicated at SC-CAMLR-XX that it intended to catch 50 000 tonnes of krill in 2001/02. Dr Sabourenkov indicated that he had visited Ukraine recently and that their fishery plans were for three vessels to continue fishing at the level of approximately 25 000 tonnes per year. During 2001/02, 8 500 tonnes of the catch of krill was peeled and the rest was frozen for human consumption or was converted to fish meal.

2.7 The Working Group welcomed the participation of scientists from two of the current krill fishing nations (USA and Japan), but noted with regret the lack of participation of scientists, and the lack of information from the three other current krill fishing nations: Republic of Korea, Poland and Ukraine.

2.8 Mr C. Jones (USA) indicated that the US krill vessel will continue to fish around South Georgia in July and August 2002 and the USA intends to fish next season with one vessel as was indicated in WG-EMM-02/18.

2.9 Japan indicated that there would be three vessels fishing for krill in 2002/03 (up from two in 2001/02) with an estimated catch of 60 000 tonnes.

2.10 Information relayed to the Secretariat indicated that Poland may not fish for krill in the 2002/03 season. Poland had previously sent two vessels fishing for krill.

2.11 Russia indicated that they had no plans to re-enter the krill fishery at this stage.

2.12 Neither Australia nor the UK had received any firm proposals for krill fishing in the future; they would notify WG-EMM as soon as any such proposals had been put forward. No other information was available on future plans for krill fishing from any other Members or non-Members.

CPUE

2.13 Data for Subareas 48.1, 48.2 and 48.3 were presented on vessel types, the mean monthly CPUE and fishing patterns from three main regional fishery associations in the Soviet fleet from 1977 to 1992 (WG-EMM-02/27).

2.14 CPUE appears dependent on vessel type; there were 16 different types of fishing vessels in the Soviet fleet. Some vessels were able to fish without restrictions due to their technical characteristics, and their CPUE depended mainly on krill availability. Other vessels were restricted by their ability to process the catch. Thus certain types of vessels provided a better indication of krill availability because some types of vessels were more common in the fishery than others, and some vessels had technical characteristics which allowed fishing under all conditions. Standardised CPUEs were also shown to change from subarea to subarea, from season to season and interannually.

2.15 Haul-by-haul data from USSR vessels operating in Subarea 48.3 from April to September 1984–1990 indicated the existence of two basic fishing grounds, one east of South Georgia and one to the west. There was also a smaller fishing ground around Shag Rocks (WG-EMM-02/63 Rev. 1). The eastern ground was more persistent, lasting from April to August, whereas the western one usually lasted from August to September.

2.16 Aggregated catch, CPUE by tows, towing time and fishing days were calculated from the Japanese fishery in Area 48 for 10 x 10 n mile squares (WG-EMM-02/28 Rev. 1). The distribution pattern of the aggregated catch generally resembled the distribution pattern of CPUE by fishing days, but not CPUE by haul and towing time.

2.17 Catch per haul is principally governed by the efficiency of the ship factory and the freezer capacity. Catch per towing time reflects the within-patch density, since krill trawlers adjust the tow length to the patch itself.

2.18 Catch per fishing day may be the better index for expressing the status of krill in the fishing grounds. Trawlers repeat searching until they come across krill in fishable aggregations. If fishable aggregations are scarce, the duration of searching time within a day increases, and consequently CPUE by fishing day decreases (paragraph 6.9).

2.19 The Working Group noted that the various measures of CPUE provided information on a number of different factors. For example, Dr P. Gasiukov (Russia) noted that CPUE per hour produces some information on krill density whereas a measure such as mean monthly CPUE per fishing day reflects the capability of the fishing vessels (WG-EMM-02/27). Additionally, information from the US fishing vessel *Top Ocean* indicated that CPUE is highly dependent on the type of product targeted by the fishery. Thus the interpretation of CPUE data requires considerable ancillary information.

2.20 The number of studies on CPUE submitted in recent years and the provision of more information on the strategies of the krill fleets make it desirable for the Working Group to review the utility of CPUE in the near future.

Description of the Fishery

2.21 A method for delineating krill fishing grounds in Area 48 based on commercial catch data for the region was proposed in WG-EMM-02/40 Rev. 1. Available information on krill distribution, abundance and movement in the region was also summarised. This could be used to improve understanding of the linkages between the fishing grounds and distribution of the krill population.

2.22 A 'fishing ground' is defined as being a predictable location where the fishery obtains relatively reliable catches from one year to the next for a number of years. Of interest is not only the total catch obtained from a location over the years, but how important that location is to the fishery each year. This is judged by that location providing a reasonable catch in a given year and that the catch remains sufficiently high on average over a number of years – the 'normalised catch'.

2.23 Some simple criteria for designating fishing grounds were presented (WG-EMM-02/40 Rev. 1). The type of analytical tools needed to convert catch data to a longitude–latitude grid of normalised catches and for determining boundaries on the grid according to the criteria was also presented. This process was developed using the commercial krill catch data from the CCAMLR database. The Working Group recognised that these analyses would form part of the SSMU Workshop.

2.24 The fishing patterns described in WG-EMM-02/40 Rev. 1 were similar to those presented in papers at past meetings. The distribution of catches across Area 48 shows distinct spatial and temporal shifts in fishing patterns since the beginning of the fishery. Total catches from each fine-scale rectangle in Area 48 (368 areas in all) were pooled for each three-month period in a split-year. The pattern of catches across all fine-scale rectangles was then statistically compared for every season between the 1980/81 and 1998/99 split-years (see also SC-CAMLR-XIX, Annex 4, Appendix D).

2.25 Autumn and winter fishing patterns were distinct from other seasons. Winter catches were concentrated around South Georgia. For autumn, the higher catches of the 1980s are evident as well as the fishing pattern being similar throughout the 1990s. The fishing patterns in spring and summer were similar in the 1980s but became segregated in the 1990s. The spring pattern has been much more variable than the tighter pattern in summer.

2.26 The summer fishery since 1991 has been more stable than the earlier years, and from 1996 there is a well established pattern compared to earlier years. The King George and Livingston Island area is the most important fishing ground in the current fishery, which has been consistently fished since 1988. The South Orkney and South Georgia regions have declined in importance since 1991, although they have been important in some years since then. Elephant Island remains relatively unimportant in the fishery. A differentiation between the eastern and western parts of the South Orkney and South Georgia areas is also evident.

2.27 There was further indication of changes from the established patterns of fishing over the past few seasons. Krill fishing had been carried out in Bransfield Strait (WG-EMM-02/18). Additionally, there had been a southward movement of the fishing fleet in recent years with winter fishing in Subarea 48.1 (WG-EMM-02/40 Rev. 1). It was uncertain whether these movements were for operational or ecological reasons.

2.28 Logbook data from Japanese krill trawlers were used to characterise their fishing strategies, especially focusing on their movement in time and space (WG-EMM-02/28 Rev. 1). A conceptual diagram of krill fishing operations was presented based on information provided from the krill fishing companies on individual krill patches, and local areas where these individual krill patches are aggregated.

2.29 Trawlers repeatedly fished a single patch or several patches nearby. When the trawlers decide to leave this local patch aggregation, they search nearby, and if they come across another fishable patch aggregation in terms of size and quality they start fishing on it. If not, the searching may be extended until the vessel finds fishable local aggregations.

2.30 Using this conceptual model, the fishing patterns of Japanese krill trawlers in recent times was examined. The distances between the starting position of a haul and the following haul was calculated using haul-by-haul data from five recent fishing seasons. A series of threshold distances were defined (10 n miles, 30 n miles and 60 n miles) and each of the consecutive operations were grouped within these thresholds and termed an ‘operation unit’.

2.31 Mean fishing position, fishing days, total catch and CPUE were calculated for each of these operation units. The 10 n mile threshold operation units were scattered throughout the historic range of the fishery. However, there were obvious differences in the distribution range between fishing seasons (e.g. widely distributed in 1997/98 and 1998/99, but more restricted in other seasons in Subarea 48.1). The formation of offshore and inshore operation units in the area north of the South Shetland Islands was also evident.

2.32 As the threshold changed to 30 and 60 n miles, the number of operation units decreased. The ranges of these units frequently overlapped spatially, but still remained discrete.

2.33 For the 30 n mile threshold operation units, most operations were completed within 2 to 4 days, but could last more than 8 days. Usually, less than 200 tonnes of krill were caught per operation unit, but occasionally 1 000 to 4 000 tonnes were removed.

2.34 For the 60 n mile threshold operation units, most operations were completed within 5 to 10 days, but occasionally operations lasted for more than 20 days. Usually less than 500 tonnes of krill were caught per operation unit, but occasionally up to 7 000 tonnes were removed. Most of the operation units with prolonged duration were located around South Georgia and the South Orkney Islands where the size of the fishing grounds is limited.

2.35 The impact of the Soviet commercial krill fishing fleet from 1987 to 1991 was estimated (WG-EMM-02/62). Soviet vessels operated in only 8 to 9% of the area of Subareas 48.2 and 48.3. The authors reported that catch of krill was only 9.4 to 15.6% of the estimated abundance of krill in the fishing grounds. Fishing mortality was estimated at less than 1% which included mortality of the catch and mortality due to damage to krill escaping from the nets.

2.36 The relationship between fishing removal at the highest level and predator demand was examined and, because the fishery consumed only 2% of the estimated predator demand, it was concluded in WG-EMM-02/62 that there was no competition between predators and the krill fishery.

2.37 The Working Group indicated that such analyses of fishery–predator competition were complex and were unlikely to be adequately assessed by such simple calculations. Further discussions of this issue are presented in paragraphs 3.35 to 3.41.

2.38 Considerable information on the developing US krill fishing venture was made available to the Working Group (WG-EMM-02/18). A US-flagged trawler started fishing operations for krill in Area 48 in July 2000. This fishery has continued and expanded each year since the initial fishing trials.

2.39 Initial fishing trials in 2000 were conducted in Bransfield Strait and north of South Georgia. In 2001, all fishing was conducted off the South Shetland Islands and in Bransfield Strait where the US vessel worked closely with other fishing fleets. In 2002, fishing operations were carried out off the Antarctic Peninsula, west of Elephant Island and northwest of the South Orkney Islands.

2.40 From July 2000 to April 2002, the US vessel made a total of 571 hauls and caught 9 461 tonnes of krill. Increasing catch rates with time are likely to be related to the increasing experience of the captain, rather than to changes in krill abundance. The decision-making processes involved during fishing operations were based on several factors, including krill abundance, weather, ice conditions, condition of krill in relation to the target product, and ad hoc information from nearby fishing fleets.

2.41 There was evidence for interactions between the type of krill, the fishing strategy and the end product. Once processing of krill began, the priority was to keep the factory running. Vessels fishing for a straight round bait market target large white or pink krill, and thus can have a different fishing pattern than vessels processing tail meat. Vessels fishing mainly for meal can use greener krill; whereas vessels producing tail meat must consider shell state and colour, and avoid green krill. Near Elephant Island in 2001 the krill shell was extremely hard and striped, which created considerable difficulties for the de-shelling equipment. The US venture is currently harvesting krill for meal and tail meat, but there are plans to expand into production of pharmaceutical-grade krill oil and soluble krill protein concentrate.

2.42 The Working Group welcomed the submission of WG-EMM-02/18 which provided information on the developmental phase of a krill fishing operation and encouraged further submissions on the continued evolution of this fishing venture. The Working Group reiterated its requirement for continued submission of detailed information from krill fishing fleets at all phases of their development.

Economics, Technology and Markets

2.43 Information from the US krill fishery indicated that in order for the krill fishery to develop, substantial investment in new vessels, gear and marketing was required (WG-EMM-02/18). At present the price of krill products and market development appears to be stagnant. Whether there will be an expansion to include additional vessels and fishing effort by the US fishery depends largely on the development of the market for its krill products.

2.44 An analysis of the predictions made by Members of their future level of krill fishing activities from Scientific Committee reports indicated that these predictions are generally less accurate than are necessary to indicate future trends in the krill fishery (WG-EMM-02/25).

2.45 A search of the Internet and follow-up enquiries by the Secretariat failed to locate relevant recent information regarding the market prices of krill (WG-EMM-02/6), but such information is available from a number of commercial sources, for example from Fish Information and Services (www.fis.com/fis) (WG-EMM-02/25). Access to such information is available by subscription only (US$500 per year). Regular access to such economic information will be necessary to provide reliable predictions of future harvesting trends.

2.46 Should the Commission consider it useful to have economic and marketing information, then the Working Group suggested that the Secretariat could be funded to identify possible sources of such market information and provide regular updates on market trends (paragraph 2.45).

2.47 Technological information that may provide early warnings of developments that could drive a future expansion in krill fishing is available from international patent databases. An examination of such patent databases revealed 376 recorded patents on products and processes involving krill (WG-EMM-02/25). It is apparent that there is considerable commercial and industrial interest in products derived from krill and that this interest is continuing.

2.48 These patents reveal some trends in the development of processes and products for krill:

- Development of technology and products for human consumption has recently been overtaken by the development of aquaculture feed products and of specialised products for pharmaceutical and medical purposes.

- There have been recent developments in harvesting methods which may make their way into the fishery and these may provide new opportunities for the production of novel products such as hydrolysates.

- The traditional fishing nations (Japan, Russia and Poland) are being joined by companies from industrialised western countries (Canada, UK and the USA) in patenting processes and products for krill with a wide spectrum of applications.

2.49 Aquaculture and human consumption are likely to require krill in large quantities, but medical and pharmaceutical requirements are for smaller quantities of high-quality krill products.

2.50 The Working Group noted that the krill fishery may be affected by the global oversupply of large fishing trawlers caused by declines in some Northern Hemisphere fisheries. The Working Group suggested that the Secretariat be tasked to contact ICES to obtain information about the number of vessels that might potentially enter the krill fishery.

Regulatory Issues

Fishery Plan

2.51 The Secretariat has further developed fishery plans, including the plan for the krill fishery, in accordance with the recommendation of SC-CAMLR-XX. Information for the plans is now held in a MS Access database. This database also includes other fishery-related information necessary for generating fishery summaries such as those developed by WG-FSA (WG-EMM-02/6). Information from the database is input to the Fishery Plan which is held in MS Excel. A copy of the fishery plan for the krill fishery in Area 48 was provided in WG-EMM-02/6.

Questionnaire on Fishing Strategies

2.52 The questionnaire on fishing strategies in the krill fishery was revised to address concerns raised by some Members that the information requested should be more quantitative in nature, and to integrate the questionnaire with the information on vessel activities which scientific observers are requested to collect (WG-EMM-02/6).

2.53 The revised questionnaire was distributed in March 2002 to representatives of the Scientific Committee, WG-EMM and Member countries involved in krill fisheries. Comments and feedback were invited, along with at-sea evaluation on board commercial krill vessels. No feedback had been received prior to the meeting, but Japanese scientists reported at the meeting that the questionnaire was now suitable for general use.

2.54 Completed questionnaires had been received from two Polish-flagged vessels. These questionnaires covered 50 days of activities in Subareas 48.1 and 48.2 and Division 41.3.2 (outside the CCAMLR Convention Area) in April, May and June 2002. One of these vessels had also completed five questionnaires covering fishing in Subarea 48.1 from March to June 2001.

2.55 The Working Group agreed that the Secretariat should collate and synthesise information from the krill fishery questionnaire for presentation at future meetings.

Forecasting Closure of the Fishery

2.56 Forecast closure dates are routinely generated and reported by the Secretariat as soon as the total reported catch in a fishery exceeds 50% of the catch limit. This is emailed regularly to Contracting Parties. CCAMLR uses an agreed regression method for forecasting closure dates. The projected closure date is the actual date when the catch is estimated to reach the catch limit, assuming the fishing continues at the current rate up to, and including, the closure date (WG-EMM-02/6).

2.57 The Working Group agreed that it will be necessary to change the current monthly reporting system used in the krill fishery to avoid a potential 30% over-run. This would require accurate information on krill catches being reported at shorter time intervals (see also paragraphs 2.64 to 2.67).

2.58 Drs S. Kawaguchi (Japan) and K. Shust (Russia), however, stressed that since the current level of catch is still well below the precautionary catch limit, it should not be an urgent task to change the reporting system.

International Scheme of Scientific Observation

2.59 Two datasets collected by scientific observers were submitted for the 2000/01 season: by the US-flagged vessel *Top Ocean*, and by a national scientific observer on board the Japanese-flagged vessel *Niitaka Maru*. At present the CCAMLR database holds data collected from only three krill-fishing cruises by designated CCAMLR scientific observers in 2000/01 (WG-EMM-02/6).

2.60 Suggested modifications to the *Scientific Observers Manual* were presented (WG-EMM-02/29). The current manual consists of nine forms; some of which were developed independently so there may be redundancies. Four of the forms, in particular, may require modification:

- Form K4 – Krill Biological Data Collection:
  It was pointed out that determining the maturity stage of krill may not be possible by non-specialists and the colour charts were unclear and needed revision. The sampling frequency from the catch should be increased to two hauls per day and the collection of length data should be accorded the highest priority.

- Form K5 – Finfish By-catch:
  As krill trawlers perform more than 10 hauls per day the current requirement to sample every haul might be modified, with the sampling frequency being advised by WG-FSA taking into account the experience of scientific observers who have worked in the krill fishery.

- Form K6 – Conversion Factor:
  Completion of this form has been difficult because, in most cases, the factories are off limit. A suggested approach was to use the catch estimates based on the fullness of the codends or the scales in the fishpond, and not to use a conversion factor to re-estimate the total catch.

- Form K7 – Krill Time Budget Data:
  As CCAMLR is introducing the Krill Fishing Strategy Questionnaire, Form K7 could be deleted.

2.61 The Working Group agreed with these recommendations and suggested that sampling for fish by-catch should be assessed by WG-FSA. A subgroup comprising Dr I. Everson (UK), Mr Jones and Drs Kawaguchi, Ramm and Sabourenkov discussed the recommended changes to the *Scientific Observers Manual*.

2.62 The subgroup noted that the krill observation logbook forms currently exist only in electronic format (i.e. Excel), and that further work is required by the Secretariat before these forms can be published in the *Scientific Observers Manual*. The subgroup made the following recommendations which were considered by WG-EMM and subsequently approved:

(i) The list of krill observation priorities as contained in the manual should be amended in order to accord the highest priority to the collection of krill length data. Collection of data on krill maturity stages was considered to be of lower priority.

(ii) The revised krill colour chart to be prepared by Dr Kawaguchi will be submitted for consideration at the 2003 meeting of WG-EMM for subsequent inclusion in the manual.

(iii) Instructions in the manual should include provision for scientific observers to seek assistance from the vessel's crew, as may be required from time to time, for their work, such as sampling by-catch or collecting data on krill product conversion factors.

(iv) A simplified sampling methodology should be developed for fish that are easily identifiable in catch samples, e.g. with a length of approximately 7 cm and more. A minimum of three hauls per day should be sampled for by-catch of fish species in accordance with instructions contained in the manual. WG-FSA should be requested to assist in the development of the methodology for sampling larvae and other small-sized fish (i.e. <7 cm).

(v) It was noted that collection of krill product conversion factors on board krill fishing vessels continues to be problematic for scientific observers because the current method requires the observer to track identifiable batches of krill through the processing line. This is not a feasible option on board most factory ships. Development of an alternative method should be given high priority for WG-EMM's intersessional work. If information on krill conversion factors continues to be difficult to obtain by observers, then Members should be requested to assist in the collection of such information directly from krill product manufacturers or provide direct measurement of green weight prior to processing.

(vi) The introductory note to the questionnaire on krill fishing strategies should incorporate a footnote indicating that the collection of data on krill product conversion factors will require development of an appropriate sampling method. Development of such a method should be given a high priority for WG-EMM's intersessional work.

2.63 The Working Group was informed that Japan would be deploying a scientific observer during winter in the coming season, specifically to examine the issue of fish by-catch. Additionally, the historical data on fish by-catch collected by Japanese scientific observers on krill fishing vessels were currently being consolidated and analysed.

Data Reporting

2.64 Fishery data reported to the Secretariat over the last two fishing seasons were presented in WG-EMM-02/6. The data that are mandatory (monthly catch, STATLANT data) are all submitted to the Secretariat, though not necessarily as promptly as would be ideal. Data that are voluntary (such as fine-scale catch and effort data and observer data) are not submitted by all Members and when they are submitted, are not presented in a uniform manner (see also paragraphs 5.43 and 5.44).

2.65 The frequency and format of data submission range from close adherence with the established procedure described in Conservation Measures 40/X (Monthly Catch and Effort Reporting System) and 122/XIX (Monthly Fine-scale Catch and Effort Data Reporting System for Trawl, Longline and Pot Fisheries) to annual submission (e.g. data for a 'split-year' submitted in October each year).

2.66 Unfortunately, the combination of the revised fishing season, the voluntary nature of most data submissions for the krill fisheries and other factors has resulted in a paucity of fishery data available to WG-EMM-02 for the most recent, completed, fishing season (2000/01: December 2000 to November 2001).

2.67 The Working Group noted that the fine-scale dataset for the 2000/01 season is incomplete. Japan usually submits aggregated data (10 x 10 n mile rectangles by 10-day periods) pertaining to a split-year (the 'old' fishing season: July to June of the following year) in October each year. As a result, the latest data submission (October 2001) provided fine-scale data for the 12-month period to June 2001. The Republic of Korea had provided fine-scale data to August 2001. In the past, Poland has submitted fine-scale data but there has been a suspension of data submission. Fine-scale data submission from Ukraine appears incomplete for June, July and August 2001.

2.68 The Working Group pointed out that although the catch of krill is small relative to the catch limits, the fishery is the largest in the Convention Area (in terms of catch weight), and that management of this fishery requires timely submission of the appropriate data (see also paragraphs 5.43 and 5.44).

Key Points for Consideration by the Scientific Committee

2.69 The Working Group drew to the Scientific Committee's attention that interpretation of CPUE data would not be possible without additional information on factors such as vessel type and product type, and that data submission on these ancillary parameters should be sought. Further, the voluntary submission of CPUE and associated data makes the krill fishery unique amongst CCAMLR fisheries which generally require mandatory submission of detailed data (paragraphs 2.13 to 2.20).

2.70 Formal annual notification of Members' intentions to participate in the krill fishery, such as that adopted for new and exploratory fisheries in the Convention Area, might facilitate identification of trends in the krill fishery. Although experience has shown that notifications are not always acted on, information on the numbers of annual notification would be useful in tracking interest in the krill fishery (paragraph 2.44).

2.71 The Working Group agreed that it does not have the expertise to fully interpret economic, marketing and technological information that is of great utility in interpreting developmental trends in the krill fishery. As regular submission and interpretation of this information is of vital interest to the Working Group, the Scientific Committee was requested to consider what mechanisms might be appropriate to access and analyse such information (paragraph 2.47).

2.72 Because it is evident that the development of krill-based aquaculture feeds will be a major factor in the future development of the krill fishery, the Working Group suggested that the Secretariat be asked to contact FAO for any information they might have on the demand for aquaculture feeds or on the development of other krill fisheries (paragraph 2.49).

2.73 The Scientific Committee was requested to enquire of the Commission what mechanisms it might want to employ to access information on factors that might affect the development of the krill fishery such as global excess fleet capacity (paragraph 2.50).

2.74 The Working Group noted that the consistency and timeliness of data reporting was deteriorating. The low level of data submission and the timing of those submissions were causing difficulties for the work of the Working Group. The Scientific Committee was requested to examine the issue of data submission from the krill fishery, including the requirements for consistency, the degree to which such submission should be voluntary and the timing of data submission (paragraphs 2.64 to 2.68).

2.75 The Working Group drew to the Scientific Committee's attention the extreme difficulty of predicting trends in the krill fishery in the absence of reliable information from fishing nations on their future plans. The voluntary nature of the submission of such information has resulted in a paucity of data available to the Working Group and this is hindering its ability to provide the Scientific Committee with information on developments of the krill fishery (paragraphs 2.64 to 2.68).

STATUS AND TRENDS IN THE KRILL-CENTRIC ECOSYSTEM

Status of Predators, Krill Resource and Environmental Influences

CEMP Indices

3.1 Updated information on the status and trends of the CEMP indices was reported in WG-EMM-02/5. A number of improvements to the indices were made by the Secretariat over the last year that included modifications to Indices A6a breeding success, A8a weight of stomach contents, A8b and A8c composition of diet. Schroeder's Index (SC-CAMLR-XV, Annex 4, Appendix H) was added to the CEMP measures of overlap between the krill fishery and krill predators. The calculation of the index is based on the same dataset as that used for the other measures of overlap.

3.2 Overall, and in respect to individual indices, 2001/02 was an average year in comparison to the time series of data available. In Area 48 there were no particular differences between the subareas for 2001/02.

3.3 Since WG-EMM-01 the Secretariat had undertaken a review and preliminary analysis of some specific CEMP data. The results of these were presented in WG-EMM-02/7. Considerable progress was made towards correcting irregularities and inconsistencies in the CEMP database. Specifically, problems with reporting of breeding success (chicks fledged per egg laid), zeros for null data, calculated weights for A8 chick diet, the lack of reporting of sampling dates for some indices, and inconsistencies in colony codes for certain CEMP sites were reported and where possible corrected. Comment sections of CEMP data forms were also found to be highly under-utilised.

3.4 The Working Group made the following recommendations:

- Researchers should be encouraged to use the most current data forms available, which are found on the CCAMLR website.
- Members should be encouraged to use comment sections of data forms and to send extra information that they believe may be useful in data validation, or for any other purposes. Such information, when given, should be clearly flagged to avoid misinterpretation during data entry.
- Sampling dates must be provided with every submission.
- Steps should be taken to ensure that colony codes are uniform from one season to the next, or that they allow for the merging or disappearance of colonies.

- Lastly, because automated data may, in the future, be used more frequently, guidelines in the standard methods should be drafted for their submission.

3.5 WG-EMM-02/7 also provided a preliminary analysis of Adélie penguin breeding population size which showed a significant decline at Anvers Island; other sites around the continent were either stable or had increased over their time series.

3.6 In discussion it was pointed out by Dr W. Fraser (USA), the Anvers Island data holder, that the results and conclusions presented in WG-EMM-02/7 were contradictory to his own more comprehensive analyses. He reported that, although a decline in population has occurred, breeding success has increased.

3.7 The Working Group noted that any analyses conducted by the Secretariat should be preceded by notification of data holders, which would have helped considerably in this case.

3.8 It was also noted that this analysis, and its deficiencies, in comparison with more comprehensive analyses, underscored the importance of design and scale in analyses of CEMP indices. These matters will be reviewed in 2003 in the CEMP Review Workshop.

3.9 With regard to WG-EMM-02/5, it was pointed out that the method for detection of anomalies was outdated and should be reviewed.

3.10 Dr Ramm pointed out that because of its increasing size, the CEMP database was in need of redesigning. It was agreed that small changes should be made to the database to increase ease and flexibility of access prior to the CEMP review. However, the Working Group agreed that major database restructuring should not be undertaken until after the CEMP Review Workshop.

3.11 WG-EMM-02/19 provided an update of CSIs used by Boyd (2001) for krill predators at Bird Island, South Georgia. It incorporated one additional species over earlier work and concluded that 2002 was a year of relatively good performance for krill predators at Bird Island, South Georgia.

3.12 Dr Constable noted the importance of updating WG-EMM with current assessments of predator performance. However, he noted that CSIs have not been properly evaluated and referred to discussions of WG-EMM-2000 (SC-CAMLR-XIX, Annex 4, paragraphs 3.50 to 3.52) on the importance of an evaluation before such analyses are adopted as a standard method of assessment. He cautioned against the routine reporting of CSIs becoming commonplace until such evaluations are satisfactorily concluded.

3.13 WG-EMM-02/46 reported on the results of an analysis of temporal variability in CEMP parameters for a population of Adélie penguins. It explored the interrelationships between CEMP parameters, particularly with measures of breeding success and found that: (i) events during the hatching period are crucial to chick survival, (ii) that the sex of foraging birds and the timing of foraging trips were important in determining whether foraging trip duration was negatively correlated with breeding success, and (iii) lower weights of females at first departure after egg laying appear to be the first indication that a season may have low breeding success.

3.14 This paper represents a significant step forward in identifying which parameters or indices hold the most power for identifying periods of poor predator performance.

3.15 The Working Group noted the utility of the approach used in WG-EMM-02/46 and encouraged other data holders with similar data to follow its approach and to see if similar relationships were revealed at other sites.

Predators

3.16 Dr Trathan identified those working papers that related to the foraging behaviour of krill-dependent predators, highlighting four main areas that were of interest to the Working Group as well as to the SSMU Workshop. These areas of interest were:

(i) satellite-tracking studies of predators;
(ii) estimates of prey consumption by predators;
(iii) issues of spatial scale; and
(iv) concerns about the overlap between predators and krill fisheries.

Satellite-tracking Studies

3.17 Dr Trathan reported that, although most satellite-tracking studies were usually restricted to data from a few individuals breeding at a few accessible colonies, such data were extremely important as they provided a detailed view of predator foraging range and behaviour not otherwise available. WG-EMM-02/15, 02/21, 02/22, 02/47, 02/53 and 02/55 all described studies of satellite tracking.

3.18 These papers highlight four important issues relevant to predator foraging: (i) that a detailed understanding of species-specific foraging ecology is necessary, particularly where individuals may adopt different foraging strategies; (ii) that during their winter (non-breeding season) dispersal, predators can travel considerable distances from their breeding colony; (iii) that foraging locations may be strongly influenced by physical features of the environment; and (iv) that interactions between species can potentially have important impacts on their foraging behaviour and their foraging range.

Individual Species Foraging Behaviour

3.19 WG-EMM-02/21 provided some general background about the foraging areas and foraging ranges of macaroni penguins breeding at Bird Island, South Georgia. The study highlighted a number of key issues relating to the foraging ecology of the species:

(i) macaroni penguins travel further from their colony during certain periods of the breeding season, for example, during incubation foraging occurs up to 572 km from the colony, whereas during chick rearing foraging is constrained to within 62 km;

(ii) differences in travel speed may occur, with birds travelling faster during their long incubation foraging trip;

(iii) birds generally showed directional foraging with most trips following similar bearings; and

(iv) the study revealed that differences between sexes may be important.

This paper highlighted the complexity of macaroni penguin foraging behaviour, suggesting that a detailed understanding for individual species is important.

Winter Dispersal

3.20 The importance of winter behaviour was highlighted by WG-EMM-02/47 and 02/55; these papers look at the winter foraging dispersal of chinstrap and Adélie penguins.

3.21 WG-EMM-02/55 examined the post-breeding dispersal of chinstrap and Adélie penguins from two colonies in the South Shetland Islands. Four of the five tracked chinstrap penguins remained close to their breeding colony staying mainly over the shelf in ice-free areas to the north of the South Shetland Islands. However, the other tracked bird travelled east towards the South Sandwich Islands. Adélie penguins also showed contrasting winter dispersal patterns. In one year the tracked birds remained close to their colony whilst the following season tracked birds travelled south into the Weddell Sea. These differing winter dispersal patterns indicate that penguins from individual colonies may have very different winter strategies and different winter feeding grounds.

3.22 WG-EMM-02/47 examined the dispersal of post-moult adult and fledging Adélie penguins from Béchervaise Island and Magnetic Island. In this study all tracked birds travelled westward either along the edge of the fast-ice or in pack-ice. Fledging birds initially travelled north before moving westwards. The authors suggested that this may represent exploratory behaviour prior to the time when these inexperienced birds learn where food concentrations exist. The authors also noted that adults were recorded in areas of known krill concentration. The study indicated that both post-moult adults and fledging birds follow a similar strategy, moving considerable distances from the breeding colony during winter.

Interactions between Foraging Behaviour and the Physical Environment

3.23 WG-EMM-02/21 and 02/47 indicated that physical features of the environment may be important in understanding where predators forage. For example, during incubation macaroni penguins from Bird Island travelled considerable distances to forage over the Maurice Ewing Bank within the Polar Frontal Zone. Similarly, Adélie penguins from Béchervaise Island travelled westward in the westward flowing coastal current before moving north of the southern boundary of the Antarctic Circumpolar Current into the eastward flowing Antarctic Circumpolar Current. Thus, WG-EMM-02/47 suggested that these Adélie penguins potentially track the ice and utilise oceanic gyres to increase their foraging efficiency. WG-EMM-02/53 also indicated that physical features may be important in determining the foraging behaviour and foraging ranges of Antarctic fur seals. For example, over a four-year period fur seals tracked from Cape Shirreff, Livingston Island, foraged over the mouth of a canyon at the edge of the continental shelf, about 40 km northwest of Cape Shirreff.

3.24 Physical features in the environment, such as submarine banks, oceanic gyres and shelf-break fronts have long been known to be areas where there are potentially higher levels of primary and secondary productivity. They may also be areas where prey are potentially aggregated.

Interactions between Species

3.25 WG-EMM-02/15 and 02/22 highlighted potential interactions between species. WG-EMM-02/15 reported a satellite-tracking study of Adélie and chinstrap penguins breeding at Signy Island, South Orkney Islands. In 2000, a year of apparent low prey availability, there was a statistically significant segregation of foraging areas between the two species; however in 2001, a year of apparent normal resource availability there was no such segregation. In 2000, the breeding success of Adélie penguins was 51% lower than the long-term mean compared to 15% lower for chinstrap penguins. Both species achieved above-average breeding success in 2001. The changes in foraging distribution and breeding success suggest that in years of apparent low resource availability, chinstrap penguins may be able to competitively exclude Adélie penguins from potential inshore foraging areas. This has considerable implications for the relative population performance of species, particularly under reduced levels of krill availability.

3.26 Dr V. Sushin (Russia) noted that Adélie penguins foraging from Signy Island were feeding to the south of the island; he wondered why they were not targeting the areas of high krill abundance known to occur to the west and northwest of Coronation Island. Dr Trathan replied that one possible reason could be that penguins from colonies on Coronation Island were using those areas.

3.27 Dr Naganobu also suggested that canyons at the edge of the shelf may influence foraging distribution, particularly if Warm Deep Water entering the canyon systems caused them to have elevated levels of primary and secondary production.

3.28 Dr W. Trivelpiece (USA) suggested that competitive exclusion of Adélie penguins by chinstrap penguins was not the only explanation for the results described in WG-EMM-02/15. He suggested that an alternative hypothesis was that foraging differences could be due to local changes in krill abundance; he added that this was plausible given the temporal differences in the tracking of Adélie penguins and chinstrap penguins. Dr Trivelpiece added, that differences in chick size and their level of independence could also have enabled Adélie penguin adults to travel further offshore. Dr Trathan responded that although these suggestions were possible, the tracking of both species had been carried out during a similar stage of breeding thereby controlling for phenological differences as much as was possible.

3.29 WG-EMM-02/22 examined potential competitive interactions between macaroni penguins and Antarctic fur seals breeding at Bird Island, South Georgia. The study highlighted changes in population size and some changes in diet over the past decade. It suggested that the competitive advantage of Antarctic fur seals may be enhanced as their populations continue to increase, particularly in years of low krill availability.

Prey Consumption

3.30 WG-EMM-02/23 presented an algorithm for synthesising information about physiology, metabolism, growth, diet, life history and activity budgets for Antarctic fur seals and macaroni penguins, two key land-based krill-dependent predators breeding at South Georgia. The outputs from the algorithm are estimates of the total population energy requirement and food consumption. A sensitivity analysis indicated that the estimates of prey consumption were most sensitive to uncertainty in some demographic variables. The analysis indicated that, assuming a diet mainly composed of krill, annual food consumption by Antarctic fur seals and macaroni penguins was 3.84 (CV = 0.11) and 8.08 (CV = 0.23) million tonnes respectively.

3.31 Dr Sushin noted that the combined total consumption figures for Antarctic fur seals and macaroni penguins at South Georgia were marginally different in this published version of Prof. I. Boyd's (UK) paper when compared to those in the earlier version tabled previously at WG-EMM. He wondered whether this was due to a difference in the data or in the method used. Prof. Croxall replied that this version used the same data and method but included a better energetic parameterisation.

Issues relating to Spatial Scale

3.32 WG-EMM-02/14 highlighted an important issue, that appropriate scales must be used when trying to assess levels of spatial correlation between foraging predators, their prey, and any potential overlap with krill fisheries. This study revealed characteristic scales apparent in the distribution of foraging predators using at-sea predator observations collected during the CCAMLR-2000 Survey. The study also had the objective of determining the spatial scales at which overlap between predators, krill and the krill fishery should be measured. The study indicated that in the Scotia Sea predator foraging demand for Antarctic krill was concentrated within a distance of 150 km from land, whilst that of the krill fishery was principally within 100 km of land. The study identified that the extent of potential overlap should be assessed at scales of 70 to 100 km to accommodate the scales of operation of the processes involved.

3.33 The study highlighted that at-sea predator observations are a valuable source of information, complementary to that from detailed satellite-tracking studies.

3.34 Dr Kawaguchi suggested that it was also important to consider other pelagic predators such as whales. Dr Hewitt agreed and reminded WG-EMM that Dr S. Reilly (IWC) had prepared a study considering the distribution of whale observations recorded during the CCAMLR-2000 Survey. This manuscript would be available to WG-EMM at a future date.

Overlap between Predators and Krill Fisheries

3.35 WG-EMM-02/53 indicated that from 1999 to 2001, 70% of the total krill harvest taken by the commercial fishery was caught within 100 km of Cape Shirreff and therefore within the foraging range of Antarctic fur seals.

3.36 WG-EMM-02/06 examined the location of reported catches of krill in Subarea 48.1 with respect to the location of known colonies of predators in the South Shetland Islands region. The annual mean distance of catches from these colonies in all seasons except 1980/81, 1981/82 and 1982/83 has been less than 50 km, and less than or equal to 25 km over the past five seasons. The smallest mean distance was 12 km in 1992/93, followed by 16 km in 1993/94 and 17 km in 2000/01. In addition, over 80% of the annual catches in Subarea 48.1 have been taken within 50 km of colonies in 12 out of the 22 seasons reported, including 99% in the 1993/94 and 2000/01 seasons, 98% in 1992/93, 93% in 1997/98 and 92% in 1999/2000.

3.37 In contrast, the authors of WG-EMM-02/62 and 02/63 Rev. 1 asserted that spatial and temporal overlap between the krill fishery at South Georgia and dependent species does not occur. Further, that functional overlap is probably not present as fishing vessels exploit krill at high densities (>100 g m^{-2}), whereas predators typically take krill at much lower densities (24 g m^{-2}) (Boyd, 2001). Similarly, in the South Orkney Islands where there may be an overlap between the krill fishery and the ecological niche of dependent species, the authors suggested the overlap is spatial rather than functional.

3.38 Prof. Croxall noted that WG-EMM-02/62 and 02/63 Rev. 1 considered the winter krill fishery at South Georgia and that this fishery operated at a time when few satellite-tracking or other data were available to describe the foraging distribution of predators. In addition, available data indicated that predators target areas of high-density krill. The value of 24 g m^{-2} quoted from Boyd (2001) in WG-EMM-02/62 and 02/63 Rev. 1 related to potentially average threshold values for maintaining fitness, derived from acoustic surveys rather than the densities of krill targeted by predators.

3.39 Dr Constable highlighted that the four indices of predator–fishery overlap reported in WG-EMM-02/06 showed some divergence. Dr Ramm emphasised that the indices included two types of metric; one set that was sensitive to the absolute amount of krill, and one set that was sensitive to the proportion of krill.

3.40 Dr Constable suggested that the Working Group should consider the value of the different predator–fishery overlap indices and make a recommendation as to which provided the measurements most relevant to the work of the group. Dr Everson agreed, and reminded the Working Group that his paper (Everson, 2002) summarised the merits of the various overlap indices. Further, that his paper described an additional index – the ‘Fishing to Predation Index’ – which provided information of the sort valuable to the Working Group. The Working Group agreed that the utility of the Agnew–Phegan (Agnew and Phegan, 1995) index was limited and that the Secretariat should discontinue to calculate it for management purposes.

3.41 The Working Group recommended that the Data Manager consider the most appropriate methods for presenting the different predator–fishery overlap indices and consider how best to present information on the relationships between these indices.

Predator Biology

3.42 WG-EMM-02/42 reported on an unusual mortality event of Adélie penguins near Mawson.

3.43 Because of the timing and magnitude of the event and the possibility of infectious disease as the cause, *CEMP Standard Methods*, Section 6, for collection of samples for pathological analysis, was implemented. Analysis of samples and post-mortem examinations of specimens revealed that most animals had fractures, internal injuries and peritonitis associated with physical trauma. The most likely cause was a severe storm that resulted in rapid transport of ice towards shore crushing many transiting penguins.

3.44 This event and the response of researchers in implementing the CEMP protocol proved the utility of CEMP standard methods for dealing with such events.

3.45 The Working Group noted the importance of reporting on the pathology of the birds. Dr K. Kerry (Australia) commented that it was the intention of the researchers involved to publish the results in a veterinarian journal.

3.46 WG-EMM-02/48 compiled 12 years of demographic studies for an Adélie penguin population and calculated age-specific mortality rates, fecundity and recruitment. A life table was constructed that provides predicted rates of population growth and breeding success. Large sample sizes and a long time sequence of data were found to be necessary to prevent year-to-year variation from obscuring long-term trends in reproductive success, juvenile survival and adult mortality. The authors suggest that sensitivity analyses be carried out in order to determine the numbers of adults and chicks that need to be marked each year in order to detect significant changes in annual adult mortality and juvenile survival as well as to detect correlations with other CEMP parameters.

3.47 The Working Group welcomed this valuable contribution to its work and noted the importance of demography data and long time series for understanding predator responses to environmental changes and to potential influences of fisheries.

3.48 Formulations of CEMP standard methods for collection and analyses of demography data should be encouraged and the advice of researchers with similar data should be sought. Dr Kerry agreed to coordinate such an approach in respect of the Adélie penguin.

3.49 WG-EMM-02/51 reported on the results of a 2002 survey of all known Antarctic fur seal breeding colonies in the South Shetland Islands by the US AMLR Program. Total pup production for the South Shetland Islands was 10 057 (±142). Comparisons to previous censuses reveal an average annual increase from 1987 to 1994 of 13.5%. Between 1994 and 1996 the rate of increase declined to 8.5% and from 1996 to the current census the averaged annual rate was only 0.9%. Changes in pup production at individual colonies were not consistent with some colonies increasing and other colonies decreasing.

3.50 The Working Group noted that the recovery of fur seals in the South Shetland Islands has not followed a similar trajectory to the rate and duration of population recovery reported for South Georgia. The reasons for the levelling off of fur seal population growth in the South Shetland Islands warrant further investigation.

Krill Biology

3.51 WG-EMM-02/13 reported for the first time on a disease found in krill off South Georgia during winter and spring. The initial stage of the disease is characterised by brown pigmentation, which becomes black later on. In its final stage the spots are perforations of the chitin shell of the animals. The infection increased from winter to spring and the later stages were not shed with the shell during moulting. It is still unclear whether the disease was caused by parasites, bacteria or viruses.

3.52 The Working Group noted that similar infections are known for crustaceans from waters of the Northern Hemisphere (e.g. Crangon or Pandalus). These diseases are obviously caused by bacteria. In the published literature it was often suggested that the outbreak of such a disease was possibly caused by mechanical damage of shrimps after escaping through the meshes of the fishing gear. From this, one might expect two additional problems: a potentially higher fishing mortality rate and a lower quality of krill products.

3.53 Dr M. Naganobu (Japan) indicated that a similar phenomenon was observed in the past in the Indian Ocean and that the infected krill were in a poor state of health.

3.54 WG-EMM-02/16 examined the level of concordance between the length-frequency distribution of krill from the South Shetland Islands and South Georgia using a stepwise model to account for the potential effects of higher growth and mortality at South Georgia. While the raw data showed little overlap, the output from the model indicated that the same pattern of recruitment of 1+ krill occurred simultaneously in both regions.

3.55 The authors suggest that it is only the 1+ krill that are advected into different regions of the Scotia Sea and that the resultant size structure is determined by regional differences in growth and mortality. The results suggest that where such differences in key demographic parameters exist, the implication of this for management advice should be considered.

3.56 Dr Constable noted that further development of models including spatial and temporal variation of demographic parameters would be helpful in understanding the dynamics of the krill population in the southwest Atlantic. It will be particularly interesting to examine the consequences to krill biomass around the different island groups, of changes in parameters such as growth and mortality, particularly if they are highly correlated. An important factor to include in these analyses is how retention and flux of krill in these areas might influence the estimation of these parameters.

3.57 Dr Trathan informed the Working Group that various modelling studies are currently being undertaken to consider the relative contributions of flux and retention in maintaining krill populations at South Georgia.

3.58 Dr Nicol pointed out that WG-EMM-02/16 used fur seal data from the western end of South Georgia and indicated that the krill population structure from this site may not be representative of the whole region.

3.59 Dr Bergström noted that genetic studies have the potential to address questions related to the movement of krill in the Scotia Sea. He indicated that initial analyses had not revealed any differences in the genetic structure of the krill population in the Scotia Sea based on data from the CCAMLR-2000 Survey, however, further analyses were in progress.

Net Sampling Surveys

3.60 WG-EMM-02/20 estimated the recruitment indices derived from German and the US LTER net sampling surveys in the northern Bellingshausen Sea since 1985. Recruitment indices varied considerably between years. Correlation analyses for R1 from various regional surveys show a significant correlation between the Bellingshausen Sea and Elephant Island as well as with South Georgia. No concordance is evident between the Atlantic and Indian Ocean survey sites. The 2002 R1 recruitment index was one of the highest values observed since the strong 1994/95 year class and an increase in stock biomass is predicted over the next year. For R2, only Elephant Island and the Bellingshausen Sea were correlated, while recruitment values from South Georgia were not.

3.61 The authors observed one phenomenon which may be crucial for the calculation of the R1 index. In the Bellingshausen Sea samples, a bimodal length-density distribution pattern occurred for the juvenile age 1+ component, especially in those years with high recruitment rates. This bimodality was observed before in the Elephant Island area, when samples from the Weddell Sea ice-edge in summer were included in the analysis. In this case the different origin of krill with different growth rates may be obviously responsible for the bimodal length-frequency composition. For the Bellingshausen Sea, the paper also discussed an alternative view to the spatial origin hypothesis. This would include the possibility of a second spawning event in the previous summer producing a subset of younger and smaller recruits.

3.62 Although the correlations were significant between R1 indices from various regions, the R1 value of 2001 from Elephant Island seemed to be too high compared to the Bellingshausen Sea results of the same year. Possibly the change in the extension of the survey grid to the south in 2001 to cover the eastern exit of the Bransfield Strait caused an inclusion of parts of the Weddell stock and overestimated the one-year-old recruits for the Elephant Island survey. A final conclusion could not be made, because the R2 values from Elephant Island were not available for 2002.

3.63 Dr Siegel suggested to continue with sampling the extended Elephant Island survey south to the Antarctic Peninsula shelf. This would give an opportunity to identify the potential boundaries of the juvenile stock affected by Antarctic Peninsula and Weddell Sea waters.

3.64 Dr Constable indicated that variability in demographic parameters highlighted by WG-EMM-02/16 and 02/20 might influence the estimated krill yield from the CCAMLR-2000 Survey. However, it was not clear that a reanalysis of the krill biomass was warranted at this stage.

3.65 The Working Group welcomed the participation of LTER scientists and the availability of data for the Working Group's deliberations. LTER scientists were encouraged to present more krill demographic data from this important long-term time series in future.

3.66 WG-EMM-02/32 reported on an Italian krill net sampling survey in the Ross Sea in January–February 2000. A distinct geographical separation can be seen between the distributions of Antarctic krill (*Euphausia superba*) and ice krill (*E. crystallorophias*), with

Antarctic krill confined to the continental slope and oceanic waters north of 74°S, and ice krill in neritic areas south of 74°S. The geometric mean biomass of Antarctic krill was 9.3 g 1 000 m^{-3}.

3.67 The paper also studied the age composition using the Macdonald and Pitcher mixture component analysis. Antarctic krill age group 1+ was missing from the Ross Sea data and age group 2+ only represented 6% of the krill stock in the area. The situation was totally different for ice krill, for which a full set of age groups was present in the net samples.

3.68 The Working Group noted that in the present study fishing depth was not standardised. It varied between stations, but was mostly shallower than 100 m, i.e. fishing was carried out in the more densely populated depth stratum for krill. The estimated krill density was less than 1 g m^{-2}. Even for the higher density depth stratum this is at least one order of magnitude lower than in the Elephant Island area for years with low biomass records. Obviously krill biomass in the Ross Sea is considerably lower than in other areas.

3.69 The Working Group also noted that the age composition described in WG-EMM-02/32 shows that krill recruitment can be extremely low in some years. The interannual variability in recruitment appears to be very high in the Ross Sea, a phenomenon also recorded from the Atlantic sector, but apparently less evident in the Indian Ocean.

Acoustic Surveys and Methods

3.70 WG-EMM-02/38 described the distribution and abundance of Antarctic krill and ice krill in the Ross Sea for acoustic surveys. The estimated krill biomass (estimated from 120 kHz) in the northern Ross Sea was 4 million tonnes in November 1994, 2 million tonnes in December 1997 and 1 million tonnes in January–February 2000. A three-frequency method was used to delineate between Antarctic krill and ice krill and to determine the average length of the targets.

3.71 Mean swarm size was 10 tonnes for Antarctic krill and 2.3 tonnes for ice krill. Total biomass of Antarctic krill was one order of magnitude higher than for ice krill.

3.72 Several members questioned the reliability of the three-frequency method to delineate between two very similar euphausiid species. A detailed discussion was deferred to Agenda Item 3.4 (paragraph 3.108).

3.73 Dr M. Azzali (Italy) answered that the empirical experience had shown in the past that the two species show distinct differences in frequency-specific volume backscattering strength and that the species separation was confirmed by the net sampling program.

3.74 WG-EMM-02/30 gave results on an acoustic survey in the Elephant Island area in summer 2001. The data-processing methods were carried out according to protocols developed during the CCAMLR-2000 Survey. The estimated average krill biomass density in the survey area was 15.3 g m^{-2} resulting in a total biomass of 1.67 million tonnes. Half of the biomass was found in the central shelf and shelf break areas, while highest densities were recorded in the southern part of the survey area, where juvenile krill dominated the stock.

The results were very similar to those obtained from US AMLR surveys in January (15.6 g m^{-2}) and February (12.8 g m^{-2}). It was noted that this biomass estimate is in the lower range of values estimated for this survey area time series.

3.75 WG-EMM-02/39 described results from four repeated acoustic surveys carried out by the British Antarctic Survey around South Georgia from November 2001 to May 2002. Krill densities showed a seasonal pattern, with a low of 5 g m^{-2} (November) at the start of the season, high during summer (46 and 72 g m^{-2}). Timing coincides with the onset of the predator breeding season, the period of peak predator demand and the period when offspring reach independence and is therefore of great importance for the functional relationship between reproductive performance of predators and abundance of krill.

3.76 The two summer estimates were the highest recorded for the survey area over the past seven years. The observed pattern of change in abundance is entirely consistent with a closed system with high seasonal growth and constant mortality, as well as with an open system with a pulsed seasonal immigration of krill into the area as a flow-through system. Future research activities are planned to collect additional information to further explore these alternative, but not mutually exclusive scenarios. The Working Group noted that the results presented in WG-EMM-02/39 were not consistent with a continuous high level input of krill into the South Georgia system required to satisfy estimated predator demand (WG-EMM-02/23).

3.77 WG-EMM-02/36 described results of acoustic surveys carried out at South Georgia using the Maximum Entropy (MaxEnt) method to reconstruct krill distribution and estimates of mean density. This method may be useful for the reconstruction of sparse and noisy acoustic line-transect survey data. Results show interannual differences in mean krill density ranging from 12 to 36 g m^{-2} in the western box and 11 to 160 g m^{-2} in the eastern box. Mean biomass estimates were similar to those obtained from the Jolly and Hampton approach, but the estimated variances differed considerably between the approaches.

3.78 The MaxEnt method also provided some persistent pattern of krill distribution, so-called 'hot-spots'. The evidence of consistent appearance of krill at these 'hot spots' may have importance for the understanding of krill distribution in general (i.e. non-random distribution and clustering of aggregations), and consequently for the survey design, and finally for the understanding of foraging behaviour of krill predators.

3.79 The Working Group welcomed the presentation of new methods to improve the accuracy of krill biomass estimates. However, the Working Group felt unable at this stage to recommend this method for future survey data analyses before the advantages of this method have been identified relative to the currently applied standard method (for further detailed discussion see paragraphs 3.106 and 3.107).

3.80 WG-EMM-02/50 highlighted that the accuracy and precision of acoustical surveys of krill abundance depend primarily on the uncertainties in identifying acoustical backscatter from Antarctic krill and estimating the mean backscattering cross-sectional area (σ_{bs}) or target strength (TS) of krill.

3.81 The Working Group noted that WG-EMM-02/36, 02/49 and 02/50 described methods for potentially reducing measurement uncertainties associated with reconstructing krill distribution and mean density from sparse data, species delineation, and TS estimation respectively. The implications for a re-analysis of the CCAMLR-2000 Survey data are unknown (for further detailed discussion on the methods, see paragraphs 3.109 and 3.110).

3.82 The Working Group also noted that the methods introduced in WG-EMM-02/49 and 02/50 will not only improve the accuracy and precision of the acoustic biomass estimates, but will also affect the mean. The implications for past surveys such as the CCAMLR-2000 Survey are yet unknown.

3.83 Dr Demer indicated that he is preparing a paper that quantifies the effects of using the stochastic distorted wave Born approximation (SDWBA) scattering model for species delineation and TS estimation on the CCAMLR-2000 Survey estimate of B_0 and associated CV.

Environmental Interactions

3.84 Dr Trathan identified that a number of papers provided details about Members ongoing work regarding the environment in areas of interest to CCAMLR. These include WG-EMM-02/17, 02/44, 02/54 and 02/60.

3.85 WG-EMM-02/17 described monitoring studies of sea-surface temperature at South Georgia from which the authors suggest temperatures have been anomalously cool in the early 2000s. WG-EMM-02/44 described how the Drake Passage Oscillation Index, first described by Naganobu et al. (1999), has now been extended backwards in time to 1952. This series is based on atmospheric pressure differences between Rio Gallegos and Esperanza. A 12-month running mean indicates considerable variability in the signal. WG-EMM-02/54 provided information on an atlas of sea-ice jointly produced by the University of Tasmania and the Australian Antarctic Division. The atlas compiles AVHRR satellite imagery initially to provide information on sea-ice in the vicinity of the CEMP sites at Béchervaise Island, near Mawson Station, at Edmonson Point, in the vicinity of the Terra Nova Bay Station, and at Ross Island. The atlas is scheduled for release in August 2002.

3.86 Dr Kerry reported that the atlas of sea-ice would be available to interested parties as a set of CD-ROMs.

3.87 WG-EMM-02/43 considered the distribution of Antarctic krill found during the Japanese RV *Kaiyo Maru* survey in January 1988 and that found during the CCAMLR-2000 Survey. The paper reports differences in sea-ice extent, oceanographic structure and krill distribution during 1988 and 2000. The authors suggested that Antarctic Surface Water, consisting of Winter Water and Summer Surface Water, was more extensive in 1988 extending northwards and covering a large area of the Scotia Sea. In contrast, Antarctic Surface Water was reduced and only occurred to the south during 2000. The authors used an environmental index of ocean temperature integrated over the top 200 m (EI $\overline{Q}_{200}$) of the water column as an index of upper ocean structure; they suggested that krill density is higher in association with colder values of the index.

3.88 WG-EMM-02/60 described how the ecosystem of the Ross Sea is composed of two related biotic systems – the Ross Sea shelf ecosystem and the Ross Sea slope ecosystem. To date, these two systems have largely escaped from the effects of human harvesting, although the Ross Sea slope ecosystem has, like all other large marine ecosystems, experienced harvesting of large baleen whales. The paper described the physical and trophic interactions in the Ross Sea, emphasising the importance of key prey species. The author suggested that the Ross Sea is an exceptional system and, given the history of scientific exploration in the region, forms a unique ecosystem laboratory for studying the biological consequences of climate change.

3.89 The Working Group agreed with the conclusion of WG-EMM-02/60 that the Ross Sea provided a unique natural location where commercial harvesting has been minimal.

Further Approaches to Ecosystem Assessment and Management

3.90 Dr Trathan indicated that only one paper was available to the Working Group that described further approaches to ecosystem assessment and management.

3.91 This paper, WG-EMM-02/26, provided information about the management of southern African fish stocks and moves towards establishing target populations for seabirds in South Africa, especially those of conservation value. It suggested that monitoring parameters that enable functional relationships to be developed between seabirds and their prey and the development of coupled predator–prey models should be considered. The paper also described anomalous breeding patterns of seabirds at Marion Island during 1997, and highlighted how large-scale global climate anomalies may episodically influence breeding success.

3.92 Dr Constable commended the paper and encouraged the authors of such studies to present their results to the proposed WG-EMM Workshop on Management Procedures that is scheduled to take place in 2005.

Other Prey Species

3.93 The Working Group considered five documents (WG-EMM-02/4, 02/9, 02/10, 02/11 and WG-FSA-02/6) describing diet studies that focused on predator–prey linkages involving prey species other than krill. These papers illustrate that there are many sources of variation in predator diets. The importance of krill, relative to other prey species, in the diets of predators varies from year to year and is also a function of season and location. The species composition of alternative prey also varies temporally and spatially.

3.94 WG-EMM-02/4 described how foraging patterns and breeding output of Antarctic shags varied between three colonies from the Antarctic Peninsula. Birds from one colony (at Py Point) made longer foraging trips and produced fewer chicks than birds from the other two colonies. This difference was attributed to differences in the species composition of the prey consumed by the birds at Py Point.

3.95 In relation to the submission of data on diet, foraging ecology and breeding biology of the blue-eyed shag, the Working Group recollected that this species is not a CEMP indicator species. However, the evaluation of its potential as a species to assist in monitoring young life-history stages of some harvested fish species had been encouraged.

3.96 Scientists engaged in this work were encouraged to prepare a synthesis of work to date so that the utility of this approach can be evaluated by WG-EMM and WG-FSA.

3.97 Consideration of the utility of the blue-eyed shag as an indicator species within CEMP would be subject to the approaches set out in WG-EMM-02/21 and paragraph 6.3.

3.98 WG-EMM-02/9, 02/10 and 02/11 described variation in the diets of sub-adult male fur seals. Interannual variation in the relative importance of krill and fish to the diets of sub-adult males was documented in WG-EMM-02/9 and spatial variation in the species composition of fish prey was documented in WG-EMM-02/10. Temporal variation in the consumption of penguins by male fur seals was documented in WG-EMM-02/11.

3.99 Variations in the consumption of benthic and pelagic fish by various predators in the Antarctic food web were reviewed in WG-FSA-02/6. In neritic zones, benthic fish that feed on demersal organisms are more important in predator diets, and, in offshore regions, pelagic fish that feed on krill are more important.

3.100 The Working Group noted a request made at last year's Workshop on Approaches to the Management of Icefish (SC-CAMLR-XX, Annex 5, Appendix D, paragraph 8.7) that consideration be given to the importance of *Champsocephalus gunnari* as a prey species. Information on the importance of *C. gunnari* to predators might be used to estimate a desired escapement. Along these lines, the Working Group noted that the 'species profile' currently being prepared for WG-FSA as background information for stock assessments of *C. gunnari* would also be useful for building models that describe the role of this fish in the ecosystem. Ultimately, a model that describes the role of *C. gunnari* in the ecosystem will need to examine the effects of fishing for both krill and the fish itself, and this will require collaborative work between WG-EMM and WG-FSA.

3.101 In regard to *C. gunnari*, the Working Group also noted that time-series data are available for icefish (e.g. survey estimates of biomass), and these data might be useful in expanding the scope of CEMP to consider predator–prey interactions based on species other than krill and for furthering the work of the CEMP review (Appendix E).

Methods

3.102 The WG-EMM Subgroup on Methods considered nine papers of which one (WG-EMM-02/52) addressed a revision of an existing CEMP standard method, two (WG-EMM-02/46 and 02/48) addressed issues relating to the interpretation of CEMP indices and four (WG-EMM-02/35, 02/37, 02/49 and 02/50) were concerned with acoustical determination of krill distribution and abundance. An additional paper (WG-EMM-02/34) that addressed the analysis of aerial surveys of penguin populations was also considered.

Modifications to Current Methods

3.103 WG-EMM-02/52 proposed changes to CEMP Standard Method C2 (Antarctic fur seal pup growth) in response to discussion in the subgroup at WG-EMM-01 (SC-CAMLR-XX, Annex 4, paragraph 3.92). The proposed revision would require that the median pupping date for the colony becomes 'Mandatory Data' and should be reported on the CEMP data form. The Working Group endorsed these changes and approved the following revised text to Procedure B:

> Determine the median pupping date (the date by which 50% of pups are born) for the colony. Weigh a random sample of about 100 pups, including a minimum of 40 of either sex, at 30-day intervals starting 30 days after the median pupping date. Ideally the last sample should be collected just prior to weaning, i.e. at about 100 to 110 days after birth. Determine the mean mass for each sex.

3.104 It was emphasised that selection of pups for weighing should be as unbiased as possible and that pups should not be selected on the basis of size and that there should be no collections targeted at a single sex. Members were encouraged to provide the median date of pupping for years in which they have previously submitted data using Standard Method C2, Procedure B.

Developments

3.105 In paragraph 3.93 of the report of WG-EMM-01 (SC-CAMLR-XX, Annex 4) it was agreed that the sampling protocols for the CCAMLR-2000 Survey should be considered as the CEMP standard method for collection of acoustic data. Similarly, the CCAMLR-2000 data-processing methods could be considered the CEMP standard method for analysis of acoustic data. While standardisation is an important objective when comparing data from different surveys, the Simrad EK500 echosounder equipment has been superseded, and potential improvements to the CCAMLR-2000 methods are presented in multiple papers. In WG-EMM-02/35, 02/37, 02/49 and 02/50 new methods are presented for: (i) estimating krill distribution and abundance from sparse acoustic backscatter data (WG-EMM-02/35), (ii) multi-frequency identification of species (WG-EMM-02/37 and 02/50), and (iii) modelling krill target strength (WG-EMM-02/49). Consequently, the authors of these papers were asked to explicitly identify the merits of these methods relative to the CCAMLR-2000 methods and identify the implications for reanalysis of existing survey data.

3.106 Maximum entropy methods have been used to reconstruct quantitative images from incomplete and noisy physical data. In WG-EMM-02/35, a method for inferring stock density and mapping distribution from acoustic line-transect data is presented. The method takes account of spatial correlation in the observed data and seeks to reconstruct a distribution of density across the whole survey area that is both consistent with the observed data and for which the entropy is maximised.

3.107 The Working Group recognised that this was another example of the many methods for interpreting sparsely sampled data. It is recommended that the maximum entropy and CCAMLR-2000 analytical methods along with other methods be evaluated and compared to each other using a simulated highly skewed krill distribution as the benchmark. The implications of the results should also be addressed regarding management issues. Such evaluation should also assess the maximum transect spacing for providing unbiased assessments.

3.108 WG-EMM-02/37 described a multi-frequency method that provides acoustical classification of two euphausiid species (*E. superba* and *E. crystallorophias*). The approach is a Bayesian approach to effectively inverting a fluid sphere model using volume backscattering measurements at three frequencies (38, 120 and 200 kHz) to estimate equivalent spherical radii of sound scatterers (one, the other, or neither of the two euphausiid species). The empirical scattering spectra are shown to be significantly different for these two very similar euphausiid species. According to the authors, the fundamental reason(s) for the differences are unknown. In many ways, the method described and employed in WG-EMM-02/37 is similar to the method proposed in WG-EMM-94/12 for delineating *E. superba* from *Salpa thompsoni* (i.e. multiple-frequency backscatter measurements and a statistical inversion of scattering models). These studies show that methods incorporating statistical fits of multiple-frequency backscatter data to physics-based scattering models have the potential to improve the accuracy and precision of acoustical identification of species. However, their effectiveness depends greatly on the uncertainties in the scattering models used. The Working Group agreed that this three-frequency method be compared to the CCAMLR-2000 two-frequency identification method. The implications of adopting the three-frequency technique for reanalysis of historical data and for analyses of future survey data should be addressed.

3.109 Model estimates of krill TS are either based empirically or on the physics of sound scattering. For Antarctic krill, Greene et al. (1991) proposed a linear model of TS versus total length (L), which is based on measurements of a variety of crustacean zooplankton (Wiebe et al., 1990), and corroborated at frequency f = 120 kHz for krill of two mean L (Foote et al., 1990; and Hewitt and Demer, 1991). The implications of using the Greene et al. model were explored (Everson et al., 1990), and the model was provisionally adopted as an international standard for estimating krill biomass (SC-CAMLR-X). Alternatively, McGehee et al. (1998) proposed a physics-based model to predict the TS of Antarctic krill versus incidence angle (θ). Based on the distorted wave Born approximation (DWBA), the model depends upon the coherent summation of scattering from elements of a discretised bent cylinder. It was empirically validated at 120 kHz near broadside incidence ($\theta \approx 90°$), but large discrepancies were observed at other angles away from the main lobe. In WG-EMM-02/50, it is shown that phase variability in the scatter from elements of a discretised bent cylinder (krill model) causes a dramatic flattening in the side-lobe regions of TS(θ), while negligibly affecting the main scattering lobe. These results are consistent with the krill TS measurements in McGehee et al. (1998). Thus, by accounting for phase-variability in the solution of the DWBA model, a more accurate and thus practical tool (SDWBA model) has been developed for predicting krill TS. A comparison between the SDWBA and Greene et al. TS models should be made and the implications of adopting a new physics-based model should be outlined.

3.110 In WG-EMM-02/49, total scattering cross-sections (σ_t) of Antarctic krill were acoustically measured over a broad-bandwidth (36 to 202 kHz) using a new technique (De Rosny and Roux, 2001). Measurement accuracy was determined to be 0.4 dB using standard metal spheres for references (Demer et al., in press), and the precision was estimated from the variability in krill TTS measurements. Opposed to the free-field requirement of conventional TS measurement techniques, the new method allows measurements of total target strength (TTS = 10log($\sigma_t/4\pi$) to be extracted from time series of reverberation in a highly echoic tank. Also intriguing is that absolute measurements of sound scatter can be made without the usual system calibration, and the animals' orientations and positions within the acoustical beam are inconsequential. TTS of Antarctic krill measured with this technique provided broad-bandwidth corroboration of the SDWBA model described in WG-EMM-02/50. This study improves upon methods for acoustical identification and target strength estimation for Antarctic krill, thus reducing the uncertainty in biomass estimation using multi-frequency echosounder data and echo integration methods.

3.111 Two papers (WG-EMM-02/46 and 02/48) identified the importance of collateral information in the interpretation of CEMP indices from Adélie penguins at Béchervaise Island. WG-EMM-02/46 assessed the relationship between CEMP parameters and the mass of individual Adélie penguins collected using an automated weighing system (APMS). The analysis indicated that the mass of female penguins on post-laying departure from the colony was positively correlated with subsequent measures of reproductive performance, whereas there was little correlation between other measures of adult mass and reproductive output.

3.112 In WG-EMM-02/48, the importance of demographic parameters in the interpretation of population size parameters were exemplified by the different roles of adult survival and juvenile recruitment in changes in population size of Adélie penguins. In recognising the importance of collateral data in interpreting CEMP indices, the Working Group identified the need to develop appropriate protocols for the collection, analysis and interpretation of such additional parameters in order to make appropriate inter-site comparisons.

3.113 WG-EMM-02/34 outlined an automated analytical approach to determining the population size of macaroni penguins from aerial surveys. The methods utilise digitised, high definition, colour photography and image analysis software to discriminate and count penguins. The Working Group encouraged further development of these methods, particularly focussing on development of appropriate analysis software. It was suggested that multiple regression techniques may improve discrimination between penguins and the background. Also, the relationship between observer counts and photo-image analysis may not be a simple linear relationship. There may be little differences between the two methods at low densities; however, biases may be evident at greater densities. This could be tested in part by examining the relationship between observer error and density.

3.114 The Working Group recognised that the membership of the Subgroup on Methods may not necessarily include the required expertise to consider and evaluate fully all of the methods submitted. The development of new standard methods should be viewed as a multi-stage process involving the following stages:

(i) a new method is described to the Working Group in a tabled paper;

(ii) the method is considered by the Working Group in terms of its potential advances over existing methods;

(iii) the new method is submitted for appropriate peer review and subsequently evaluated with regard to its suitability for use by CCAMLR;

(iv) the Working Group decides whether to incorporate the new method into its program; and

(v) a full description of the method is lodged with the Secretariat.

3.115 The Working Group recognised that the role of the Subgroup on Methods should be to facilitate, rather than carry out, this process.

Future Surveys

3.116 A design for an acoustical survey of the Ross Sea and adjacent area of the Pacific Ocean in the early austral summer 2003/04 was presented in WG-EMM-02/31 for discussion and approval by WG-EMM. In addition to planned acoustical measurements of the distributions and abundances of Antarctic krill and ice krill, concurrent observations will be made of their top predators. Moreover, samples for studies of krill demography, energetics, physiology and genetics will be gathered using net tows, and the associated water masses will be characterised using CTD and XBT sampling.

3.117 While indicating that the CCAMLR-2000 Survey methods will be followed, there are many notable differences. The Italian survey plan is to use zigzag transects with ad hoc sampling densities, rather than planned randomly-spaced parallel-line transects. The planned analyses of these data are based on rectangles of constant area, rather than assumed-independent transect lines. Species delineation is to be effected using a three-frequency algorithm described in WG-EMM-02/37 rather than the two-frequency algorithm used in the CCAMLR-2000 Survey. Krill samples will be collected using a Hamburg Plankton Net rather than a RMT-8 net. While each of these planned methods has merit, they are inconsistent with the methods described in the CCAMLR website and used in the CCAMLR-2000 Survey data collection and analysis. Because of the many differences in the survey and analysis methods, it is anticipated that the results from the proposed multi-disciplinary survey may be difficult to compare to the CCAMLR-2000 Survey results.

3.118 WG-EMM commended the initiative of the Italians to conduct the survey.

3.119 It was noted that the problems encountered in surveying the Ross Sea area are somewhat different to those in other areas (i.e. species and species mixture, water masses and ice conditions). The historical data on water masses and krill distributions should be considered in the survey design.

3.120 While randomly-spaced parallel-line transects are highly recommended, it is recognised that dead-heads are eliminated by using zigzag transects and sampling time is thus reduced. However, one drawback of zigzag transects is that the sampling density is not uniform. In this case, the current sampling plan has different survey densities on-shore versus off-shore and for the expected distributional areas of *E. superba* and *E. crystallorophias*.

3.121 While zigzag transects may be processed as two sets of parallel-line transects, the conditions of random spacing and independence are not met. The authors agreed to use randomly-spaced parallel-line transects if five or more days of ship time can be acquired. However the survey will be conducted in early summer when ice conditions are likely to strongly influence the vessel track.

3.122 To make the survey results comparable to other surveys, WG-EMM strongly advised that the authors adopt the CCAMLR-2000 Survey sampling protocols and process the data two ways – using the CCAMLR-2000 Survey methods and the newer techniques discussed in the plan.

3.123 It was recommended that New Zealand be asked whether they could collaborate on the survey of the Ross Sea to extend the survey coverage.

Key Points for Consideration by the Scientific Committee

3.124 Arising from an analysis of submissions to the CEMP database, Members were encouraged to use the current data submission forms and to provide additional information in comment fields where this will assist data validation (paragraph 3.4).

3.125 The CEMP database requires modification to increase ease of access to data prior to the CEMP Review Workshop. However, a full redesign of the database should not be undertaken until the workshop (paragraph 3.10).

3.126 Based on CEMP data submitted to the CCAMLR database and from standard annual krill surveys for krill in Subarea 48.3, 2001/02 has been a good year for krill in comparison to the available time series of data (paragraphs 3.2 and 3.11).

3.127 In considering indices of predator–fisheries overlap, the Working Group noted that there was divergence in the four indices currently used and that an assessment of their utility to the work of WG-EMM should be evaluated. It was suggested that the Agnew–Phegan index was of limited utility and that the Secretariat should discontinue to calculate it (paragraph 3.40).

3.128 Developments of methods for the identification of krill, the determination of target strength and the analysis of distribution and abundance using acoustic survey data have the potential to provide reanalysis of historical krill survey data, including the CCAMLR-2000 Survey (paragraphs 3.105 to 3.110).

3.129 Analysis of time series of krill demography over a range of sites in the Scotia Sea and Bellingshausen Sea indicated large-scale concordance in krill recruitment. These analyses highlight the importance of considering the impact of regional differences in rates of krill growth and mortality when determining parameter values to be used to develop precautionary catch limits for krill using the GYM (paragraphs 3.54 to 3.56 and 3.62 to 3.64).

3.130 The Working Group endorsed a revision to CEMP Standard Method C2 (Antarctic fur seal pup growth), Procedure B, which clarified issues of sampling and interpretation of this index (paragraph 3.103).

3.131 The Working Group also clarified procedures and protocols for considering and evaluating new methods to derive indices of relevance to its work (paragraph 3.114).

WORKSHOP TO DEFINE PREDATOR UNITS

4.1 Last year the Scientific Committee endorsed the proposal by WG-EMM to hold a Workshop on Small-scale Management Units, such as Predator Units (SSMU Workshop), during its meeting this year (SC-CAMLR-XX, paragraphs 6.11 and 6.12 and 6.15 to 6.19, and Annex 4, paragraphs 4.1 to 4.11 and 5.9 to 5.13). The aim of the workshop was to define these units in order to facilitate the subdivision of the precautionary yield in Area 48 but that the manner in which the overall catch limit would be subdivided would be determined at a future meeting (SC-CAMLR-XX, paragraph 6.18).

4.2 The workshop was convened by Dr Trivelpiece from 7 to 15 August 2002. The report of the workshop is attached as Appendix D.

4.3 The Working Group welcomed the report of the workshop and thanked Dr Trivelpiece and the steering committee for facilitating such a successful meeting and for the workshop participants for such a thorough assessment of the subdivision of Subareas 48.1, 48.2 and 48.3 for use as small-scale management units.

4.4 The Working Group extended its special thanks to Dr Constable for his persistent vision, perseverance and hard work throughout all stages of the workshop.

4.5 The Working Group accepted the report, noting that it was the best scientific assessment available on the subdivision of Area 48.

4.6 The Working Group agreed that future preparations for workshops should include the development of format styles for the preparation of the report. These would include guidelines for satisfactory production of figures, maps and tables. It was envisaged that such styles would help ensure that the initial preparation of figures, tables and text would not need to be revised for report production.

STATUS OF MANAGEMENT ADVICE

Designation of Protected Areas

5.1 The WG-EMM Subgroup on Designation and Protection of CEMP Sites considered items that had been referred to it. These tasks included: (i) review of four marine protected areas that sought designation as Antarctic Specially Protected Areas (ASPAs) under the Antarctic Treaty, and (ii) review of revised CEMP site maps. The Subgroup also considered the organisation of its work by addressing: (i) a consolidation of the terms of reference for the subgroup, as there has been an increase in tasking since the subgroup was formed in 1992, and (ii) the possibility of renaming the subgroup to better reflect its current tasks.

5.2 The subgroup reviewed four management plans for protected sites containing marine areas that sought protection as ASPAs under the Antarctic Treaty. Three of the sites had already been afforded protection as SSSIs under the Antarctic Treaty. These were SSSI No. 36 (Eastern Dallman Bay, WG-EMM-02/57), SSSI No. 35 (Western Bransfield Strait, WG-EMM-02/58), and SSSI No. 1 (Cape Royds, WG-EMM-02/59). One of the sites (Terra Nova Bay, WG-EMM-02/56) was a revised plan for a proposed new protected area under the Antarctic Treaty.

5.3 Subgroup members first reviewed the three plans for the SSSIs that were currently afforded protection by the Antarctic Treaty. The management plans for these sites originated in the USA and had been revised to meet the new format as ASPAs adopted when Annex V of the Protocol on Environmental Protection to the Antarctic Treaty came into force. Additionally, new data available since the management plans had been written were used to slightly adjust boundaries.

5.4 The following main evaluation criteria identified by the Commission (CCAMLR-XIX, paragraphs 11.20 and 11.21) were used to review the three revised SSSIs plans:

(i) whether a site proposed for designation as a marine protected area affects actual or potential harvesting of marine resources in relation to Article II of the Convention; and

(ii) whether the draft management plan for the proposed site might prevent or restrict CCAMLR-related activities.

5.5 The Cape Royds plan (WG-EMM-02/59), which included a 500 m wide marine coastal strip to protect the seaward access and near-shore feeding ground of Adélie penguins was recommended for CCAMLR approval by the subgroup.

5.6 Plans for Eastern Dallman Bay (WG-EMM-02/57) and Western Bransfield Strait (WG-EMM-02/58) were reviewed. It was noted that these plans afforded protection to marine areas within Subarea 48.1 and have been in force for about a decade. Both management plans limited access to the area for scientific study of the marine environment, for essential management purposes consistent with plan objectives, and/or transit through the area.

5.7 Members commented that these two sites were located within the area of the Palmer Long-Term Ecological Research Program (PAL-LTER), which is a study providing useful long-term data of interest to CCAMLR. It was noted that both sites included potential areas for fisheries that are suitable for bottom trawling. It was also noted that no conflict with CCAMLR objectives had been raised since adoption by the Antarctic Treaty Consultative Meeting (ATCM) in 1991 and protection was unlikely to result in conflict in the future. Thus, the subgroup recommended CCAMLR approval for both plans.

5.8 The subgroup reviewed the plan which originated in Italy for Terra Nova Bay (WG-EMM-02/56). As this is a new proposal being reviewed by the ATCM and CCAMLR, additional review criteria identified in SC-CAMLR-XIX, paragraph 11.21 were applied. This plan includes a narrow strip of coastal waters immediately south of Terra Nova Bay Station. The subgroup recommended CCAMLR approval of the plan. The subgroup also recommended that the originators of the plan add the location of the nearby Adélie penguin population to the map.

5.9 The subgroup also made the following comments regarding consistency to the originators of the four plans:

(i) The subgroup observed that the plans for Eastern Dallman Bay, Western Bransfield Strait, and Terra Nova Bay did not contain a time frame for assessing whether the areas continue to serve the purposes for which they were designated. The subgroup recommended that a period for assessment, such as the five years noted in the Cape Royds plan, be included in all plans seeking Antarctic Treaty protection. The subgroup recommended that this would be best done by adding an additional point regarding the time frame for assessment of whether the site continues to serve the purposes for which it was designated, rather than including it with field visits to determine whether management and maintenance measures are adequate.

(ii) The subgroup also recommended the inclusion of a list of references in each plan that would allow interested parties to obtain more detailed information on the sites and to check the accuracy of the plan.

(iii) Finally, the subgroup recommended that originators of revised management plans currently afforded protection under the Antarctic Treaty include a brief summary of the main changes from the current plan in force when submitted to the ATCM for approval.

5.10 WG-EMM concurred with the subgroup's recommendation for CCAMLR approval for all four management plans noted, and with the recommendations for improvements directed to the originators of each plan.

5.11 The Scientific Committee (SC-CAMLR-XVIII, paragraph 4.40(v)) noted that a number of older maps of CEMP sites had deficiencies. Since 2000, the Secretariat has sent annual requests to Members to produce and submit good quality revised maps of CEMP sites for inclusion in the CEMP database. Revised maps had been submitted by a number of countries and reviewed by the subgroup. All submitted maps are now available on the CCAMLR website. As of 2002, maps are still missing for a number of sites. Members responsible for CEMP research at these sites are Brazil, Italy and the USA. The subgroup encouraged these Members to submit maps as soon as practical.

5.12 The subgroup noted that the brief guidelines for maps found in Conservation Measure 18/XIX (Annex 18/A) lacked detail. A copy of the Guidance Notes for Producing Maps for Inclusion in Management Plans from the Antarctic Treaty (CEP-I Final Report, Appendix 3) was distributed as an information item. It was suggested that advice on modern map production guidelines for protected areas should be considered intersessionally, in order to provide better guidance on producing maps of CEMP sites. WG-EMM endorsed the subgroup's intersessional plan to consider improvements to CCAMLR's guidance to producers of maps for CEMP sites.

5.13 The subgroup considered its current terms of reference as follows:

(i) To review the details of proposals relating to designation and protection of CEMP monitoring sites and review of CEMP management plans (SC-CAMLR-XI, Annex 7, paragraph 4.5).

(ii) To develop a methodology for assessment of proposals for marine protected areas forwarded in accordance with Article 6(2) of Annex V of the Protocol on Environmental Protection to the Antarctic Treaty (SC-CAMLR-XVIII, paragraph 8.98; CCAMLR-XVIII, paragraph 4.9).

(iii) To provide advice on marine protected areas that seek designation as an Antarctic Specially Protected Area (ASPA) or an Antarctic Specially Managed Area (ASMA) under the Antarctic Treaty (CCAMLR-XIII, paragraphs 11.16 to 11.18).

(iv) To provide advice on the implementation of closed areas that may be proposed in accordance with the provisions of Article IX.2(g) of the Convention, specifically with regard to 'the designation of the opening and closing of areas, regions or subregions for purposes of scientific study or conservation, including special areas for protection and scientific study' (CCAMLR-XIX, paragraph 11.21).

5.14 It was noted that proposals for closed areas made by WG-FSA would not ordinarily be passed on to WG-EMM or the subgroup for advice.

5.15 The subgroup chair noted the usefulness of an informal document produced by the Secretariat that summarised CCAMLR decisions related to the evaluation of Antarctic Treaty management plans containing marine areas submitted to CCAMLR for approval. WG-EMM recommended that the Secretariat submit this document formally to WG-EMM in 2003 for further review by the subgroup. Additionally, it was recommended that at the 2003 meeting the subgroup summarise its current terms of reference, with reference to past CCAMLR decisions, in a manner that properly places the tasks in context.

5.16 The Working Group recommended that the name of the subgroup be changed to 'Advisory Subgroup on Protected Areas'.

Harvesting Units

5.17 The Working Group was to consider a report from an intersessional group, co-convened by Drs Naganobu and Constable, which had been asked to develop the approach for designating appropriate scales for harvesting units in the CCAMLR Convention Area (SC-CAMLR-XX, paragraphs 5.6 to 5.11).

5.18 Dr Constable reported on behalf of the group, noting that Dr Naganobu had collated a large number of references and information to help with this task. Dr Constable also indicated that he had insufficient time in the past year to help complete this work.

5.19 The Working Group thanked Dr Naganobu for progressing this issue and looked forward to progress being made on this task in the coming year.

5.20 Dr Constable indicated to the Working Group that he, unfortunately, would be unlikely to be able to attend to this work in the near future. Dr Nicol agreed to assume Dr Constable's responsibilities on this intersessional group.

Small-scale Management Units

5.21 The Working Group agreed with the recommendations of the SSMU Workshop, that the proposed divisions of the region provided in the report be used by the Commission as a basis on which to subdivide the precautionary catch limit for krill in Area 48 as well as helping further the work of the Commission and the Scientific Committee in developing management procedures for krill fisheries that can accommodate localised effects on predators.

5.22 The Working Group agreed with the subdivision of Area 48 into the following units recommended in the workshop report, noting the nested hierarchy of areas described in the report:

- (i) Subarea 48.1
  - (a) 48.1 Pelagic Area
  - (b) 48.1 Land-based Predator Area
    - (i) Western Antarctic Peninsula
    - (ii) Drake Passage
      1. West
      2. East
    - (iii) Bransfield Strait
      1. West
      2. East
    - (iv) Elephant Island

- (ii) Subarea 48.2
  - (a) 48.2 Pelagic Area
  - (b) 48.2 Land-based Predator Area
    - (i) West South Orkney
    - (ii) East South Orkney
      1. North
      2. South

- (iii) Subarea 48.3
  - (a) 48.3 Pelagic Area
  - (b) 48.3 Land-based Predator Area
    - (i) West South Georgia
    - (ii) East South Georgia

- (iv) Subarea 48.4.

5.23 The Working Group noted that there was insufficient time at the workshop to consider a finer division of Subarea 48.4, but that this could be achieved at a later meeting using the principles established by the workshop.

5.24 The Working Group requested that the Secretariat, in consultation with the Convener of the Working Group and the Chair of the Scientific Committee, develop maps of these units in GIS form.

5.25 The Working Group noted the uncertainty surrounding the extrapolation of known foraging characteristics of land-based predators to colonies for which no foraging information was known (Appendix D, paragraphs 5.17, 5.19 and 5.28). It was noted that the proposals took account of the known information and assisted by, though not dependent on, the extrapolated results.

5.26 The Working Group noted (Appendix D, paragraph 5.34) that:

(i) this assessment is the first of its kind in CCAMLR;

(ii) this assessment used a variety of datasets that enabled the detailed analyses presented here, such that deficiencies in one dataset could be compensated by strengths in others;

(iii) fine-scale fisheries data were very important to the success of this assessment;

(iv) a number of uncertainties remain regarding the relationships between predators, krill and the fishery and further information on krill, krill movement, predator demand and predator foraging grounds may provide opportunities to refine these boundaries in the future;

(v) the next step is to develop an understanding of the linkages and dynamics between these areas in order to facilitate the subdivision of the precautionary catch limit for krill in Area 48, taking account of the oceanography and the environmental variability of the region;

(vi) this assessment has demonstrated the utility of satellite tagging programs for an understanding of the relationships between predators, krill and the fishery, and, as a result, the workshop highly recommended further studies of this kind; and

(vii) the manner in which these proposed small-scale management units are used may have implications for monitoring that would need to be considered by the Commission.

5.27 The Working Group agreed that the term 'small-scale management unit' provides a reference to the recommended subdivision described in paragraph 5.21, but that work remains to determine how these units would be used to achieve those purposes.

5.28 With respect to the tasks in paragraph 5.21, the Working Group noted that refinements to the boundaries may be required over time to fully meet the requirements of the Commission in its implementation of those tasks. The Working Group agreed to consider such proposals for refinements as they arise in the work on these tasks.

5.29 The Working Group invited Members and interested specialists to provide submissions to help the Working Group address these tasks into the future.

5.30 The Working Group agreed that the submission of haul-by-haul krill fishery data is necessary for future assessments of activities in these units. It requested that the Scientific Committee consider how the confidentiality requirements for the Japanese krill fishery could be met while maintaining the spirit and intent of the Rules for Access and Use of CCAMLR Data.

5.31 The Working Group agreed that the steering committee for the review of CEMP to be undertaken next year be asked to include in their review consideration of the utility of CEMP Integrated Study Regions and whether the proposed small-scale management units might provide a suitable alternative structure for future work on the relationships between krill, predators and the fishery.

Generalised Yield Model

5.32 New information was presented which may contribute to the development of input parameters used in the GYM.

5.33 The influence of regional differences in growth and mortality on population size structure was examined using data on the length-frequency distribution of krill in the Scotia Sea using samples from the South Shetland Islands and South Georgia collected annually from 1991 to 2000 (WG-EMM-02/16). The study found a higher mortality rate at South Georgia than at the South Shetland Islands, and this was consistent with published values and with other euphausiids species. Findings also indicated that first year krill are advected into different regions of the Scotia Sea where the resultant population size structure is determined by regional differences in growth and mortality.

5.34 In another study (WG-EMM-02/20), the proportional recruitment indices for one- (R1) and two-year-old (R2) krill were found to differ substantially between years in the upstream area of Elephant Island. Recruitment indices showed a significant correlation for 1-year-old krill between scientific surveys from the northern Bellingshausen Sea, the Elephant Island area and South Georgia. The correlation was weaker for R2 recruitment indices. No correlation was detectable between the krill recruitment of Atlantic and Indian Ocean survey sites.

5.35 WG-EMM-02/36 presented a MaxEnt reconstruction of krill distribution and estimates of mean krill density within two survey boxes to the northeast and northwest of South Georgia. The reconstruction yielded mean krill densities for which the confidence limits were often narrower than for estimates based upon more conventional techniques (e.g. Jolly and Hampton, 1990).

5.36 The Working Group considered these developments and proposed that sensitivity analyses be conducted to examine regional differences in growth and mortality and their impact on estimates of yield calculated using the GYM. It was possible that variations in these parameters may not have a significant effect on the output.

5.37 Dr G. Kirkwood (UK) advised that his group in London was re-coding the main modules of the GYM based on available literature and documentation. This re-coding would allow independent validation of the GYM and the results of this work would be reported at next year's meeting.

5.38 Dr Constable advised that a new front-end module had been added to the GYM. This updated version of the GYM, together with supporting documentation, is available on CD-ROM from either Dr Constable or the Secretariat.

5.39 Dr Gasiukov reported that a recent critique on the use of the delta distribution for the analysis of trawl survey data had found that the estimator of the mean was not robust to seemingly small departures from the assumed delta distribution (Syrjala, 2000). This finding may apply to CCAMLR's mixture analysis program (CMIX). The Working Group noted that sensitivity analyses had been conducted during the development of CMIX (de la Mare, 1994) and that the output from the CMIX program did provide some measure of the degree to which the model assumptions were violated.

5.40 The Working Group noted that the Subgroup on Assessment Methods of WG-FSA was reviewing the analytical tools developed and used by WG-FSA. This review will include further evaluation of the GYM and CMIX. It also noted that there was considerable overlap in the development of quantitative methods for use by the Working Group and encouraged Members to remain aware of the work of that subgroup.

5.41 The Working Group also noted that the Secretariat was developing a database on CCAMLR software. This database would allow working groups to track each version of software developed and used by CCAMLR. The database would also include links to background documents and papers, user guides, validation analyses and references to working group meetings where the software had been used. A copy of the database, in its present state of development, was available at the meeting.

Existing Conservation Measures

5.42 The Working Group noted that Conservation Measure 217/XX established a uniform season (1 December to 30 November of the following year) for all fisheries in the Convention Area. Accordingly, the fishing season for krill in Division 58.4.2 had been revised in Conservation Measure 45/XX. The fishing seasons for krill in Area 48 and Division 58.4.1 were revised in 2000 (Conservation Measures 32/XIX and 106/XIX) along the same lines.

Data Reporting

5.43 The Working Group noted once again that monthly catch data (with no specified format) and STATLANT data were the only types of mandatory data required from krill fisheries (see also paragraph 2.64). It was also noted that the krill fishery in Area 48 was the largest fishery in the Convention Area and that its development had been a prime reason for establishing CCAMLR. Inconsistencies between conservation measures for krill fisheries and other fisheries were discussed.

5.44 The Working Group reaffirmed the need for detailed data on catch and effort (e.g. data submitted by fine-scale rectangle or haul-by-haul), and for the timely submission of such data using a consistent format (see also Section 2). However, consensus could not be reached on the timing for the introduction of such a requirement. This debate is longstanding, being first initiated at SC-CAMLR-VII (SC-CAMLR-VII, paragraph 2.45) in 1988 and remains unresolved (SC-CAMLR-XX, paragraphs 5.13 to 5.18 and Annex 4, paragraph 4.4; SC-CAMLR-XVIII, Annex 4, paragraphs 2.4 and 12.2(vii); SC-CAMLR-XVII, Annex 4, paragraphs 2.4 and 12.2(ii); SC-CAMLR-XVI, Annex 4, paragraphs 2.10 and 10.2; SC-CAMLR-XV, paragraph 10.8(vii); SC-CAMLR-XIV, Annex 4, paragraph 3.29;

SC-CAMLR-XIII, Annex 5, Table 3; SC-CAMLR-XII, Annex 4, paragraph 3.24 and Table 6; SC-CAMLR-X, Annex 5, paragraphs 7.18(i) and (ii) and Table 8; SC-CAMLR-IX, paragraphs 2.63 and 2.68 and Annex 4, paragraphs 113 and 115; SC-CAMLR-VIII, paragraphs 2.39, 2.40 and 2.42 and Annex 5, Table 4).

5.45 The SSMU Workshop had clearly indicated the value of detailed data on catch and effort. While some of these data had been provided by workshop participants, data representing approximately 30% of catches taken in 2000/01 had not been available for analysis. In addition, valuable time at the workshop could have been saved had data been submitted in a consistent format to the Secretariat prior to the meeting.

5.46 In addition, WG-EMM had discussed the need for detailed CPUE data which would reflect changes in abundance and could be used for input, for example, to the forthcoming workshop on the CEMP review, other planned workshops or revised assessment using the GYM.

5.47 WG-EMM also recognised the importance of data collected by scientific observers. It was agreed that these data complemented the detailed catch and effort data sought from Flag States. However, the irregular voluntary collection of observer data limited the scope of analyses based on such data.

5.48 Dr Shust questioned the need for detailed data, given that recent annual krill catches are stable and lower than those reported during the early years of the fishery. He also expressed concern that the collection and submission of detailed catch and effort data would place a significant burden on the crew of fishing vessels and may be sufficient to prevent new vessels entering the fishery.

5.49 In response, Mr Jones indicated that such data requirements were not considered to be demanding on the crew of a US-flagged fishing vessel. This vessel has recently joined the fishery and provided detailed haul-by-haul data.

5.50 The Working Group agreed that there were now compelling reasons for requiring detailed catch and effort data to be submitted regularly in standard format by all Members involved in krill fishing.

5.51 The Working Group advised the Scientific Committee that it cannot see a resolution of this matter in the short term. Consequently, the need for detailed catch and effort data in krill fisheries was referred to the Scientific Committee for further advice, including that of the Commission.

Key Points for Consideration by the Scientific Committee

5.52 WG-EMM recommended to the Scientific Committee:

(i) approval of the four management plans for protected sites containing marine areas that sought protection as ASPAs under the Antarctic Treaty (WG-EMM-02/56, 02/57, 02/58 and 02/59) (paragraph 5.10);

(ii) transmission of recommendations for improvements to the originators of the four plans (paragraphs 5.8 to 5.10);

(iii) endorsement of future tasks for the subgroup: (a) review of guidance for the production of maps of protected areas, (b) review of a paper by the Secretariat that summarises CCAMLR decisions related to the evaluation of Antarctic Treaty management plans containing marine areas that were submitted to CCAMLR for approval, and (c) production of a paper summarising its current terms of reference (paragraphs 5.12 and 5.15); and

(iv) endorsement of revision of the subgroup name 'Advisory Subgroup on Protected Areas' (paragraph 5.16).

5.53 A correspondence group will continue to examine the feasibility of subdividing some CCAMLR statistical areas into manageable harvesting units (i.e. as areas in which the CCAMLR objectives will need to be achieved) (paragraphs 5.17 to 5.20).

5.54 The Working Group recommended that the Scientific Committee accept the proposed divisions of the region in paragraph 5.22 and that these divisions be used by the Commission as a basis on which to subdivide the precautionary catch limit for krill in Area 48 as well as helping further the work of the Commission and the Scientific Committee in developing management procedures for krill fisheries that can adequately manage for localised effects on predators (paragraph 5.21).

5.55 The Working Group also drew the attention of the Scientific Committee to paragraphs 5.23 and 5.26 to 5.31.

5.56 The Working Group advised that work is continuing with the development and validation of the GYM. A new front-end module had been added to the GYM (available on CD-ROM). In addition, the main modules of the GYM are being re-coded by an independent programmer and this work will enable further validation. A reference database on CCAMLR software is being developed by the Secretariat (paragraphs 5.37 and 5.38).

5.57 The Working Group reaffirmed the need for detailed data on catch and effort from krill fisheries, and for the timely submission of such data using a consistent format. However, consensus could not be reached on the timing for the introduction of such a requirement. This debate is longstanding and was first initiated at SC-CAMLR-VII (paragraph 5.44).

5.58 The SSMU Workshop had clearly indicated the value of detailed data on catch and effort. While some of these data had been provided by workshop participants, data representing approximately 30% of catches taken in 2000/01 had not been available for analysis. In addition, valuable time at the workshop could have been saved had data been submitted in a consistent format to the Secretariat (paragraph 5.45).

5.59 Detailed data will be required to complete WG-EMM's work plan, including work at next year's workshop on the CEMP review and other planned workshops (paragraph 5.46).

5.60 WG-EMM cannot see how this matter can be resolved at working group level. Consequently, advice is sought from the Scientific Committee and the Commission on how to implement the submission of detailed catch and effort data to the Secretariat (paragraph 5.51).

FUTURE WORK

Review of CEMP

6.1 Prof. Croxall presented the report of the Interim Steering Committee for the CEMP Review (Appendix E).

6.2 The Working Group accepted and endorsed this report, together with its associated intersessional work plan. It thanked the Convener and members of the Interim Steering Committee for their work both intersessionally and at the meeting. The Working Group then commented on certain aspects of the report.

6.3 In respect of recommendations concerning the potential expansion of CEMP to include monitoring of predator–prey interactions for species other than krill, the Working Group specifically endorsed Appendix E, paragraphs 17 and 18. It noted that, if appropriate outline proposals were received, the nature and scope of potentially appropriate monitoring programs should be a topic for review and consideration by WG-EMM in its program of future work.

6.4 In relation to Appendix E, paragraph 21, Dr Kawaguchi expressed a concern of Japanese scientists that any management procedures developed in association with these approaches should not unnecessarily constrain or restrict current fishing operations.

6.5 In respect of the section on management advice, and especially Appendix E, paragraphs 22 to 24, Drs Sushin and Shust indicated that this aspect of the CEMP Review Workshop in 2003 is based on the assumption of potential competitive interactions between the krill fishery and the krill-dependent predators for krill resources. They stressed that this hypothesis is not proved yet and that its validity needs further examination by WG-EMM.

6.6 In relation to Appendix E, paragraph 30, Dr Fraser noted the importance of taking account of site-specific methodological and data differences, particularly in respect of Adélie penguins at Anvers Island (paragraphs 3.5 and 3.6) and recommended that analysis of CEMP data should be undertaken in close consultation with data holders.

6.7 The Working Group and Interim Steering Committee agreed with this and noted that all holders of data in the CEMP database would need to be informed of the potential analyses of their data as part of the CEMP review. This announcement should be accompanied by an invitation to participate in the appropriate aspects of the work associated with the CEMP review. It was agreed that this task should be added to the intersessional work plan of the CEMP review group.

6.8 With reference to further work on CSIs and on identification of anomalies (Appendix E, paragraphs 32 and 33), Dr Constable recommended that further work on the former should address issues raised in SC-CAMLR-XIX, Annex 4, paragraph 3.51. In respect of the latter, any work should build on the approach developed by the Subgroup on Statistics (SC-CAMLR-XVI, Annex 4, Appendix D). It was agreed that the Report of the Interim Steering Committee for the CEMP Review (Appendix E) would incorporate appropriate cross references.

6.9 Concerning the potential of CPUE indices, Dr Kawaguchi noted that WG-EMM-02/28 Rev. 1 showed fine-scale catch data in relation to catch per tow, catch per towing time and catch per day. He suggested that fine-scale catch data showed good correlation with catch per day and therefore, krill fine-scale catch data at this scale should be sufficient for the CEMP review. The Working Group agreed.

6.10 The Working Group endorsed the principle of inviting to the workshop international experts with experience of linking ecological and statistical models (Appendix E, paragraph 58). It provided the Interim Steering Committee with suggestions and endorsed the procedure set out in Appendix E, paragraph 59. Any budgetary implications should be discussed with the Secretariat at the earliest opportunity and well before the budget for the Scientific Committee is compiled.

6.11 In reviewing the intersessional work plan, Dr Constable suggested that the review generally, and tasks 1 to 3 in particular, might benefit from a summary of the spatial and temporal scales at which CEMP indices integrate and of the degree to which CEMP indices/parameters vary with consumption of krill. It was agreed to include this in the work plan.

6.12 The Working Group noted that there were important resource implications associated with the intersessional work plan. It noted that the work plan accorded explicit high priority to certain tasks, many of which required work by the CCAMLR Data Manager and his staff. This would require workloads substantially in excess of that needed to deliver the existing level of management of CEMP data in order to report to the Working Group. Some of this work would need to start very soon.

6.13 The CEMP Review Steering Committee should work with the Data Manager and Secretariat to define the extra resources needed for the CEMP review in order that these could be included in the review by the Scientific Committee of its resources and budget requirements for 2003. The need to provide the 2003 meeting of WG-EMM with the annual review and analysis of CEMP data (e.g. WG-EMM-02/5) should be considered by the CEMP Review Steering Committee.

6.14 The Working Group agreed that the Interim Steering Committee should continue its work as the formal steering committee for the CEMP review.

6.15 Dr D. Miller indicated that, in his new role as Executive Secretary, it would no longer be appropriate for him to continue as a member. He was thanked for his input to date.

6.16 Prof. Croxall indicated that, for practical and logistic reasons, he wished to share the responsibility of the convenership of the CEMP Review Steering Committee. The Interim Steering Committee had recommended Dr Southwell as a Co-convener. This was agreed by the Working Group.

Predator Surveys

6.17 During correspondence prior to WG-EMM-02, the Subgroup on Land-Based Predator Surveys recognised the complexity of regional surveys of land-based predators, given that they would cover large areas and multiple species. It was recognised from the outset that a coordinated strategy and design would be essential for planning and implementing such surveys.

6.18 As a first step in dealing with the likely complexity of regional surveys, Dr Southwell developed and circulated to the subgroup a general framework for decision-making as a tool for survey design planning (WG-EMM-02/45).

6.19 The subgroup discussed the contents of WG-EMM-02/45 and considered a general way forward for assessing the feasibility of regional surveys of land-based predators.

6.20 The subgroup recognised that the large amount of data on land-based predator abundance from previous local, and in some cases, regional-scale surveys would be invaluable in planning future regional surveys. In particular, these data offer the potential for use as 'pilot' data for evaluating candidate survey designs. It would be important to liaise with data holders to assess the possibility of using these data for evaluation purposes.

6.21 There was agreement that maximising the use of new and emerging technologies would be essential to the success of any broad-scale surveys. To this end, the subgroup will work intersessionally to investigate the suitability of various technologies for survey work, including satellite imagery and aerosondes as survey platforms, and report to WG-EMM-03 through a working paper.

6.22 It was noted that a technological development (use of image analysis to automatically count penguins from aerial photographs) outlined in a paper considered in the Report of the Subgroup on Methods (WG-EMM-02/34, paragraph 11) is of great potential value to broad-scale land-based predator surveys.

6.23 The issue of a synoptic circumpolar survey was discussed in relation to an alternate strategy of staged regional surveys carried out over a number of years. There was agreement that staging surveys would be more feasible in requiring a more achievable logistic requirement in each year, and would allow prioritising regions by importance or by usefulness in developing techniques.

6.24 The subgroup recognised that collaboration and coordination with other interested parties, for example the SCAR expert groups on bird biology and seals, would enhance the feasibility of the regional surveys, by utilising appropriate specialist expertise. Collaboration with regard to the large logistical requirements of regional surveys would also be important.

6.25 A broad work plan and timetable was discussed. It was agreed that assessing the overall feasibility would require numerous tasks, including review of existing methods and data, review of new and emerging technologies, assessment of candidate survey designs and methods by field experimentation and simulation, and determining required and available logistical support. Under this work plan, preliminary work would require approximately five to six years and actual survey work was unlikely to be possible before 2008/09.

6.26 It was considered that the subgroup should produce a prospectus and a more detailed background document on land-based predator surveys for consideration at WG-EMM-03. The prospectus and background document would identify the objective and rationale of such surveys, provide an assessment of the design, methodological and logistical issues to be addressed, identify potential stakeholders and collaborators, and outline a preliminary work plan.

Model Development

6.27 At its meeting last year, the Working Group tasked Dr Constable with convening an intersessional correspondence group to consider the development of models on predator–krill–environment interactions and fishery–krill–environment interactions (SC-CAMLR-XX, Annex 4, paragraph 5.8). In this respect, the correspondence group was to consider:

(i) the status of existing models, including data requirements;
(ii) variety of modelling approaches being undertaken; and
(iii) modelling approaches which may be useful in management.

6.28 Dr Constable reported that the intersessional group had not been convened, but that he had attended a workshop just prior to the WG-EMM meeting held by the Scientific Committee of the International Whaling Commission (SC-IWC) on Approaches to Modelling Food Webs, held at the Southwest Fisheries Science Center, La Jolla, California, USA. A report of that meeting should be available next year through the IWC.

6.29 A discussion amongst interested members of the Working Group was held during the course of the meeting and identified a number of modelling activities currently under way:

(i) SC-IWC work on evaluating food web models;

(ii) Antarctic ecosystem and food-web modelling being undertaken at:

   (a) Australian Antarctic Division (Drs Constable and I. Ball);

   (b) British Antarctic Survey (Drs E. Murphy, Reid and Trathan);

   (c) Old Dominion University (Dr E. Hofmann);

   (d) US AMLR Program, Southwest Fisheries Science Center (Mr Jones);

   (e) University of California, Santa Cruz (Drs Alonzo, M. Mangel and Watters); and

   (f) University of California, Santa Barbara (Palmer Long-Term Ecological Research Program – Dr R. Ross);

(iii) ICES Working Group on Ecosystem Modelling;

(iv) Mote International Symposium in Fisheries Ecology on 'Confronting Tradeoffs in the Ecosystem Approach to Fisheries Management' held in conjunction with Florida State University at the Mote Marine Laboratory, Sarasota, Florida, 5 to 7 November 2002; and

(v) Fisheries Centre, University of British Columbia, Canada – developments in Ecopath with Ecosim.

6.30 The Working Group agreed to maintain the correspondence group to help prepare and develop an agenda for the workshop to be held in conjunction with WG-EMM in 2004.

6.31 Dr Constable indicated that he would need some assistance to help coordinate this work. The Working Group requested that members consider this request and notify Dr Constable in the near future (in time for SC-CAMLR-XXI) if they are able to help with this coordination.

Review of Procedures for the Electronic Submission of Meeting Documents

6.32 The Working Group reaffirmed its policy for the electronic submission of meeting documents. Documents must be submitted to the Secretariat by email and by the deadline (see paragraph 1.5). The Working Group agreed that any revision necessary to documents after the deadline and arising from legitimate mistakes would need to be clearly indicated so that readers may easily identify changes.

Long-term Work Plan

Planning for Future Meetings

6.33 The Working Group reviewed progress towards its long-term goal of developing a feedback approach to manage the krill fishery, by which management measures are adjusted in response to ecosystem monitoring. The schedule of meetings and workshops leading to this had been summarised in SC-CAMLR-XX, Annex 4, paragraph 6.3.

6.34 The Working Group also noted progress toward the shorter term requests of the Scientific Committee and Commission (SC-CAMLR-XIX, paragraphs 5.14 and 5.15; CCAMLR-XIX, paragraph 10.11) to subdivide the precautionary catch limit of krill in Area 48.

6.35 The long-term plan of the Working Group was revised to reflect progress during 2002 and needs for future work (Table 3).

6.36 The Working Group agreed that the results of the workshops would provide advice for use in the development of the long-term plan. It was recognised that such advice may be improved when better scientific information becomes available.

6.37 The Working Group agreed that the workshop planned in 2003 would be held during the first week of WG-EMM-03, and that plenary sessions discussing core business would be held in the second week. This format would allow participants and invited experts to attend selected parts of the meeting if they so wished. WG-EMM recognised that this format may not be suitable for all future workshops because some workshops may require input from plenary sessions.

6.38 The Working Group welcomed the invitation from the British Antarctic Survey to host the 2003 meeting in Cambridge, UK, from 18 to 29 August 2003. WG-EMM recognised that the timing of the 2003 meeting was constrained by the availability of a suitable meeting venue.

6.39 Participants were reminded that proposals for future meetings of WG-EMM should be scheduled, when possible, earlier in the year (e.g. July). This would allow sufficient time for the full translation of the report prior to the meeting of the Scientific Committee.

Intersessional Work

6.40 Intersessional work identified by the Working Group is listed in Table 4. Work identified by the Steering Committee for the CEMP Review is listed in Appendix E, Attachment 4.

Historic Record of Work Undertaken by WG-EMM

6.41 The Working Group also reviewed the history of development and completion of tasks which it had put forward since 1995 (WG-EMM-02/12). It was agreed that this paper, produced annually, provided a valuable aide-mémoire of developments undertaken by WG-EMM. However, the Working Group also recognised that it had established a five-year plan starting in 2001. Accordingly, it was agreed that WG-EMM-02/12 provided a suitable archive of tasks undertaken from 1995 to 2001. A similar record was required in the future, however that record should begin with the five-year plan.

6.42 WG-EMM welcomed the Secretariat's development of a database of CCAMLR meeting documents (WG-EMM-02/8). This database was a useful way of making all WG-EMM documents available to participants. Two further developments were proposed: adding a link between meeting documents which had been subsequently published and the published reference, and writing routines for exporting data to commonly used bibliographic software packages (e.g. EndNote).

6.43 It was agreed that this database should be made available to WG-EMM participants through a secure section of the CCAMLR website. In addition, WG-EMM agreed that copies of the database could be made available in DVD format, with password protection, to participants on request. Password protection was necessary in order to protect these documents under the Rules for Access and Use of CCAMLR Data.

Rules for Access and Use of CCAMLR Data

6.44 WG-EMM briefly discussed the Rules for Access and Use of CCAMLR Data (CCAMLR-XI, paragraph 4.35). The underlying principle was that data should be freely available for work within CCAMLR. Under these rules, the Secretariat may release data held in CCAMLR databases as follows:

- if data are requested for use within CCAMLR (e.g. analysis in support of WG-EMM and preparation of meeting documents), then data are released to the data requester and the data originator is advised that the data have been released and their proposed use; and

- if data are requested for use outside CCAMLR (e.g. work for publication), then permission to release the data is first sought from the data originator and then, only if permission is granted, the data are released.

6.45 During the course of the meeting, a number of issues regarding the rules had been raised and WG-EMM agreed that these should be referred to the Scientific Committee for consideration. The main issues were:

- How can the principle of maintaining access to data for CCAMLR work be retained while providing appropriate consideration for data owners to ensure their interests are also retained?

- Is there a need for consultation with data originators at the time of release and/or during subsequent analyses of certain types of data (e.g. CEMP data) for use within CCAMLR?

- How might the rules be revised in relation to the distribution of meeting documents (e.g. wider circulation of the database of CCAMLR meeting documents)?

Key Points for Consideration by the Scientific Committee

6.46 The Steering Committee for the CEMP Review was tasked with reviewing the terms of reference and preparing detailed plans for the workshop on 'Utility of CEMP' scheduled during the 2003 meeting of WG-EMM. The Working Group endorsed and accepted the work of the Steering Committee, and the work plan for the intersessional period leading to the workshop (Appendix E) (paragraph 6.2).

6.47 The Working Group endorsed the principle of inviting to the workshop international experts with experience in linking ecological and statistical models. Prof. Croxall and Dr Southwell, co-conveners of the Steering Committee, agreed to contact such experts in order to determine their availability and any budgetary implications for the Scientific Committee (paragraph 6.10).

6.48 Important resource implications were also associated with the intersessional work. Certain tasks have explicit high priority, many of which required work by the Data Manager and his staff. This would require workloads substantially in excess of that needed to deliver the existing level of management of CEMP data. The Steering Committee would work with the Data Manager to quantify the required resources and budgetary implications for the Scientific Committee (paragraphs 6.12 and 6.13).

6.49 A broad work plan and timetable was discussed, with preliminary work requiring some five to six years for completion. The actual survey work was likely to begin from approximately 2008/09 onwards (paragraph 6.25).

6.50 The Working Group agreed that staged, regional surveys would appear preferable over a single synoptic circumpolar survey. Staged surveys would allow an achievable logistic requirement in each year, and would allow prioritising of regions by importance or by usefulness in developing techniques (paragraph 6.23).

6.51 The Subgroup on Land-Based Predator Surveys would prepare a prospectus and a detailed background document for consideration at the 2003 meeting of WG-EMM (paragraph 6.26).

6.52 The Working Group advised that the correspondence group would help prepare and develop an agenda for the workshop to be held in conjunction with WG-EMM in 2004 (paragraph 6.30).

6.53 WG-EMM had reviewed progress towards its long-term goal of developing a feedback approach to manage the krill fishery (paragraph 6.33) and the revised work plan is summarised in Table 3. Work identified by the Working Group for the 2002/03 intersessional period is listed in Table 4 and tasks identified by the Steering Committee for the CEMP Review are listed in Appendix E (paragraph 6.40).

6.54 The next workshop (Utility of CEMP) will be held in 2003 during the first week of WG-EMM-03 and plenary sessions discussing core business will be held in the second week (paragraph 6.37).

6.55 The Working Group welcomed the invitation from the UK to host the 2003 meeting in Cambridge, UK, from 18 to 29 August 2003 (paragraph 6.38).

6.56 The budget implications on the Secretariat's work to develop a database of CCAMLR meeting documents work will need to be considered at SC-CAMLR-XXI (paragraphs 6.42 and 6.43).

6.57 During the course of the meeting, a number of issues regarding the rules of data access were raised, and these were referred to the Scientific Committee for consideration (paragraph 6.45).

OTHER BUSINESS

World Fisheries Congress

7.1 The Working Group noted the proposal (WG-EMM-02/24) that the original invitation to Prof. Boyd to lead a session on 'Reconciling Fisheries with Conservation in the Antarctic' at the next World Fisheries Congress (WFC) (Vancouver, Canada, 2 to 6 May 2004) might be extended to enable greater potential participation by CCAMLR scientists.

7.2 The Working Group agreed with this proposition and recommended that the Conveners of WG-EMM and WG-FSA should join Prof. Boyd as co-leaders of this session. They would all share the responsibility of coordinating the preparation of the 30-minute presentation.

7.3 It also recommended that CCAMLR should publicise the existence of this session at the WFC as an important opportunity to present CCAMLR science and management in a global context.

7.4 The Working Group encouraged scientists engaged in research and management in relation to CCAMLR to submit abstracts of oral/or poster presentations to the WFC so that a good representation of the best of CCAMLR science would be available for selection.

UBC Workshop on Modelling Antarctic Ecosystems

7.5 The Working Group noted that the University of British Columbia Fisheries Centre had made a first announcement (and call for papers) for a workshop on 'Modelling Antarctic Ecosystems' to be held at the University of British Columbia, Canada, 14 to 17 April 2003. The edited workshop proceedings would be published as a Fisheries Centre Research Report. Further information is available from events@fisheries.ubc.ca.

International Whaling Commission

7.6 The Working Group noted that the SC-IWC had met in Japan from 27 April to 9 May 2002. Dr K.-H. Kock (Germany) was the CCAMLR Observer at that meeting and his report is presented in SC-CAMLR-XXI/BG/2.

7.7 Dr Kock reported that the SC-IWC was considering holding a workshop in collaboration with CCAMLR in 2003 to analyse data collected during the CCAMLR-2000 Survey. The workshop would investigate links between krill distribution and abundance, environmental factors and whale distribution and abundance. The SC-IWC had also discussed future collaboration with CCAMLR.

7.8 WG-EMM looked forward to advice from SC-CAMLR on these initiatives.

SO-GLOBEC

7.9 The Working Group noted that the SO-GLOBEC Program was in its second field season following a series of successful cruises in the Antarctic autumn and winter of 2001. A special issue of *Deep-Sea Research* was being produced containing the results of this first season's cruises. Currently the US SO-GLOBEC Program was operating in the Marguerite Bay area using two ships to complete a time series of studies from February to September.

7.10 Preliminary results from the SO-GLOBEC studies, and other work of relevance to SO-GLOBEC, will be presented at the GLOBEC 2nd Open Science Meeting in Qingdao, China, from 15 to 18 October 2002. Sessions relevant to WG-EMM will include: variability in Antarctic marine populations physical and biological causes, development and application of indices/variables for the description/prediction of ecosystem dynamics, novel mechanisms for linking climate and fisheries and interactions between small-, meso- and large-scale physical and ecosystem processes.

Genetics Correspondence Group

7.11 Dr Bergström advised that the correspondence group had been active during the intersessional period, and that some related work had been reported in the informal poster presented at the meeting (paragraph 1.6). One of the group members, Ms A. Hjelmgren had established an email mailing list and anyone interested in discussing krill genetics was urged to contact her (anna.hjelmgren@rossini.zool.gu.se).

7.12 Dr Bergström reminded WG-EMM that genetic material was available for studies. This material had been collected both during the CCAMLR-2000 Survey and during the 2001 survey aboard the *Polarstern.* Samples collected during the latter expedition come from the Elephant Island area and an area close to the Neumayer Station in the eastern Weddell Sea.

7.13 The Working Group briefly considered sampling and methodological protocols for studies on krill genetics. A recent study (Jarman and Nicol, 2002) had identified problems with existing sampling protocols. WG-EMM tasked the group with identifying and/or developing suitable sampling and methodological protocols for conducting studies on krill stock discrimination.

7.14 In addition, the Working Group noted that a subgroup of WG-FSA had been tasked with identifying, in conjunction with the SCAR EVOLANTA Program, up-to-date information on stock identity for species within the Convention Area. That subgroup was coordinated by Dr E. Fanta (Brazil) and a link should be established between the work of the correspondence group and WG-EMM.

International Workshop on Krill

7.15 Dr Kawaguchi informed WG-EMM that Japan will be hosting an 'International Workshop on Understanding Living Krill for Improved Management and Stock Assessment'. This workshop will be held at the Port of Nagoya Public Aquarium, Japan, from 1 to 4 October 2002.

Survey Design and Analysis

7.16 The Working Group noted the proposal to hold a course on survey design and analysis at the Kristineberg Marine Research Station, Fiskebäckskil, Sweden, in September 2003 immediately following WG-EMM-03. The course will be organised by Dr Bergström and Ms M. Thomasson, with expert contributions from Drs Everson, Hewitt, Demer and Siegel. Dr Bergström was hoping to secure full funding for the course. Alternatively, a course fee would need to be charged to recoup some of the costs.

Ross Sea Research

7.17 The Working Group noted that an informal one-day meeting on research in the Ross Sea would be held immediately prior to its 2003 meeting. The informal meeting would consider relevant documents submitted to WG-EMM-03 as well as other material brought by participants. A verbal report would be presented at WG-EMM-03. The Working Group encouraged all scientists involved with research in the Ross Sea to contact Drs Azzali and S. Corsolini (Italy) or P. Wilson (New Zealand) to discuss participation and contributions to the informal meeting.

Japanese Survey

7.18 Dr Naganobu invited participants to collaborate in a planned survey to be conducted by the RV *Kaiyo Maru*. The dates and areas of the survey are not yet determined.

Observers at WG-EMM-03

7.19 The Working Group considered participation by observers from other international organisations at its 2003 meeting. It was agreed that no observers would be required at that meeting.

Submission of Synopses to SC-CAMLR

7.20 The Working Group considered a proposal from the Scientific Committee that the synopses of its meeting documents be circulated at the meeting of SC-CAMLR (SC-CAMLR-XX, paragraph 18.4). WG-EMM agreed to do this in the form of a background document.

CCAMLR Science Editorial Board

7.21 The Editorial Board of *CCAMLR Science* met during WG-EMM-02, and a brief report of that meeting would be submitted as a background paper to SC-CAMLR-XXI.

SC-CAMLR Agenda

7.22 The Working Group provided advice on proposed modifications to the agenda of SC-CAMLR-XXI which had been circulated during the meeting by the Chair of the Scientific Committee.

ADOPTION OF THE REPORT AND CLOSE OF THE MEETING

8.1 The report of the eighth meeting of WG-EMM was adopted.

8.2 In closing the meeting, Dr Hewitt thanked all participants for their contributions to the meeting and the workshop. The meeting had successfully developed the work of WG-EMM in line with its five-year work plan.

8.3 Dr Hewitt also thanked the local organisers of the meeting, Drs Sue and Wayne Trivelpiece for providing an excellent venue and support. This had greatly contributed to the success of the meeting.

8.4 Dr Hewitt thanked the Secretariat for their work in support of WG-EMM, both at the meeting and during the intersessional period.

8.5 Dr Everson, on behalf of the Working Group, thanked Dr Hewitt for his continued leadership and contribution to WG-EMM.

8.6 The meeting was closed.

REFERENCES

Agnew, D.J. and G. Phegan. 1995. A fine-scale model of the overlap between penguin foraging demands and the krill fishery in the South Shetland Islands and Antarctic Peninsula. *CCAMLR Science*, 2: 99–110.

Boyd, I.L. 2001. Integrated environment–prey–predator interactions off South Georgia: implications for management of fisheries. *Aquatic Conservation: Marine Freshwater Ecosystems*.

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

Demer, D.A. Submitted. An estimate of error for the CCAMLR 2000 estimate of krill biomass. *Deep-Sea Res.* (CCAMLR-2000 Special Issue).

Demer, D.A., S.G. Conti, J. De Rosny and P. Roux. In press. Absolute measurements of total target strength from reverberation in a cavity. *J. Acoust. Soc. Am.*

De Rosny, J. and P. Roux. 2001. Multiple scattering in a reflecting cavity: application to fish counting in a tank. *J. Acoust. Soc. Am.,* 109: 2587–2597.

Everson, I. 2002. Consideration of major issues in ecosystem monitoring and management *CCAMLR Scienc*e, 9: 213–232.

Everson, I., J.L. Watkins, D.G. Bone and K.G. Foote. 1990. Implications of a new acoustic target strength for abundance estimates of Antarctic krill. *Nature*, 345: 338–340.

Foote, K.G., I. Everson, J.L. Watkins and D.G. Bone. 1990. Target strengths of Antarctic krill (*Euphausia superba*) at 38 and 120 kHz. *J. Acoust. Soc. Am.,* 87 (1): 16–24.

Greene, C.H., T.K. Stanton, P.H. Wiebe and S. McClatchie. 1991. Acoustic estimates of Antarctic krill. *Nature*, 349: 110 pp.

Hewitt, R.P. and D.A. Demer. 1991. Krill abundance. *Nature*, 353: p. 310.

Jarman, S.N. and S. Nicol. 2002. Sources of variance in studies of krill population genetics. *CCAMLR Science*, 9: 107–116.

Jolly, G.M. and I. Hampton. 1990. A stratified random transect design for acoustic surveys of fish stocks. *Can. J. Fish Aquat. Sci.*, 47: 1282–1291.

McGehee, D.E., R.L. O'Driscoll and L.V. Martin Traykovski. 1998. Effects of orientation on acoustic scattering from Antarctic krill at 120 kHz. *Deep-Sea Res.,* II, 45: 1273–1294.

Naganobu, M, K. Kutsuwada, Y. Sasai, S. Taguchi and V. Siegel. 1999. Relationships between Antarctic krill *(Euphausia superba*) variability and westerly fluctuations and ozone depletion in the Antarctic Peninsula area. *J. Geophys. Res.*, 104, C9: 20,651–20,665.

Syrjala, S.E. 2000. Critique on the use of the delta distribution for the analysis of trawl survey data. *ICES J. Mar Sci*., 57: 831–842.

SC-CAMLR. 2000. Report of the B_0 Workshop. In: *Report of the Nineteenth Meeting of the Scientific Committee (SC-CAMLR-XIX)*, Annex 4, Appendix G. CCAMLR, Hobart, Australia: 209–273.

Wiebe, P.H., C.H. Greene, T.K. Stanton and J. Burczynski. 1990. Sound scattering by live zooplankton and micronekton: empirical studies with a dual-beam acoustical system. *J. Acoust. Soc. Am.,* 88 (5): 2346–2360.

Table 1: Catch (tonnes) of krill from the Convention Area in the 2000/01 fishing season (December 2000 to November 2001) reported in monthly catch and effort reports. The percentage of the monthly catch reported in fine-scale data is shown in brackets.

Calendar		Catch of Krill Reported from Area 48					
Year	Month	Total	Japan	Rep. of Korea	Poland	Ukraine	USA
2000	December	2 305 (100)	1 707 (100)	598 (100)			
2001	January	3 394 (101)	3 161 (101)	232 (100)			
	February	6 422 (98)	6 388 (99)		34 (0)		
	March	7 509 (77)	5 908 (98)		1 601 (0)		
	April	12 730 (81)	9 029 (112)	264 (100)	3 437 (0)		
	May	17 907 (83)	12 865 (100)	1 202 (99)	2 970 (0)	870 (100)	
	June	17 161 (85)	9 929 (100)	1 013 (103)	2 166 (0)	2 492 (79)	1 561 (100)
	July	14 152 (24)	7 782 (0)	1 041 (104)	2 302 (0)	3 027 (78)	
	August	12 166 (31)	6 452 (0)	1 430 (104)	1 186 (0)	3 097 (75)	
	September	7 177 (33)	3 360 (0)	1 321 (0)		2 496 (95)	
	October	2 414 (80)		423 (0)		1 991 (97)	
	November	0					
Season total		103 335 (67)	66 580 (75)	7 525 (79)	13 696 (0)	13 973 (85)	1 561 (100)

Table 2: Catch (tonnes) of krill from the Convention Area in the 2001/02 fishing season (December 2001 to November 2002) reported in monthly catch and effort reports submitted by 16 July 2002. The percentage of the monthly catch reported in fine-scale data is shown in brackets.

Calendar		Catch of Krill Reported from Area 48					
Year	Month	Total	Japan	Rep. of Korea	Poland	Ukraine	USA
2001	December	0					
2002	January	1 940 (21)	143 (0)			1 400 (0)	397 (101)
	February	11 832 (25)	6 009 (0)			3 000 (0)	2 823 (106)
	March	16 157 (13)	6 602 (0)	2 268 (0)		3 383 (0)	2 013 (100)
	April	22 230 (12)	8 153 (0)	2 212 (0)	1 891 (0)	6 502 (0)	2 563 (104)
	May	17 115 (0)	7 979 (0)	1 958 (0)	2 801 (0)	3 611 (0)	
	June	7 812 (7)	5 653 (0)	1 595 (0)	3 566 (0)		564 (100)
	July	na					
	August	na					
	September	na					
	October	na					
	November	na					
Season total		77 085 (11)	34 539 (0)	8 033 (0)	8 258 (0)	17 896 (0)	8 359 (103)

Table 3: Revised plan of work scheduled between 2002 and 2005.

Issue	2002	2003	2004	2005
Subdivide Precautionary Catch Limit	Discussion	Discussion	Recommendation	
Revised Krill Management Procedure				
Delineation of small-scale management units in Area 48	Workshop			
CEMP review	Planning session	Workshop		
Selection of appropriate predator–prey–fishery–environment models	Discussion	Planning session	Workshop	
Evaluation of management procedures including objectives, decision rules, performance measures	Discussion	Discussion	Planning session	Workshop
Reporting requirements from fishery	Discussion	Awaiting guidance from the Scientific Committee		
Monitoring requirements from CEMP	Discussion	Discussion	Discussion	Discussion
Assessment of Predator Demand				
Large-scale surveys of land-based predators	Discussion	Discussion	Discussion	Discussion
Subdivision of Large FAO Statistical Areas				
Establishment of harvesting units	Discussion	Discussion		

Table 4: List of tasks identified by WG-EMM for the 2002/03 intersessional period. The paragraph numbers (Ref.) refer to this report unless stated otherwise. √ – general request, √√ – high priority

	Task	Ref.	Priority	Action Required	
				Members	Secretariat
	Status and trends in krill fisheries				
1.	Continue submission of krill fishery descriptions at all phases of their development.	2.42	√	Members	Remind
2.	Contact ICES and obtain information about the number of vessels from north Atlantic fisheries that might potentially enter the krill fishery.	2.50	√		Implement
3.	Collate and synthesise information from the krill fishery questionnaire.	2.55	√	Continue data submission	Implement
4.	Contact the FAO for information that they might have on the demand for krill for aquaculture feeds or on the development of other krill fisheries.	2.72	√		Implement
5.	Remind Members that the management of krill fisheries requires timely submission of appropriate data.	2.68–2.70, 2.74, 2.75	√√	Members	Remind
	Scientific Observers Manual				
6.	Revise krill observation logbook forms.	2.60–2.62	√	Members	Remind
7.	Request WG-FSA to assist in the development of the methodology for sampling larvae and other small-sized fish (i.e. <7 cm) taken as by-catch in krill fishing.	2.62(iv)	√	WG-FSA	Remind
8.	Develop an alternative method for collecting data on board fishing vessels on krill product conversion rates.	2.62(v)	√	Members	Remind
9.	Revise krill colour chart for its subsequent inclusion in the manual.	2.62(ii)	√	Dr Kawaguchi	Remind
	Status of the krill-centric ecosystem				
10.	Notify data holders of any forthcoming CEMP data analysis to be conducted by the Secretariat.	3.7	√√		Implement
11.	Encourage Members to use the current CEMP data submission forms and to provide additional information in comment fields where this will assist data validation.	3.4, 3.124	√		Implement
12.	Reorganise the CEMP database in order to increase ease and flexibility of accessing data.	3.10, 3.125	√√		Implement
13.	Discontinue calculation of the Agnew–Phegan index of predator–fishery overlap.	3.40, 3.127	√		Implement

	Task	Ref.	Priority	Action Required	
				Members	Secretariat
14.	Consider the best methods for presenting the different predator–fishery overlap indices and the way each index relates to the others available.	3.41	√		Implement
15.	Coordinate formulation of CEMP standard methods for collection and analysis of predator demography data, seek advice of researchers with similar data.	3.48	√	Dr Kerry (in respect of Adélie penguins)	
16.	Present more krill demographic data from the US Long-Term Ecological Research Program.	3.65	√	USA	Remind
17.	Revise as agreed Procedure B of Standard Method C2.	3.103, 3.130	√√		Implement
18.	Provide median dates of fur seal pupping for years in which Members have previously submitted data using Standard Method C2, Procedure B.	3.104	√	Members	Remind
19.	Request authors of papers WG-EMM-02/35, 02/37, 02/49 and 02/50 to explicitly identify the merits of new methods proposed relative to methods used during the CCAMLR-2000 Survey, and identify the implications for reanalysis of existing survey data.	3.105	√	Authors identified	Remind
20.	Implement a multi-stage process for developing new CEMP standard methods.	3.114	√	Members	Coordinate
	Status of management advice				
21.	Review of guidelines for the production of maps of protected areas.	5.52(iii)	√	Advisory Subgroup on Protected Areas	Coordinate
22.	Submit outstanding maps of CEMP sites; place maps on the website.	5.11	√	Members	Remind/implement
23.	Revise and submit a document summarising CCAMLR decisions related to the evaluation of ATCM management plans containing marine areas.	5.15, 5.52(iii)	√	Advisory Subgroup on Protected Areas	Implement
24.	Revise current terms of reference of the Subgroup on CEMP Sites in a manner that properly places new tasks in context of decisions taken by CCAMLR.	5.15, 5.52(iii)	√	Advisory Subgroup on Protected Areas	Implement
25.	Conduct sensitivity analysis to examine regional differences in krill growth and mortality and their impacts on estimates of yield calculated using the GYM.	5.36	√	Members	
26.	Identify and/or develop suitable sampling and methodological protocols for conducting studies on krill stock discrimination.	7.13	√	Genetics Correspondence Group (Convener, Dr Bergström)	Remind
27.	Develop GIS maps of small-scale units identified by the SSMU Workshop for Area 48.	5.22, 5.24	√√	WG-EMM Convener, Dr Hewitt; SC Chairman, Dr Holt	Implement as required

	Task	Ref.	Priority	Action Required	
				Members	Secretariat
	Future work of WG-EMM				
28.	Conduct WG-EMM business in accordance with the revised plan of work.	6.35, 6.53	√√	WG-EMM Convener, Members	Remind, coordinate and implement, where appropriate
29.	Preparation for the Workshop on the CEMP Review as required in accordance with the adopted plan of intersessional work.	6.2, 6.37	√√	Implement (Steering Committee and identified scientists)	Implement specific tasks identified
30.	Request Steering Committee for the Review of CEMP to include in the workshop review of consideration of the utility of CEMP Integrated Study Regions and whether the proposed small-scale management units might provide a stable structure for future work on the relationships between krill, predators and the fishery.	5.31	√√	Steering Committee	Remind
31.	Continue the work on the development of models on predator–krill–environment interactions and fishery–krill–environment interactions in order to help prepare and develop an agenda for the workshop on modelling to be held in conjunction with WG-EMM-04.	6.30, 6.31	√	Correspondence Group (Convener, Dr Constable)	Remind, assist as required
32.	Continue the work on designating scales for harvesting units.	5.19, 5.20	√	Correspondence Group (Convener, Dr Naganobu, Dr Nicol)	Remind
33.	Investigate the suitability of various technologies for predator survey work, including satellite imagery and aerosondes as survey platforms.	6.21	√	Subgroup on Land-Based Predator Surveys	
34.	Produce a prospectus and a more detailed background document on land-based predator surveys for consideration at WG-EMM-03.	6.26	√	Subgroup on Land-Based Predator Surveys	
35.	Establish a link between the work of the WG-FSA subgroup tasked with identifying up-to-date information on stock identification in the Convention Area and the SCAR EVOLANTA subgroup coordinated by Dr Fanta.	7.14	√	Genetics Correspondence Group (Convener, Dr Bergström)	Remind
36.	Invite Members to provide submissions to help refine boundaries of small-scale management units identified by the SSMU Workshop.	5.29	√	Members	Remind
	Working Group documents				
37.	Reaffirm that only papers accompanied by a complete one-page synopsis and submitted electronically by the deadline identified by the Scientific Committee would be considered at future meetings.	1.5, 6.32	√√	Members	Remind

	Task	Ref.	Priority	Action Required	
				Members	Secretariat
38.	Make available to WG-EMM participants the database of CCAMLR meeting documents in accordance with agreed procedures.	6.42, 6.43, 6.56	√		Implement
39.	Develop format styles for the preparation of workshop reports, including guidelines for production of figures, maps and tables.	4.6	√	Members	Implement in consultation with Members
	Research and development		√		
40.	Review the utility of CPUE in krill fisheries in the near future.	2.20	√	Members	Remind
41.	Publicise a session 'Reconciling Fisheries with Conservation in the Antarctic' to be held during the World Fisheries Congress (Canada, 2–6 May 2004).	7.3	√	Members	Implement

APPENDIX A

AGENDA

Working Group on Ecosystem Monitoring and Management
(Big Sky, Montana, USA, 5 to 16 August 2002)

1. Introduction
   1.1 Opening of the meeting
   1.2 Adoption of the agenda and organisation of the meeting

2. Status and trends in the krill fishery
   2.1 Fishing activity
   2.2 Description of the fishery
   2.3 Regulatory issues
   2.4 Key points for consideration by the Scientific Committee

3. Status and trends in the krill-centric ecosystem
   3.1 Status of predators, krill resource and environmental influences
   3.2 Further approaches to ecosystem assessment and management
   3.3 Other prey species
   3.4 Methods
   3.5 Future surveys
   3.6 Key points for consideration by the Scientific Committee

4. Workshop to define predator units

5. Status of management advice
   5.1 Designation of protected areas
   5.2 Harvesting units
   5.3 Small-scale management units
   5.4 Generalised yield model
   5.5 Existing conservation measures
   5.6 Key points for consideration by the Scientific Committee

6. Future work
   6.1 CEMP review
   6.2 Predator surveys
   6.3 Model development
   6.4 Review of procedures for the electronic submission of meeting documents
   6.5 Long-term work plan
   6.6 Key points for consideration by the Scientific Committee

7. Other business

8. Adoption of the report and close of the meeting.

APPENDIX B

LIST OF PARTICIPANTS

Working Group on Ecosystem Monitoring and Management
(Big Sky, Montana, USA, 5 to 16 August 2002)

AKKERS, Theressa (Ms)	Research Support and Administration Research and Development Marine and Coastal Management Private Bag X2 Rogge Bay 8012 South Africa takkers@mcm.wcape.gov.za
AZZALI, Massimo (Dr)	CNR-IRPEM Largo Fiera della Pesca, 2 60100 Ancona Italy azzali@irpem.an.cnr.it
BALL, Ian (Dr)	Australian Antarctic Division Environment Australia Channel Highway Kingston Tasmania 7050 Australia ian.ball@aad.gov.au
BERGSTRÖM, Bo (Dr)	Kristineberg Marine Research Station S-450 34 Fiskebäckskil Sweden b.bergstrom@kmf.gu.se
CONSTABLE, Andrew (Dr)	Australian Antarctic Division Channel Highway Kingston Tasmania 7050 Australia andrew.constable@aad.gov.au
CORSOLINI, Simonetta (Dr)	Dipartimento di Scienze Ambientali Università di Siena Via delle Cerchia, 3 53100 Siena Italy corsolini@unisi.it

CROXALL, John (Prof.)	British Antarctic Survey High Cross, Madingley Road Cambridge CB3 0ET United Kingdom j.croxall@bas.ac.uk
DEMER, David (Dr)	US AMLR Program Southwest Fisheries Science Center 8604 La Jolla Shores Drive La Jolla, CA 92037 USA david.demer@noaa.gov
DOMMASNES, Are (Mr)	Institute of Marine Research PO Box 1870 Nordnes 5817 Bergen Norway are.dommasnes@imr.no
EMERY, Jennifer (Mrs)	US AMLR Program Southwest Fisheries Science Center 8604 La Jolla Shores Drive La Jolla, CA 92037 USA jennifer.emery@noaa.gov
EVERSON, Inigo (Dr)	British Antarctic Survey High Cross, Madingley Road Cambridge CB3 0ET United Kingdom i.everson@bas.ac.uk
FRASER, William (Dr)	Polar Oceans Research Group Department of Biology Montana State University Bozeman, MT 59717 ubiwf@montana.edu
GASIUKOV, Pavel (Dr)	AtlantNIRO 5 Dmitry Donskoy Str. Kaliningrad 236000 Russia pg@atlant.baltnet.ru

GOEBEL, Michael (Mr) | US AMLR Program
Southwest Fisheries Science Center
8604 La Jolla Shores Drive
La Jolla, CA 92037
USA
mike.goebel@noaa.gov

HEWITT, Roger (Dr) | US AMLR Program
8604 La Jolla Shores Drive
La Jolla, CA 920378
USA
roger.hewitt@noaa.gov

HOLT, Rennie (Dr) | Chair, Scientific Committee
US AMLR Program
Southwest Fisheries Science Center
PO Box 271
La Jolla, CA 92038
USA
rennie.holt@noaa.gov

JONES, Christopher (Mr) | US AMLR Program
Southwest Fisheries Science Center
8604 La Jolla Shores Drive
La Jolla, CA 92037
USA
cdjones@ucsd.edu

KAWAGUCHI, So (Dr) | National Research Institute of Far Seas Fisheries
Orido 5-7-1, Shimizu
Shizuoka 424-8633
Japan
kawaso@affrc.go.jp

KERRY, Knowles (Dr) | Australian Antarctic Division
Environment Australia
Channel Highway
Kingston Tasmania 7050
Australia
knowles.kerry@aad.gov.au

KIGAMI, Masashi (Mr)	Japan Deep Sea Trawlers Association Ogawacho-Yasuda Building 6 Kanda-Ogawacho, 3-chome Chiyoda-ku Tokyo 101-0052 Japan
KIRKWOOD, Geoff (Dr)	Renewable Resources Assessment Group Imperial College RSM Building Prince Consort Road London SW7 2BP United Kingdom g.kirkwood@ic.ac.uk
KOUZNETSOVA, E.N. (Dr)	VNIRO 17a V. Krasnoselskaya Moscow 107140 Russia vozrast@vniro.ru
NAGANOBU, Mikio (Dr)	National Research Institute of Far Seas Fisheries Orido 5-7-1, Shimizu Shizuoka 424-8633 Japan naganobu@affrc.go.jp
NICOL, Steve (Dr)	Australian Antarctic Division Environment Australia Channel Highway Kingston Tasmania 7050 Australia steve.nicol@aad.gov.au
PENHALE, Polly (Dr)	National Science Foundation Office of Polar Programs 4201 Wilson Blvd Arlington, VA 22230 USA ppenhale@nsf.gov
REID, Keith (Dr)	British Antarctic Survey High Cross, Madingley Road Cambridge CB3 0ET United Kingdom k.reid@bas.ac.uk

ROSS, Robin (Dr)	Marine Science Institute University of California Santa Barbara, CA 93106 USA robin@icess.ucsb.edu
SHUST, Konstantin (Dr)	VNIRO 17a V. Krasnoselskaya Moscow 107140 Russia antarctica@vniro.ru
SIEGEL, Volker (Dr)	Bundesforschungsanstalt für Fischerei Institut für Seefischerei Palmaille 9 D-22767 Hamburg Germany siegel.ish@bfa-fisch.de
SOUTHWELL, Colin (Dr)	Australian Antarctic Division Environment Australia Channel Highway Kingston Tasmania 7050 Australia colin.southwell@aad.gov.au
SUSHIN, Viatcheslav (Dr)	AtlantNIRO 5 Dmitry Donskoy Str. Kaliningrad 236000 Russia sushin@atlant.baltnet.ru
THOMASSON, Maria (Ms)	Kristineberg Marine Research Station S-450 34 Fiskebäckskil Sweden m.thomasson@kmf.gu.se
TRATHAN, Philip (Dr)	British Antarctic Survey High Cross, Madingley Road Cambridge CB3 0ET United Kingdom p.trathan@bas.ac.uk

TRIVELPIECE, Sue (Dr)	US AMLR Program Antarctic Ecosystem Research Division PO Box 1486 19878 Indian Oaks Rd/Hwy 78 Ramona, CA 92065 USA sueskua@aol.com
TRIVELPIECE, Wayne (Dr)	US AMLR Program Southwest Fisheries Science Center 8604 La Jolla Shores Drive La Jolla, CA 92037 USA waynezt@aol.com
TUTTLE, Robin (Ms)	Office of Science and Technology National Marine Fisheries Service National Oceanic and Atmospheric Administration SSMC-III, Room 12643 1315 East-West Highway Silver Spring, MD 20910 USA robin.tuttle@noaa.gov
WATKINS, Jon (Dr)	British Antarctic Survey High Cross, Madingley Road Cambridge CB3 0ET United Kingdom j.watkins@bas.ac.uk
WATTERS, George (Dr)	Southwest Fisheries Science Center Pacific Fisheries Environmental Laboratory 1352 Lighthouse Avenue Pacific Grove, CA 93950-2097 USA gwatters@upwell.pfeg.noaa.gov
WILSON, Peter (Dr)	Manaaki Whenua – Landcare Research Private Bag 6 Nelson New Zealand wilsonpr@landcare.cri.nz

Secretariat:

Denzil MILLER (Executive Secretary)	CCAMLR
Eugene SABOURENKOV (Science Officer)	PO Box 213
David RAMM (Data Manager)	North Hobart 7002
Genevieve TANNER (Communications Officer)	Tasmania Australia
Rosalie MARAZAS (Website and Information Services Officer)	ccamlr@ccamlr.org

APPENDIX C

LIST OF DOCUMENTS

Working Group on Ecosystem Monitoring and Management
(Big Sky, Montana, USA, 5 to 16 August 2002)

WG-EMM-02/1	Provisional Agenda and Provisional Annotated Agenda for the 2002 Meeting of the Working Group on Ecosystem Monitoring and Management (WG-EMM)
WG-EMM-02/2	List of participants
WG-EMM-02/3	List of documents
WG-EMM-02/4	Do fish prey size affect the foraging patterns and breeding output of the Antarctic shag *Phalacrocorax bransfieldensis*? R. Casaux and A. Baroni (Argentina)
WG-EMM-02/5	CEMP indices 2002: analysis of anomalies and trends CCAMLR Secretariat
WG-EMM-02/6	Krill fishery information CCAMLR Secretariat
WG-EMM-02/7	A review and preliminary analysis of CEMP data CCAMLR Secretariat
WG-EMM-02/8	Database of CCAMLR working documents CCAMLR Secretariat
WG-EMM-02/9	The diet of the Antarctic fur seal *Arctocephalus gazella* at the Danco Coast, Antarctic Peninsula R. Casaux, A. Baroni and A. Ramón (Argentina)
WG-EMM-02/10	Geographical variation in the diet of the Antarctic fur seal *Arctocephalus gazella* R. Casaux, A. Baroni, F. Arrighetti, A. Ramón and A. Carlini (Argentina)
WG-EMM-02/11	The diet of the Antarctic fur seal *Arctocephalus gazella* at Harmony Point, South Shetland Islands: evidence of opportunistic foraging on penguins? R. Casaux, L. Bellizia and A. Baroni (Argentina)

WG-EMM-02/12	History of development and completion of tasks put forward by WG-EMM (1995–2001) Secretariat
WG-EMM-02/13	Incident of Antarctic krill (*Euphausia superba*) mass infection near the coasts of South Georgia Island (Subarea 48.3) M.S. Savich (Ukraine)
WG-EMM-02/14	Spatial distribution of predator/prey interactions in the Scotia Sea: implications for measuring predator/fisheries overlap K. Reid, M. Sims, R.W. White and K.W. Gillon (United Kingdom) (*Deep-Sea Research* (CCAMLR-2000 Special Issue), submitted)
WG-EMM-02/15	Conflict or co-existence? Foraging distribution and competition for prey between Adélie and chinstrap penguins A.S. Lynnes, K. Reid, J.P. Croxall and P.N. Trathan (United Kingdom) (*Marine Biology*, in press)
WG-EMM-02/16	Krill population dynamics in the Scotia Sea: variability in growth and mortality within a single population K. Reid, E.J. Murphy (United Kingdom), V. Loeb and R.P. Hewitt (USA) (*Journal of Marine Systems*, 36: 1–10)
WG-EMM-02/17	Current temperature conditions off South Georgia during recent years (satellite data on Subarea 48.3) G.P. Vanyushin (Russia)
WG-EMM-02/18	The US commercial krill fishery in Area 48: development, fishing patterns, and decision making C.D. Jones and M. Hull (USA) (*CCAMLR Science*, submitted)
WG-EMM-02/19	Combined standardised indices of predator performance at Bird Island, South Georgia, 1973–2002 K. Reid (United Kingdom)
WG-EMM-02/20	Are krill recruitment indices from meso-scale survey representative for larger areas? V. Siegel (Germany), R.M. Ross and L.B. Quetin (USA)
WG-EMM-02/21	Seasonal and interannual variation in foraging range and habitat of macaroni penguins *Eudyptes chrysolophus* at South Georgia K.E. Barlow and J.P. Croxall (United Kingdom) (*Marine Ecology Progress Series*, 232: 291–304)

WG-EMM-02/22	Are penguins and seals in competition for Antarctic krill at South Georgia? K.E. Barlow, I.L. Boyd, J.P. Croxall, K. Reid, U.J. Staniland and A.S. Brierley (United Kingdom) (*Marine Biology*, 140: 205–213)
WG-EMM-02/23	Estimating food consumption of marine predators: Antarctic fur seals and macaroni penguins I.L. Boyd (United Kingdom) (*Journal of Applied Ecology*, 39: 103–119)
WG-EMM-02/24	World Fisheries Congress J.P. Croxall (United Kingdom)
WG-EMM-02/25	Detecting trends in the krill fishery S. Nicol and J. Foster (Australia)
WG-EMM-02/26	Conserving seabirds competing with fisheries for food – observations from southern Africa and Marion Island R.J.M. Crawford, C.M. Duncombe Rae and D.C. Nel (South Africa)
WG-EMM-02/27	Soviet krill fishery in the Atlantic sector of Antarctic in 1977–1992: Part II – CPUE changes and fleet displacement F.F. Litvinov, P.S. Gasiukov, A.Z. Sundakov and O.A. Berezhinskiy (Russia)
WG-EMM-02/28 Rev. 1	Fishing patterns of Japanese krill trawlers S. Kawaguchi, T. Kameda and Y. Takeuchi (Japan)
WG-EMM-02/29	The krill fishery observer manual – points to be revised S. Kawaguchi (Japan)
WG-EMM-02/30	Results of an acoustic investigation of Antarctic krill, *Euphausia superba*, biomass-density in the Elephant Island area in January/February 2001 M.A. Thomasson (Sweden), J.H. Emery (USA), J. Rademan (South Africa), R.P. Hewitt (USA) and B.I. Bergström (Sweden)
WG-EMM-02/31	Design of the Italian acoustic survey in the Ross Sea for the Austral summer 2003/04 M. Azzali, A. Sala and S. Manoukian (Italy)

WG-EMM-02/32	Krill of the Ross Sea: distribution, abundance and demography of *Euphausia superba* and *Euphausia crystallorophias* during the Italian Antarctic expedition (January–February 2000) A. Sala, M. Azzali and A. Russo (Italy) (*Scientia Marina,* 66 (2): 123–133)
WG-EMM-02/33	Spatial and temporal variability in foraging patterns of krill predators at Signy Island and South Georgia P.N. Trathan, J.L. Tanton, A.S. Lynnes, M.J. Jessopp, H. Peat, K. Reid and J.P. Croxall (United Kingdom)
WG-EMM-02/34	Estimating penguin populations using image analysis of colour aerial photography P.N. Trathan (United Kingdom)
WG-EMM-02/35	Maximum entropy reconstruction of stock distribution and inference of stock density from line-transect acoustic survey data A.S. Brierley, S.F. Gull and M.H. Wafy (United Kingdom) (*ICES Journal of Marine Science*, submitted)
WG-EMM-02/36	MaxEnt reconstructions of krill distribution and estimates of krill density from acoustic surveys at South Georgia 1996–2000 M.H. Wafy, A.S. Brierley, S.F. Gull and J.L. Watkins (United Kingdom) (*CCAMLR Science*, submitted)
WG-EMM-02/37	The three-frequency method for classifying the species and assessing the size of two euphausiids (*Euphausia superba* and *Euphausia crystallorophias*) M. Azzali, G. Lanciani and I. Leonori (Italy) (*CCAMLR Science*, submitted)
WG-EMM-02/38	Relationships between distribution of two euphausiid species and oceanographic characteristics in the Ross Sea (January–February 2000) A. Russo, M. Azzali, E. Biffi, G. Lanciani and E. Paschine (Italy) (*Antarctic Science*, submitted)
WG-EMM-02/39	Seasonal variation in acoustic estimates of krill density at South Georgia during 2001/2002 C. Goss, S.A. Grant, N. Cunningham, J.L. Watkins, P.N. Trathan, E. Murphy and K. Reid (United Kingdom)

WG-EMM-02/40 Rev. 1	Defining fishing grounds in the Scotia Sea I.R. Ball and A.J. Constable (Australia), S. Kawaguchi (Japan) and D. Ramm (CCAMLR Secretariat) (*CCAMLR Science*, submitted)
WG-EMM-02/41	Defining predator foraging ranges, illustrated using Adélie penguin foraging tracks from Mawson coast I.R. Ball, A.J. Constable, J. Clarke and L. Emmerson (Australia) (*CCAMLR Science*, submitted)
WG-EMM-02/42	Deaths of Adélie penguins at Mawson November–December 2001 investigated K. Kerry and L. Irvine (Australia)
WG-EMM-02/43	Comparison between the CCAMLR-2000 and KY 1988 surveys on environmental variability of krill in the Scotia Sea, Antarctica M. Naganobu (Japan), M. Brandon (United Kingdom), K. Ito, K. Segawa (Japan) and V. Siegel (Germany) (*Deep-Sea Research* (CCAMLR-2000 Special Issue), submitted)
WG-EMM-02/44	Short note: time series of Drake Passage Oscillation Index (DPOI) from 1952 to 1988 M. Naganobu and K. Kutsuwada (Japan)
WG-EMM-02/45	Assessing the feasibility of regional surveys of land-based predator abundance in the Southern Ocean: a framework for decision making and planning C. Southwell (Australia)
WG-EMM-02/46	An assessment of temporal variability and interrelationships between CEMP parameters collected on Adélie penguins at Béchervaise Island L.M. Emmerson, J. Clarke, K. Kerry and C. Southwell (Australia) (*CCAMLR Science*, submitted)
WG-EMM-02/47	Post-fledging and winter migration of Adélie penguins (*Pygoscelis adeliae*) in the Mawson region of east Antarctica J. Clarke and K. Kerry (Australia), C. Fowler (USA), R. Lawless, S. Eberhard and R. Murphy (Australia) (*Marine Ecology Progress Series*, submitted)
WG-EMM-02/48	Demographic characteristics of the Adélie penguin population of Béchervaise Island after 12 years of study J. Clarke, K. Kerry, A. Townsend and L. Emmerson (Australia) (*CCAMLR Science*, submitted)

WG-EMM-02/49	Broadbandwidth total target strength measurements of Antarctic krill (*Euphausia superba*) from reverberation in a cavity D.A. Demer and S. G. Conti (USA) (*ICES Journal of Marine Science*, submitted)
WG-EMM-02/50	Reconciling theoretical versus empirical target strengths of krill; effects of phase variability on the distorted wave Born approximation D.A. Demer and S.G. Conti (USA) (*ICES Journal of Marine Science*, submitted)
WG-EMM-02/51	Antarctic fur seals in the South Shetland Islands: pup production and population trends M.E. Goebel (USA), V.I. Vallejos (Chile), W.Z. Trivelpiece, R.S. Holt (USA) and J. Acevedo (Chile)
WG-EMM-02/52	A proposal for modifications to Standard Method C2: fur seal pup growth M.E. Goebel (USA)
WG-EMM-02/53	Foraging range and at-sea locations of female Antarctic fur seals, Cape Shirreff, Livingston Island, from 1999–2002 M.E. Goebel, S.N. Sexton and D.P. Costa (USA)
WG-EMM-02/54	Atlas of coastal sea ice in eastern Antarctica K. Michael, K. Hill, K. Kerry and H. Brolsma (Australia)
WG-EMM-02/55	The winter distribution of Adélie and chinstrap penguins from two breeding colonies in the South Shetland Islands of Antarctica S.G. Trivelpiece and W.Z. Trivelpiece (USA)
WG-EMM-02/56	Proposal for a new Antarctic Specially Protected Area, Terra Nova Bay, Ross Sea Proposed by Italy
WG-EMM-02/57	Management plan for Site of Special Scientific Interest No. 36 – Eastern Dallmann Bay Submitted by the USA
WG-EMM-02/58	Management plan for Site of Special Scientific Interest No. 35 – Western Bransfield Strait Submitted by the USA
WG-EMM-02/59	Management plan for Site of Special Scientific Interest (SSSI) No. 1 Submitted by the Secretariat

WG-EMM-02/60	The Ross Sea, Antarctica, where all ecosystem processes still remain for study D. Ainley (USA)
WG-EMM-02/61 Rev. 1	Meeting of the Interim Steering Committee for the CEMP Review (Big Sky, Montana, USA, 3 August 2002)
WG-EMM-02/62	Fishing intensity of Russian fleet krill fishery in Subarea 48.2 and 48.3 S.M. Kasatkina and V.F. Ivanova (Russia) (*CCAMLR Science*, submitted)
WG-EMM-02/63 Rev. 1	Distribution of the Soviet fishing fleet and catches (CPUE) in Subdivision 48.3 during 1986–1990 V.A. Sushin, P.C. Gasiukov, A.V. Zimin and S.M. Kasatkina (Russia)

Other Documents:

SC-CAMLR-XXI/BG/2	Observer's Report from the 54th Meeting of the Scientific Committee of the International Whaling Commission (Shimonoseki, Japan, 27 April to 9 May 2002) CCAMLR Observer (K.-H. Kock, Germany)
WG-FSA-02/6	The role of fish in the Antarctic marine food web: differences between inshore and offshore waters in the southern Scotia Arc and west Antarctic Peninsula E. Barrera-Oro (Argentina)
	Draft fish species profiles I. Everson (United Kingdom)
	Abstracts of WG-EMM-01 presentation papers to be published in *CCAMLR Science*, Vol. 9 (2002)

APPENDIX D

REPORT OF THE WORKSHOP ON SMALL-SCALE MANAGEMENT UNITS, SUCH AS PREDATOR UNITS

(Big Sky, Montana, USA, 7 to 15 August 2002)

CONTENTS

REPORT OF THE WORKSHOP ON SMALL-SCALE MANAGEMENT UNITS, SUCH AS PREDATOR UNITS

(Big Sky, Montana, USA, 7 to 15 August 2002)

INTRODUCTION

1.1 Last year, the Scientific Committee endorsed the proposal by WG-EMM to hold a Workshop on Small-scale Management Units, such as Predator Units, during its meeting this year (SC-CAMLR-XX, paragraphs 6.11, 6.12 and 6.15 to 6.19; SC-CAMLR-XX, Annex 4, paragraphs 4.1 to 4.11 and 5.9 to 5.13). The aim of the workshop was to define these units in order to facilitate the subdivision of the precautionary yield in Area 48, but that the manner in which the overall catch limit would be subdivided would be determined at a future meeting (SC-CAMLR-XX, paragraph 6.18).

1.2 The delineation of small-scale management units would be achieved primarily by collating and comparing information on: (i) local predator foraging ranges and population distributions (especially of land-based predators); (ii) krill abundance, dispersion and movement; and (iii) fishing fleet behaviour and patterns of fishing (SC-CAMLR-XX, paragraph 6.16).

1.3 The workshop was convened by Dr W. Trivelpiece (USA), from 7 to 15 August 2002.

1.4 A Steering Committee convened by Dr Trivelpiece, comprised Drs A. Constable (Australia), R. Hewitt (USA), S. Kawaguchi (Japan), V. Sushin (Russia), P. Trathan (UK) and D. Ramm (Secretariat). This committee helped prepare for the workshop, including the preparation of the draft agenda, coordination and standardisation of data and the development of direction for the analyses.

1.5 It was noted that a meeting was held between Drs Kawaguchi, Constable, Ramm and I. Ball (Australia) at the CCAMLR Secretariat from 3 to 7 June 2002 to help develop analyses appropriate for fisheries data as requested by the Scientific Committee (SC-CAMLR-XX, paragraph 6.17). The results of this work were submitted to the meeting in WG-EMM-02/28 and 02/40.

1.6 The Agenda is given as Attachment 1 to guide the discussion and work of the workshop.

1.7 The work was divided into the major sections of the agenda and coordinated by Drs Trivelpiece (predator distribution and abundance), Trathan (predator foraging areas), Hewitt (krill distribution and abundance) and Kawaguchi (krill fishery). Dr Constable prepared the report with the assistance of these coordinators and Dr Ball, Ms J. Emery (USA), Dr P. Gasiukov (Russia), Mr M. Goebel (USA), Mr C. Jones (USA) and Drs K. Reid (UK) and G. Watters (USA).

PRINCIPLES FOR THE DEVELOPMENT OF
SMALL-SCALE MANAGEMENT UNITS

1.8 Last year, WG-EMM endorsed the use of the principles for developing small-scale management units described in WG-EMM-01/52 as a guide for its work this year in developing these units (SC-CAMLR-XX, Annex 4, paragraph 4.10). Dr Constable provided an overview of these principles and other elements of this paper. He described how the paper proposed the integration of data from the local krill populations, foraging areas of related predators, fishing ground information and potential influences of the environment (SC-CAMLR-XX, Annex 4, paragraph 5.10). He noted that these units could not only be used to subdivide the catch in Area 48 but would help: (i) to reduce the potential for undesirable local effects on predators by spreading catch and effort; and (ii) to ensure undesirable effects do not arise by providing the opportunity for a spatially-structured monitoring program (SC-CAMLR-XX, Annex 4, paragraph 4.4). With regard to the second point, these units could be used to provide strategic advice on the potential effects of fishing as intended through CEMP (SC-CAMLR-XX, Annex 4, paragraph 4.5). He noted that these units do not have to be ecosystem units but are simply units to help management (SC-CAMLR-XX, Annex 4, paragraph 4.8).

1.9 In his presentation, Dr Constable also summarised the results of discussions by the Steering Committee as well as methods proposed to be used in the development of small-scale management units. These points and the subsequent discussion are summarised in the following paragraphs.

1.10 The Workshop thanked Dr Constable for his detailed presentation of the principles, methods for characterising the spatial subdivision of krill, the krill fishery and predator foraging areas, and issues to be considered in the further development of small-scale management units. The presentation was archived with the CCAMLR Secretariat.

1.11 Papers specifically relevant to the workshop included:

(i) fisheries – WG-EMM-02/06, 02/18, 02/28, 02/40 and 02/63 Rev. 1; and
(ii) predators – WG-EMM-02/05, 02/14, 02/33, 02/41, 02/51, 02/53 and 02/55.

1.12 Data provided to the workshop are described under each section of the analyses below.

1.13 The workshop agreed that the primary part of its work was to determine:

(i) krill aggregations, which are predictable locations where krill are found at relatively high densities from one year to the next over a number of years;

(ii) predator foraging areas, which are predictable locations where a predator obtains food from one year to the next over a number of years; and

(iii) fishing grounds, which are predictable locations where the fishery obtains relatively reliable catches from one year to the next over a number of years.

1.14 The workshop agreed to use the method in WG-EMM-02/40 to determine these predictable locations. Such locations are identified by their relative within-year importance averaged over a number of years rather than being determined as an average density, consumption or catch over time. Thus, the method is designed to account for interannual variation in the importance of locations, where a location is a fine-scale area, say 10 x 10 n miles. The key features of the method are:

(i) bin the data at an appropriate spatial scale, e.g. 10 x 10 n mile areas;

(ii) normalise data within each year to provide a measure of the relative importance of different locations in each year;

(iii) smooth the data within each year using a bivariate normal kernel smoothing algorithm to take account of uncertainty in the location of the observations as well as uncertainty in the values in the spaces between observations;

(iv) average these values over the time series to give an average importance of those locations; and

(v) identify grounds or areas of importance by determining a threshold such that the area covers, say 95%, of the accumulated importance of the region.

1.15 For predators, the workshop agreed to circumscribe the foraging areas, in the first instance, using an average maximum foraging distance as described in WG-EMM-02/33. Within those ranges, the workshop agreed to subdivide them further by delineating the foraging grounds using the method described above combined with the approach in WG-EMM-02/41, which was based on methods previously described (Barlow and Croxall, 2001; Trathan et al., 1998; Wood et al., 2001; Worton, 1989). The additional step that preceded the above method was to convert tracking data to foraging densities at an appropriate scale, say 0.1° latitude x 0.2° longitude.

1.16 Areas of greatest importance to land-based predators would be identified by:

(i) estimating a characteristic foraging pattern (distance by foraging density) for each species using the methods above;

(ii) determining the location and distribution of colonies of each species of the most abundant land-based predators (i.e. centres of abundance/biomass);

(iii) use the relevant characteristic foraging pattern of each species to circumscribe a potential foraging ‘footprint’ associated with each population centre for the respective species;

(iv) weight the foraging area for each population centre by the biomass of predators in that centre; and

(v) sum all the weighted values from (iv) for each grid square in the area.

1.17 The partitioning of the foraging areas into predator units would be undertaken based on these overall estimates of biomass-weighted foraging density as well as by considering variation in the foraging locations of individual species. The latter consideration is important to ensure that individual species requirements will be met within the overall subdivision, particularly those of much lower abundance. Prof. J. Croxall (UK) indicated that there were no rare or endangered species that needed to be given special status in this analysis.

1.18 The workshop agreed that a nested approach to the subdivision of the region was necessary in order to account for the features described above as well as accounting for the potentially different summer (breeding) and winter (non-breeding) foraging activities by predators. It was considered that a subdivision based on summer breeding activities would result in a number of smaller areas. Winter foraging distributions would likely be comprised of several of these smaller predator units.

1.19 Dr Constable noted that issues surrounding the movement of krill from one small-scale management unit to another would need to be considered when the manner in which these units would be used by the Commission was to be discussed. He also noted that the small-scale management units would mostly be determined by species that have specific foraging areas rather than species that have widely distributed foraging activities.

1.20 Dr W. Fraser (USA) noted that oceanographic and bathymetric features may be primary determinants of foraging locations by predators. The workshop noted that these and other environmental influences may be important but these would be considered following the initial work on krill, predators and the fishery.

1.21 The workshop agreed that there were some natural locations for delineating small-scale management units, such as between the island groups. Other areas that may be easily separated could be between Bransfield Strait and Drake Passage.

1.22 The workshop agreed to begin its work by reviewing the spatial patterns in the available data for krill, predators and the fishery on a smaller scale than subareas, including consideration of how to account for seasonal and interannual variation in the behaviour of predators and the fishery. In part, the methods for analysing the data would account for this but the workshop noted that some consideration may be given to these issues in the final synthesis.

1.23 Although there is potential for future changes in krill, predator foraging and the fishery, as well as having more data in the future on existing patterns, the workshop noted the view of the Scientific Committee that the information available to the workshop is the best information available for delineating small-scale management units (SC-CAMLR-XX, Annex 4, paragraph 5.13).

1.24 Dr G. Kirkwood (UK) noted that consideration will need to be given to separating the areas foraged by land-based predators, which primarily include the shelf areas, from the areas foraged by sea-based predators. Also, Dr I. Everson (UK) noted that the fishery was mostly concentrated in the foraging range of land-based predators. He noted that the CCAMLR-2000 Survey could be used to identify whether fishable concentrations of krill are likely to occur in the offshore areas.

1.25 The workshop welcomed the participation of members from the USA Palmer LTER Program who could provide an overview of the region to the southwest of the primary fishing areas in the South Shetland Islands. It was noted that this area could provide a location for monitoring the behaviour of the Antarctic marine ecosystem in the absence of fishing. The workshop encouraged further participation of this group in future meetings of WG-EMM.

1.26 The workshop agreed that the use of diet data was outside the scope or time available for delineating small-scale management units, although such information would be useful in determining how to subdivide catch limits in the future, if necessary.

1.27 Presentations were provided to the workshop outlining the data available for analyses and the patterns currently observed:

(i) predators at South Georgia and South Orkney Islands – Dr Trathan;
(ii) fur seals at Livingston Island – Mr Goebel;
(iii) penguins at South Shetland Islands – Dr Trivelpiece;
(iv) demersal fish species around South Shetland and South Orkney Islands – Mr Jones;
(v) krill distribution and abundance – Dr Hewitt;
(vi) Japanese krill fishery – Dr Kawaguchi; and
(vii) Soviet krill fishery – Dr Sushin.

1.28 Dr Ball had developed software ('Tracks and Fields') to support the methods described above for predators, fisheries and krill. He gave a brief presentation on how the software worked as well as a brief tutorial on how to use it as part of the method for determining areas of importance, which also required the use of standard spreadsheet and statistical packages. The workshop thanked Dr Ball for his presentation and for providing this software, which was used by all participants for analysing their datasets. The software with its manual was archived with the CCAMLR Secretariat.

1.29 Dr J. Watkins (UK) presented results from a simulation study undertaken by Drs E. Murphy and S. Thorpe (UK) on the potential movement of krill through the Scotia Sea based on the distribution of krill determined from the CCAMLR-2000 Survey and the use of the oceanographic model from the Ocean Circulation and Climate Advanced Modelling project. The advantage of this model over other models previously used is its use of known wind vectors to drive the model. It was noted that krill from the Scotia Sea were likely to be split to the southeast of South Georgia so that not all would pass directly by South Georgia, but that some would be advected directly past the South Sandwich Islands. The model also indicated the potential for retention of krill in the island areas, particularly around the Antarctic Peninsula and the South Orkney Islands. Dr Watkins noted the potentially important role of the ice-edge extent in driving the distribution of krill. The workshop thanked Dr Watkins for his presentation and encouraged further work using this model.

KRILL FISHERY

2.1 The patterns of the krill fishery were analysed according to the method outlined in paragraph 1.14. This analysis considered the relative importance of 10 x 10 n mile areas to the fishery when subdivided in the following ways:

(i) historical fishing period (five-year periods); and
(ii) country.

2.2 These analyses were then integrated to provide advice on the nature of fishing grounds in the region.

2.3 The data used in these analyses were catch data taken from the CCAMLR database reported for 10-day periods from 1986 to 2000. Data were extracted from the database for 10 x 10 n mile areas. Records for which only fine-scale data were available (30 x 30 n mile areas) had the catches evenly divided into nine areas in order to match the appropriate scale.

2.4 Data were also available for the USSR krill fishery around South Georgia between 1986 and 1990, as presented in WG-EMM-02/63 Rev. 1. These data were analysed in a similar way but were based on haul by haul data and summarised by 3 x 1.5 n mile areas.

Historical Fishing Period

Average Annual Importance of Fishing Locations

2.5 The average normalised catches for two periods, 1986–1990 and 1996–2000, are shown in Figures 1 and 2 respectively. These show how the major fishing areas included South Georgia, South Orkney Islands and Elephant Island. In recent years, the fishery has concentrated more on the South Shetland Islands and South Georgia with less emphasis on the South Orkney Islands and Elephant Island.

Seasonal Importance of Fishing Locations

2.6 The average importance of different locations within each season is shown in Figure 3. The figure shows the progression of the fishery during the year from October through to September (quarter 2 – October to December, quarter 3 – January to March, quarter 4 – April to June, quarter 1 – July to September). This shows the general trend of the fishery concentrating in Subareas 48.1 and 48.2 at the beginning of the fishing year, moving further south in summer and then moving north in winter. South Georgia is not important from October to March.

2.7 In terms of differences between the 1986–1990 and 1996–2000 periods, the South Orkney and South Shetland Islands have increased in importance during July to September in recent years. The South Orkney Islands have become much less important for the two quarters between October and March. King George and Livingston Islands have become more important for the three quarters between October and June.

USSR Krill Fishery around South Georgia from 1986 to 1990

2.8 The analysis of the USSR krill fisheries in Subarea 48.3 has been based on haul-by-haul data for 1986 to 1990. It covers the main fishing season for this area, which was from April to September (quarters 4 and 1 according to CCAMLR split-years). This period comprises 10 quarters in all – 5 years x 2 quarters per year. The results are shown in Figure 4.

2.9 The workshop agreed that there are three clearly identifiable areas to the north of South Georgia:

(i) a main eastern fishing ground, which is well pronounced during all fishing seasons and present in nine out of 10 quarters in this fishing period;

(ii) a small eastern fishing ground, which can be observed only in the April–June quarter and was observed in only two of those quarters in the fishing period; and

(iii) a western fishing ground, which exists only during the July–September quarter but was present in all years.

Country

2.10 The fishing patterns of five main countries were examined for each of the two periods (Figure 5). Japan, Republic of Korea and Poland were fishing in both periods, while the USSR fleet fished in the 1986–1990 period and the Ukrainian fleet fished in the 1996–2000 period.

2.11 Japan changed its predominant fishing locations from primarily Elephant Island followed by the South Orkney and South Shetland Islands in the earlier period to the South Shetland Islands and South Georgia in the later period, with the South Shetland Islands being of primary importance to the fishery in recent years.

2.12 The Republic of Korea has expanded from the Elephant Island region to include all the island groups.

2.13 The USSR and Ukrainian fleets have concentrated on the South Orkney Islands and South Georgia.

2.14 Poland has moved its fishery from being primarily around South Georgia to being primarily around the South Shetland Islands and Elephant Island.

Fishing Grounds

2.15 The workshop agreed that the following fishing grounds could be identified from these analyses:

(i) eastern South Georgia – east of 37.5°E;
(ii) western South Georgia – west of 37.5°E;
(iii) northwest of South Orkney Islands;
(iv) Elephant Island; and
(v) Drake Passage – north of King George and Livingston Islands.

2.16 The workshop agreed that the fishery was currently concentrated in the vicinity of the shelf break in these areas.

2.17 The workshop noted that the importance of Bransfield Strait is very small at present and that the fishery does not extend to the west of Livingston Island because of hazardous bathymetry and difficult conditions.

2.18 Drs Gasiukov and Sushin indicated that the fishing grounds at South Georgia may come from different sources of krill and are influenced by the oceanography of the region (WG-EMM-02/63 Rev. 1), such that:

(i) catches in the eastern fishing ground comprise krill associated with the eastern route of krill drift to South Georgia; and

(ii) catches in the western ground comprise krill associated with the western route of krill drift to South Georgia.

2.19 Drs Trathan and Everson indicated that these grounds may not be differentiated in such a way but may be connected through the seasonal transport of krill across the northern area of South Georgia.

2.20 The workshop noted that oceanography is likely to influence the availability of krill in these grounds and that further consideration would be needed to understand the connections between these areas and the potential for interannual fluctuation in krill availability. However, it was agreed that the analyses presented to the workshop are sufficient for circumscribing fishing grounds and to facilitate the delineation of small-scale management units. Those other issues will need to be considered when identifying how those units will be used in the future.

KRILL

3.1 Analyses of krill distributions were undertaken for the CCAMLR-2000 Survey as well as for eight small-scale surveys undertaken by the US AMLR Program around the Antarctic Peninsula (1998–2002).

CCAMLR-2000 Survey

3.2 Sample-weighted krill densities for the CCAMLR-2000 Survey were obtained using the smoothing algorithm in 'Tracks and Fields' (Figure 6). These results show aggregations of krill to the northwest and southeast of South Georgia, aggregations near Maurice Ewing Bank, high density of krill around the South Orkney Islands and aggregations of krill around the South Shetland Islands, particularly Livingston Island and in Bransfield Strait, and Elephant Island. Also, there were large aggregations in areas away from the island shelf areas to the east of the South Orkney Islands.

Predictable Krill Locations in Subarea 48.1

3.3 Areas where predictable concentrations of krill were found from 1998 to 2002 were estimated using the eight small-scale acoustic surveys undertaken by the US AMLR Program.

3.4 Data were analysed using the methods described in paragraph 1.14. The raw data were Nautical Area Scattering Coefficients (NASCs) for each 1 n mile interval, which was used as a measure of krill density for those intervals (MacLennan and Fernandez, 2000). The method was modified to obtain relative densities (importance) of krill for each 1 n mile grid square for each survey. The normalised, smoothed densities arising from 'Tracks and Fields' were accumulated densities at each point according to the contributions of other points dictated by the smoothing algorithm. Thus, the relative density at each point needed to be restored to a relative density per unit effort. This was achieved by dividing the relative density at that point by the relative effort for that point. The relative effort was obtained by using 'Tracks and Fields', but using the sampling effort at each point (=1) in place of the values for krill density and smoothing as for density. The resulting density values were then normalised to restore the relative densities for comparison across years.

3.5 The parameters used in 'Tracks and Fields' are given in each figure.

3.6 The results for the eight acoustic surveys in Subarea 48.1 are shown in Figure 7. The average relative densities of krill in January and in February–March are shown in Figure 8.

3.7 For January, these results indicate that the average location of aggregations occurs to the northwest of Elephant Island with lesser aggregations to the northeast and south of Elephant Island, to the north of Livingston Island, and to the northwest and immediately to the south of King George Island. Some smaller aggregations are present further to the west and east of the South Shetland Islands.

3.8 For February–March, these results indicate that the average location of aggregations occurs predominantly to the north of Livingston Island with lesser aggregations to the north of King George Island and even smaller aggregations further east, including around Elephant Island. There is also an aggregation in Bransfield Strait around the shelf break off the Antarctic Peninsula to the southeast of King George Island.

3.9 Overall, the aggregations in this area are concentrated over the shelf and at the shelf break.

3.10 The workshop agreed that Subarea 48.1 could be separated into the following areas based on the persistent locations of high densities of krill:

(i) Elephant Island;
(ii) Bransfield Strait to the south of Livingston and King George Islands;
(iii) Drake Passage to the north of Livingston and King George Islands; and
(iv) west of Livingston Island.

3.11 The workshop noted that there were higher aggregations of krill to the north of Livingston Island compared to the north of King George Island but it was difficult to separate the two.

KRILL PREDATORS

Patterns of Distribution and Abundance

4.1 The distribution and indices of abundance of predators were used to help determine centres of foraging activity in the South Atlantic. This was to be achieved by combining the information on predator distribution and abundance with the known information on foraging ranges from the main areas currently being regularly monitored.

4.2 The workshop agreed to concentrate on the distribution and abundance of four main groups of krill predators: land-based predators, including Antarctic fur seals, macaroni, gentoo, chinstrap and Adélie penguins and black-browed albatrosses, and krill-eating fish species.

Land-based Predator Breeding Colonies

4.3 For the land-based predators, data on the distribution and abundance of breeding colonies were compiled from the following sources: Woehler (1993), Trathan et al. (1996) and WG-EMM-02/51.

4.4 For the purposes of the workshop the colony information for each species was pooled into centres of biomass. The pooling of colonies was based on an assessment of whether the colonies were likely to have overlapping foraging ranges. Colonies were considered to have a functional overlap where the distance between colonies was less than the critical foraging distance (CFD) where

$$\text{CFD} = \text{maximum foraging distance}/\sqrt{2}.$$

4.5 Colonies were initially grouped together with those colonies with which they directly overlapped. These groups were aggregated where individual colonies occurred in more than one group, this procedure was carried out until no single colony occurred in more than one colony group (see Figure 9). The numbers of predators in the colonies included in each group were summed and the colony group was centred on the colony with the largest breeding population size.

4.6 Distributions of colonies and the resulting centres of biomass in Subareas 48.1, 48.2 and 48.3 are shown in Figures 10 to 19 and listed in Attachment 2.

Fish

4.7 The spatial distribution and abundance of krill-eating finfish biomass on shelf regions in Area 48 was assessed using data obtained from recent research trawl surveys conducted by the US AMLR Program in the South Shetland Islands (1998, 2001), and the South Orkney Islands (2000), and from Russian and UK surveys around South Georgia (2000). These surveys were undertaken using bottom trawls made in depths ranging from 50 to 500 m, which encompasses the majority of the biomass of demersal finfish species.

4.8 Surveys conducted in the vicinity of the South Shetland Islands and Elephant Island included diet analysis for 20 of the most abundant species (Figure 20). Of these, 14 species were found to feed on krill (>25% average stomach contents). These species were pooled in the subsequent analysis of the spatial distribution and abundance of krill-feeding fish. Information for krill predators around South Georgia was restricted to *Champsocephalus gunnari*, which is the most abundant and primary krill-eating finfish species.

4.9 All research survey hauls were standardised to kg/n mile, and treated in an identical manner to that of other krill predators examined during the workshop. The abundance information was smoothed using 'Tracks and Fields' with kernel options set at a 0.1 smoothing level, a maximum distance of 3, and densities gridded to 0.1° latitude and 0.1° longitude resolution. Data were normalised and truncated at 95%.

4.10 The resulting spatial distributions are plotted in Figure 21.

4.11 Around the South Shetland Islands and Elephant Island (Figure 21a), the highest densities of krill-eating finfish biomass were west of Elephant Island and north of King George Island. This pattern is likely to be relatively consistent across years, as these areas also served as primary fishing grounds when the commercial fishery operated in this subarea.

4.12 Around the South Orkney Islands (Figure 21b), there were three modes in the spatial distribution and abundance of krill-eating finfish. The highest densities were on the western shelf of the islands, with another important area to the north, and a region of lesser importance on the eastern shelf.

4.13 Around South Georgia (Figure 21c), the surveys indicated that the highest densities of *C. gunnari* were on the western shelf of South Georgia, near Shag Rocks, and other smaller areas of lesser importance. However, other surveys, from which the data were not available at the workshop, indicate that there may be areas of importance in the southeast shelf region of South Georgia as well (SC-CAMLR-XX, Annex 5, Appendix D, paragraph 5.24). Thus, it is likely that most shelf areas within the 500 m isobath of South Georgia are important krill feeding areas for *C. gunnari*, as well as other krill-eating finfish.

Spatial Patterns of Foraging

Subarea 48.1

4.14 Satellite-tracking data for penguins were made available to the workshop from studies in Subarea 48.1 undertaken through the US AMLR and NSF programs. These data were obtained using satellite tags (PTTs) deployed on Adélie, chinstrap and gentoo penguins, which were breeding at two colonies at the South Shetland Islands (Subarea 48.1), Cape Shirreff on the Drake Passage side of Livingston Island, and Copa in Admiralty Bay on the Bransfield Strait side of King George Island. The studies were undertaken from 1996 to 2002 (see Table 1 for details).

4.15 All PTTs were epoxied to the lower back feathers of the penguins to minimise the effects of drag and location data were obtained from the ARGOS satellite-tracking system.

4.16 ARGOS provides a Location Quality (LQ) code for each location fix, based on the number of uplinks received and the results of four plausibility checks (‘NOPC’, ARGOS 2000). LQs range from 0 to 3 with an ARGOS predicted accuracy of <150 m to 1 km+. Two other LQ codes, ‘A’ and ‘B’ are assigned lower assurance (due to fewer uplinks and/or lower NOPC).

4.17 All PTTs used on birds during the breeding season were set for continuous transmissions at 50 s intervals. PTTs deployed on chinstrap penguins from March to July 2000 and on Adélie penguins from February to April 2001 and February to March 2002 were set to transmit for 12 h on and 72 h off in order to save battery power during the winter period. Satellite data were sorted by site, individual, date and time. Only location data of classes 0 to 3 were used in these analyses.

4.18 The workshop noted that the number of replicates were small in many of the tracking periods. For that reason most conclusions by the workshop were drawn from the composite foraging area for each species, where all samples for a species were pooled together.

Chinstrap Penguins

4.19 The results are illustrated in Figure 22, which shows chinstrap penguins foraging over the shelf areas near the colonies being monitored at both Cape Shirreff and Copa. This pattern was consistent between breeding and winter seasons from 2000 to 2002.

4.20 In winter, two chinstrap penguins tagged at the Cape Shirreff colony were tracked from February to May 2000. Birds left the colony and travelled southwest, keeping well inshore until they reached the vicinity of Snow Island (area of concentration, Figure 22b). Here, they spent two to three weeks just off the western coast of Snow Island before moving well offshore. The birds remained in this offshore region for another two weeks, moving slowly to the northeast throughout the period. In mid-April, they returned to the inshore shelf area off Livingston Island and were proceeding to the northeast, on the shelf, when their signals were lost near Nelson Island from late April to early May.

4.21 From February to May 2000, three penguins were tracked from the Copa colony in Admiralty Bay, from where they proceeded to the northwestern end of King George Island where they spent the remainder of the March to May period foraging on the shelf in this vicinity (Figure 22c).

4.22 During the incubation period in November 2000, birds were at sea for 5- to 10-day intervals and their foraging distributions extended well beyond the shelf break (Figure 22d).

4.23 Foraging distributions of chinstrap penguins during the chick-rearing stage of the reproductive cycle were largely confined to the shelf, within approximately 10 km of the colony at Cape Shirreff, although some penguins were observed to make frequent trips out to the shelf break, approximately 30 km from the colony (Figures 22e and 22f).

Adélie Penguins

4.24 The results are illustrated in Figure 23, which shows the foraging areas for Adélie penguins from Copa colony in Admiralty Bay on King George Island. These penguins concentrate their foraging in Bransfield Strait (Figure 23a), particularly over the shelf and shelf break to the south off the western shore of the Antarctic Peninsula. Foraging trips are typically 10 to 14 days in length following clutch completion (Figure 23b). There were two distinct patterns followed by approximately half the birds tagged. One group moved to the southwest, the other proceeded to the northeast, entering the upper Weddell Sea in the 1996 season (not shown here).

4.25 Early winter distributions of Adélie penguins tagged at the Copa colony in 2001 and 2002 (Figures 23c and 23d) showed marked differences in behaviour of the three animals tagged each season. The behaviour in 2001 was similar to the incubation foraging behaviour described above while in 2002 the foraging tracks went deep into the Weddell Sea on the east side of the Antarctic Peninsula.

4.26 The workshop agreed to use the incubation foraging pattern for the purposes of its work.

Gentoo Penguins

4.27 The foraging distribution of gentoo penguins during the chick-rearing period in 2002 is shown in Figure 24. Gentoo penguins forage very close to the colony, where 90% of their locations were within the 100 m bathymetric contour line off Cape Shirreff.

Antarctic Fur Seals

4.28 Studies of foraging range and at-sea locations of Antarctic fur seals in the South Shetland Islands were conducted by the US AMLR Program at Cape Shirreff, an ice-free peninsula (ca. 2.5 km^2) on the north side of Livingston Island, South Shetland Islands (62°29'S, 60°47'W). Cape Shirreff has the largest breeding colony of Antarctic fur seals in the South Shetland Islands (SSI) and together with San Telmo Islands (<1 km northwest of Cape Shirreff) has an annual pup production of 8 500+ (85% of the total SSI pup production) (WG-EMM-02/51). The continental shelf (to 500 m) extends to approximately 30 km north at Cape Shirreff.

4.29 All individuals in the Cape Shirreff study were females from 23 to 76 days post-partum. Length, girth, and mass were recorded, and an ARGOS-linked PTT (Kiwisat 100, Sirtrack Ltd.), time-depth recorder (Wildlife Computers Mark 7) and a VHF radio transmitter were attached mid-back. Females were recaptured with their pups after one to three trips to remove all instruments; the mother and pup were released together after recording mass, length and girth.

4.30 Each PTT had a unique ID code and a transmission repetition rate of 34 s while the seal was at the surface. PTTs were equipped with a wet/dry conductivity switch.

Transmissions were continuous until the instrument logged 120 min 'dry', putting the PTT in a 'sleep' mode (saving battery life). The instruments were programmed to re-transmit after a two-minute 'wet' interval was detected.

4.31 For the data received from ARGOS, previous studies have determined that 'A' and 'B' assigned locations are frequently acceptable locations (Vincent et al., 2002; Boyd et al., 1998) and that often 'A' locations, in spite of their lower ARGOS rating, were considerably better than LQ-0 locations and of similar accuracy to LQ-1 locations (Vincent et al., 2002). Thus, for the Cape Shirreff study, all locations (LQ 1–3, A, B) were initially included regardless of their LQ rating. Starting with all ARGOS downloaded data (LQ 0–3, A, B), location fixes were filtered to eliminate positions that required an animal to travel at speeds greater than 4 m/s. Consecutive locations flagged for having travelling rates of >4 m/s were alternately deleted to determine which locations had the greatest error.

4.32 The sites of capture and release were recorded with a GPS unit accurate to 15 m. The accuracy of the onshore ARGOS location fixes was obtained by comparing positions with the more accurate GPS fixes.

4.33 Departure and arrival times were recorded using VHF transmitters and a continuously operating logging station. Trip durations were calculated using VHF data. Maximum distance travelled, considered a female's maximum range, was calculated from the most distant ARGOS location received. The total distance travelled was recorded as the sum of the distances between locations.

4.34 The analyses comprised data obtained during January and February in each year from 1999 to 2002 (Table 2). Trip duration, foraging range and total distance travelled are shown in Table 3.

4.35 Data were analysed using 'Tracks and Fields' and the results are shown in Figures 25 to 27. Parameters used to smooth the data are shown in each figure.

4.36 Although the mean foraging range and trip duration varied from year to year, at-sea locations for fur seals in all years were centred over an area of the continental shelf and slope region approximately 40 km northwest of Cape Shirreff (Figure 26).

4.37 The distribution of foraging locations in February were more broadly distributed over the continental shelf slope region, were bimodal and were on average further west of Cape Shirreff (Figure 27).

Subarea 48.2

4.38 Foraging areas were determined for Adélie penguins and chinstrap penguins at Signy Island (Table 4). Methods of PTT attachment and deployment are described in WG-EMM-02/15. Tracks were obtained for both species during the summer chick-rearing period.

4.39 'Tracks and Fields' was used to smooth the foraging tracks for these two species. The method followed that used for Subarea 48.3. The input to the program was ARGOS satellite-tracking data that had previously been screened to remove all low-quality positions; only positions of quality class 3, 2, 1 and 0 were used. Summaries of the ARGOS data are given in Tables 5 and 6. The parameters used in 'Tracks and Fields' were:

Trip duration maps	Yes
Smoothing parameter	0.1
Maximum distance	100
Latitude step size	0.1
Longitude step size	0.2
Truncation value	0.0005
Density isopleth	0.05
Minimum speed	0.0

4.40 The average annual footprints for chinstrap and Adélie penguins are shown in Figures 28 and 29 respectively.

Subarea 48.3

4.41 Foraging areas were determined for macaroni penguins, black-browed albatrosses and Antarctic fur seals at Bird Island (Table 4). Antarctic fur seals were also monitored at Husvik in 1998. Methods of PTT attachment and deployment are described in WG-EMM-02/21 and 02/22 and references therein.

4.42 The data analysis method used and parameter inputs to 'Tracks and Fields' were the same as that used for Subarea 48.2 with additions as described below. The ARGOS data available for analysis are described in Tables 7 to 9. Only summer data are used in this analysis.

4.43 An additional level of screening was carried out for black-browed albatrosses. This was to remove the effects of long-time intervals between positions that could distort the smoothing of foraging time allocation; these occasionally occurred where intervening low quality positions had been screened. Data were also screened to remove positions east of 0°E and north of 50°S.

4.44 All data were analysed according to breeding chronology. Thus, for Antarctic fur seals each of the breeding seasons were analysed separately. Similarly, for black-browed albatrosses, incubation was analysed separately from brood guard and chick rearing. For macaroni penguins, the breeding season was divided into incubation, brood guard, chick rearing and premoult. All foraging trips were analysed according to actual colony chronology, as this can vary slightly in some years.

4.45 In the 'Tracks and Fields' analysis a consistent set of parameters were chosen. This was selected after experimentation with the software to ensure results adequately reflected the input data. As smoothing is a non-parametric process, the assessment to compare different sets of parameters was made subjectively. A spatial analysis of the residuals from the smoothing was carried out by eye to ensure that smoothing was not extended too far beyond the input data.

4.46 The output of the 'Tracks and Fields' analysis was used to prepare average spatial foraging distributions for the various species for their various breeding periods during the summer breeding season. For this, the output data 'Isopleth Threshold' was used. Annual estimates of smoothed spatial foraging distribution for a given period were averaged and normalised using scripts written in S-Plus (Mathsoft Inc.) (archived with the secretariat). These average breeding chronology footprints were subsequently merged to provide an average footprint for the complete breeding season. The different chronological periods were weighted using the relative time duration that each period contributed to the total duration of the breeding season.

4.47 The average annual footprint for black-browed albatrosses, macaroni penguins, and Antarctic fur seals are shown in Figures 30 to 32 respectively.

Designation of Foraging Areas

4.48 The foraging areas for predators of krill were to be derived from aggregating the foraging locations of all colonies across all species.

4.49 The method proposed to achieve this involved extrapolating the characteristics of known foraging areas for each species described above to the centres of biomass for which no foraging data are available (paragraphs 4.3 to 4.6).

4.50 The foraging ranges were then pooled by weighting each grid square in the foraging range by the estimates of the colony or biomass centre along with the estimated foraging intensity for that square. These values are then summed across all biomass centres and species to give the distribution of foraging intensities expected across the region.

4.51 The workshop agreed to keep separate the foraging areas of the monitored colonies from the extrapolated foraging areas but would consider both when formulating its views on the different foraging areas in each subarea.

Extrapolated Foraging Areas

4.52 The general method for extrapolating to colonies without foraging information included the following steps for each species in each subarea:

(i) estimating the 'maximum foraging distance';

(ii) estimating the 'characteristic foraging density' by distance from the centre of foraging;

(iii) determining the centre of foraging for the colonies without foraging data; and

(iv) estimating a foraging area for those colonies based on the above information.

4.53 This method would produce estimated summer foraging areas for each species in each subarea. Data used for estimating these characteristic areas were derived where possible from the same subarea for which the data were needed. This was not always the case. Table 10(a) shows the origin of the data used for each species in each subarea.

4.54 Maximum foraging distance is the maximum distance, in nautical miles, from the centre of foraging in the areas encompassing 95% of the foraging activities of the species. The estimated distances are given in Table 10(b).

4.55 Characteristic foraging density was the density of foraging estimated as a function of distance from the centre of foraging to the maximum foraging distance. It is expressed as a proportion of the maximum intensity. The characteristic foraging densities are shown in Table 10(c). This table also shows the general spread of the distribution of characteristic summer foraging areas. In some cases, such as macaroni penguins in Subarea 48.3, almost all of the foraging effort occurs over a small area but a small amount of effort is spread over a large area.

4.56 The central point of most foraging areas was located at the position of the colonies and centres of biomass. The central points for chinstrap penguins in Subarea 48.1 were located half way between the colony and the shelf break. In addition, the central point for the Adélie penguin colony at Signy Island (Subarea 48.2) was moved south from the colony by the maximum foraging distance because it was believed that these penguins would primarily forage on the south side of the South Orkney Islands (WG-EMM-02/15). The coordinates of these foraging centres are given in Table 11.

4.57 Dr Ball provided the software 'Range Plotter', which placed a foraging distribution around a nominated foraging centre. In his earlier presentation of the use of 'Range Plotter', Dr Ball had indicated how the software could wrap the foraging area around the coast of land, including islands, and that the shape of the distribution could be altered.

4.58 The workshop thanked Dr Ball for providing such a useful piece of software to help complete its work. The software was archived with the CCAMLR Secretariat.

4.59 The workshop agreed that a circular foraging area placed around the nominated foraging centre was used in the absence of knowledge about the primary foraging directions of species at locations for which no foraging data were available (see paragraph 1.23). No limits were placed on the extrapolated foraging areas. The distribution of foraging density from the centre of foraging followed the characteristic foraging density for the appropriate species and region.

4.60 The workshop also agreed that this application of circular foraging areas could lead to having foraging extrapolated to areas where no foraging occurs.

4.61 Drs Sushin, Shust and Gasiukov stressed that this approximation of circular foraging areas gave a picture which is in contrast with the observed spatial foraging patterns described earlier in Subareas 48.2 and 48.3. This use of the method does not take into account observed direction of foraging trips or the effect of land on the foraging range. They requested that the method be evaluated at the next meeting of WG-EMM.

4.62 The workshop agreed to view the extrapolated foraging areas for each species within a subarea as well as the combined plots of all subject species. These would be plotted in two ways:

(i) overlap of foraging ranges, which would illustrate the total area likely to be used as well as overlap between foraging areas between colonies and between species; and

(ii) biomass-weighted foraging areas, which would have each foraging range weighted by the biomass of the colony (centre of biomass) and the characteristic foraging density, showing the areas of greatest use by predators.

4.63 The biomasses for each colony or centre of biomass were determined as the number in the colony multiplied by an estimate of the average weight of an adult of the respective species from the CCAMLR database (Attachment 2).

4.64 Dr Watters developed a function 'plot blobs' within S-Plus to plot these figures for the workshop. This function is able to:

(i) overlay other plots, such as bathymetric or coastline maps;

(ii) restrict a presentation to a given subarea;

(iii) plot foraging densities within the foraging range or simply indicate the foraging range using uniform colour;

(iv) rescale the foraging densities to a common relative scale across figures, where the relative scale is from zero to the maximum foraging density; and

(v) weight the foraging densities from each colony or species by a selected set of statistical weights, say colony biomass or consumption.

4.65 The function requires input data as an S-Plus data frame, 'In.Data' with the following columns (labels are case sensitive):

(i) Longitude;
(ii) Latitude;
(iii) Isopleth.Threshold; and
(iv) colony.

4.66 The statistical weights need to be included in an S-Plus list with all unique colony names from the input data table.

4.67 The workshop thanked Dr Watters for developing this function for use by the workshop. The workshop greatly appreciated his efforts to develop this flexible and useful plotting routine. The function was archived with the Secretariat.

4.68 The results are illustrated for each subarea in Figures 33 to 35.

Delineation of Foraging Areas

Subarea 48.1

4.69 The workshop considered the results in Figure 33 as well as the known abundance and foraging ranges described for Antarctic fur seals (Figures 13 and 25 to 27), chinstrap penguins (Figures 11 and 22), Adélie penguins (Figures 10 and 23), gentoo penguins (Figures 12 and 24) and finfish (Figure 21).

4.70 The workshop agreed that the predator foraging areas could be broadly divided between Elephant Island, Drake Passage to the north of the South Shetland Islands and Bransfield Strait. In addition, the workshop noted that the foraging of Adélie penguins was likely to be concentrated in the eastern end of Bransfield Strait while chinstrap and gentoo penguins were likely to be concentrated in the western end. It was also noted that the primary location of foraging in Drake Passage was to the north of Livingston Island from Cape Shirreff.

4.71 The workshop agreed that an additional division based on these foraging areas could be made between Greenwich and Roberts Islands perpendicular to the axis of the South Shetland Islands and dividing both the shelf area in Drake Passage as well as Bransfield Strait.

Subarea 48.2

4.72 The workshop considered the results in Figure 34 as well as the known abundance and foraging ranges described for Adélie penguins (Figures 14 and 29), chinstrap penguins (Figures 15 and 28), gentoo penguins (Figure 16) and finfish (Figure 21b). It also noted the foraging area of black-browed albatrosses to the west of the South Orkney Islands (Figure 30).

4.73 The workshop noted that the biomass of land-based predators was concentrated towards the eastern end and south of the South Orkney Islands. It also noted the observed foraging areas were to the south and southwest of Signy Island for Adélie penguins and south for chinstrap penguins, and to the west of the South Orkney Islands for black-browed albatrosses. In addition, the density of krill-eating finfish was observed to be split to the west, north and east of Coronation Island.

4.74 The workshop agreed that the area to the west of the western end of Coronation Island could be separated from the remaining shelf area to the east of that point. This separation appeared best to be perpendicular to the shelf break to the north of Coronation Island.

4.75 The workshop noted the uncertainty as to whether penguins were likely to forage to the north of Coronation Island. It is conceivable that the large colonies of penguins on Laurie and Powell Islands would have access to the northern waters, unlike the penguins on Signy Island. However, it was noted that the northern side may be differentiated from the southern side.

4.76 Given the uncertainty as to whether penguins concentrated their foraging on the southern side of the island, the workshop agreed that the north and south of South Orkney Islands be separated in the interim pending more information on the foraging activities of penguins from Laurie Island.

Subarea 48.3

4.77 The workshop considered the results in Figure 35 as well as the known abundance and foraging ranges described for macaroni penguins (Figures 17 and 31), gentoo penguins (Figure 18), Antarctic fur seals (Figures 19 and 32) and finfish (Figure 21c). It also noted the foraging areas of black-browed albatrosses (Figure 30).

4.78 The workshop agreed that the primary area of foraging was centred to the northwest of South Georgia due to the concentration of land-based predators in the region as well as the known foraging locations of fur seals, macaroni penguins and black-browed albatrosses. It was also recognised that the area to the east and southeast of South Georgia was an important foraging location due to the foraging activities of the black-browed albatrosses and the presence of gentoo penguins at the southeast end of the island.

4.79 The workshop agreed that the distribution and feeding activity of krill-eating finfish provided some evidence to support the division of the shelf region into east and west, and to separate South Georgia from Shag Rocks. However, it was noted that this was only one year of data with no diet data to help explain the distribution.

4.80 Dr Everson indicated that there was a body of knowledge on diet and foraging activities of *C. gunnari* in the published literature, including work led by Dr K.-H. Kock (Germany), as well as well as in papers tabled at WG-FSA that could be used to further explore the spatial segregation of krill-eating finfish in the South Georgia region.

4.81 Dr Kirkwood proposed that the division between areas be indicated by north–south boundaries so that they are consistent with the work of WG-FSA. Such boundaries had been considered for *C. gunnari* by WG-FSA in 2000 (SC-CAMLR-XIX, Annex 4, Figure 24), although these boundaries were determined to facilitate a simple separation of Shag Rocks and South Georgia, and to provide a means of analysing survey data from the region.

4.82 The workshop noted that there is some uncertainty as to whether land-based predators forage on the south side of South Georgia during the breeding season.

4.83 Dr Trathan drew the attention of the workshop to the paper submitted by Prof. I. Boyd (UK) last year (WG-EMM-01/26) which estimated areas of highest consumption of krill by fur seals in the region. Using a different method, but the same data, the results of that analysis were similar to the results of the extrapolated foraging areas shown in Figure 35.

4.84 As for Subarea 48.2, the uncertainty as to whether predators forage on the southern side of the island meant that the workshop agreed that the shelf to the south of South Georgia be separated in the interim pending more information on the foraging activities in the region.

SYNTHESIS

5.1 The workshop reviewed the analyses described above for each statistical subarea to integrate the observed divisions in spatial distributions of krill, the krill fishery and krill predators into a spatial subdivision of each subarea.

5.2 The workshop recalled its decision to establish a nested hierarchy of areas such that the first division would be between the pelagic area and the area considered important to the summer breeding colonies of land-based predators. This division was to be based on the maximum foraging distance of the land-based predators. The second set of divisions was to be based on local units in which aggregations of krill, fishing grounds and predator foraging areas, as defined earlier in the report, could be separated from other areas. The workshop also agreed that separation of areas specific to individual predator species may be needed. This would form the third level of the hierarchy of areas.

Subarea 48.1

5.3 The integrated results for Subarea 48.1 are presented in Figure 36. This figure shows the divisions between Elephant Island, the South Shetland Islands and the Western Antarctic Peninsula, derived from the analysis of krill aggregations and the fishery. The workshop agreed to also maintain a division between Bransfield Strait and Drake Passage on the basis of this analysis.

5.4 The division between the pelagic area and the land-based predator area is shown in Figure 36(d).

5.5 The assessment of the predator divisions based primarily on the known foraging grounds of Antarctic fur seals at Cape Shirreff and the differences between Adélie and chinstrap/gentoo penguin foraging areas is overlaid on the extrapolated foraging areas in Figures 36(e) and 36(f). This pattern of division is supported by the analysis of krill-eating finfish (Figure 36g).

5.6 The workshop noted that the division between Greenwich and Roberts Islands overlaps with part of the observed krill aggregations (Figure 36h).

5.7 The workshop agreed that this subarea could be divided into pelagic and land-based predator areas and that the land-based predator area could be further subdivided into four main zones: Western Antarctic Peninsula, Drake Passage, Bransfield Strait and Elephant Island. These four zones were considered to provide a reasonable separation between the spatial structures of krill, the fishery and predator foraging grounds in that region.

5.8 The workshop also agreed to a further subdivision of Drake Passage and Bransfield Strait areas on the basis of the separation of the foraging areas of individual species. Both these areas were divided into east and west components with a boundary between Greenwich and Roberts Islands perpendicular to the axis of the South Shetland Islands.

5.9 This agreed subdivision of Subarea 48.1 is shown in Figure 37.

5.10 Dr M. Naganobu (Japan) drew the attention of the workshop to the oceanography of the region and explained why he believed that the subdivision of Bransfield Strait and Drake Passage into eastern and western areas, as indicated by the dotted line, was likely not to be warranted because of the movement of krill through the region. He explained that part of the Antarctic Circumpolar Current divides near the western end of Livingston Island bringing a strong west–east flow of water into the northern side of Bransfield Strait. This water moves around the eastern end of King George Island to form an area of coastal upwelling to the north of Livingston and King George Island. This area has high productivity, supporting krill and its predators. This water movement also helps drive the difference between the South Shetland Islands and Elephant Island. An area of cold coastal water is retained on the south side of Bransfield Strait.

5.11 The workshop agreed that future work on how these proposed small-scale areas could be used for management will need to consider the oceanography of the region and the potential linkages between these areas, including the movement of krill.

Subarea 48.2

5.12 The integrated results for Subarea 48.2 are presented in Figure 38.

5.13 The aggregation of krill observed in the CCAMLR-2000 Survey was centred over the South Orkney Islands, including part of the northern shelf break and extending south over the larger area of shelf less than 500 m in depth (Figure 38a). The fishery is largely concentrated to the northwest of Coronation Island (Figure 38b).

5.14 The division between the pelagic area and the land-based predator area is shown in Figure 38(c).

5.15 The assessment of the predator divisions based primarily on the known foraging grounds of black-browed albatrosses and chinstrap and Adélie penguins shows a northeast to southwest division in foraging locations at the western tip of Coronation Island (Figure 38d).

5.16 This division is supported by the extrapolated foraging areas (Figure 38e) and the aggregations of krill-eating finfish (Figure 38f). The extrapolated foraging areas are very much influenced by the large number of penguins on Laurie and Powell Islands. The workshop noted that the fish distribution may vary over time but the evidence in the analysis presented here does support the division.

5.17 The workshop noted that it may be possible that penguins are restricted in their foraging to the south of the islands despite the extrapolated foraging grounds extending to the north of the islands (see paragraphs 4.59 to 4.61 for discussion of the method used for extrapolation). If this were the case, then it would be reasonable to separate the north side of the South Orkney Islands from the south side.

5.18 Dr Trivelpiece indicated to the workshop that such a division is likely, given that Adélie and chinstrap penguins forage over shelf areas and that the majority of the shelf area in the region is to the south of the islands.

5.19 Dr Everson indicated that it is conceivable that birds on Laurie or Powell Islands could forage to the north and south of Coronation Island. He suggested that satellite-tracking studies of these penguins would be very useful in identifying where the foraging locations are for these colonies.

5.20 The workshop agreed that an additional division along the axis of the South Orkney Islands to divide the southeastern foraging area identified above is warranted, pending further information on the foraging locations of birds in the east of the South Orkney Islands.

5.21 The agreed subdivision of Subarea 48.2 is shown in Figure 39.

Subarea 48.3

5.22 The integrated results for Subarea 48.3 are presented in Figure 40.

5.23 The workshop noted the two main areas of krill aggregations observed in the CCAMLR-2000 Survey and known from many UK surveys in the region (Figures 40a and 40b). The analysis of the USSR krill fishery from 1986 to 1990 showed a distinct pattern associated with the shelf break. There was a clear separation of these winter fishing grounds at 37.5°W. Although this separation was based on winter fishing patterns, the workshop agreed to use this as a basis for subdividing the region.

5.24 The division between the pelagic area and the land-based predator area is shown in Figure 40(c).

5.25 The assessment of predator divisions based primarily on the known foraging grounds of black-browed albatrosses, Antarctic fur seals and macaroni penguins shows that the division of the fishing grounds also divides the known foraging areas (Figure 40d).

5.26 A division of the South Georgia region at 37.5°W is supported by the extrapolated foraging areas (Figure 40e) and by the assessment of *C. gunnari* densities from surveys in 2000 (Figure 40f). The workshop noted that the fish distribution may vary over time but evidence in the analysis presented here does support the division.

5.27 The workshop also noted the separation of Shag Rocks and the South Georgia shelf by WG-FSA. However, it was noted that this separation was likely to be achieved by the boundary of the land-based predator foraging area and so did not warrant the addition of a new boundary as nearly all the Shag Rocks shelf region fell outside of the range of the South Georgia land-based predator foraging footprint.

5.28 The workshop noted that it may be possible that land-based predators are restricted in their foraging to the west and north of the island despite the extrapolated foraging grounds extending to the southwest of the island (see paragraphs 4.59 to 4.61 for discussion of the method used for extrapolation). If this were the case, then it would be reasonable to separate the southwestern side of South Georgia from the rest of the shelf areas. However, the workshop did not find sufficient reason to justify the separation of this part of the shelf.

5.29 The workshop agreed to a subdivision of the South Georgia area by a single north–south boundary at 37.5°W. This is shown in Figure 41.

5.30 The workshop noted that further work on the oceanography of the region and on the distribution of *C. gunnari* may provide insights into the relationship between these areas and how they may be used for management purposes.

ADVICE TO WG-EMM

5.31 The workshop recommended that the subdivisions of Subareas 48.1, 48.2 and 48.3 shown in Figures 37, 39 and 41 be considered as the best available advice on small-scale management units in the region.

5.32 The workshop noted the uncertainty surrounding the extrapolation of known foraging characteristics of land-based predators to colonies for which no foraging information was known. It was noted that the method for extrapolating predator foraging areas for colonies without foraging information might lead to the conclusion that foraging might occur in areas in which predators do not forage in reality. However, the proposals take account of the known information and are based, although not dependent, on the extrapolated results.

5.33 The workshop noted that these proposals provide a structure for considering how to subdivide the precautionary catch limit for krill in Area 48 as well as for developing management procedures for krill fisheries that can adequately take account of localised effects on predators.

5.34 The workshop noted that:

(i) this assessment is the first of its kind in CCAMLR;

(ii) this assessment used a variety of datasets that enabled the detailed analyses presented here, such that deficiencies in one dataset could be compensated by strengths in others;

(iii) fine-scale fisheries data were very important to the success of this assessment;

(iv) a number of uncertainties remain regarding the relationships between predators, krill and the fishery and further information on krill, krill movement, predator demand and predator foraging grounds may provide opportunities to refine these boundaries in the future;

(v) the next step is to develop an understanding of the linkages and dynamics between these areas in order to facilitate the subdivision of the precautionary catch limit for krill in Area 48, taking account of the oceanography and the environmental variability of the region;

(vi) this assessment has demonstrated the utility of satellite-tagging programs for an understanding of the relationships between predators, krill and the fishery, and, as a result, the workshop highly recommended further studies of this kind; and

(vii) the manner in which these proposed small-scale management units are used may have implications for monitoring that would need to be considered by the Commission.

CLOSE OF THE WORKSHOP

5.35 Dr Hewitt thanked all the participants for their diligence and hard work over the course of the meeting. In particular, he thanked Dr Trivelpiece and his steering committee for all their preparation and the thought they had put into ensuring the success of the workshop. He also thanked the providers of data, without which none of these assessments could have been undertaken.

5.36 Special thanks were given to the providers of software and statistical routines, Drs Ball and Watters.

5.37 The workshop also extended its special thanks to Dr Constable for his persistent vision, perseverance and hard work throughout all stages of the workshop.

5.38 The workshop closed on 15 August 2002.

REFERENCES

Barlow, K.E. and J.P. Croxall. 2001. Seasonal and interannual variation in foraging range and habitat of macaroni penguins at South Georgia. Document *WG-EMM-01/19*. CCAMLR, Hobart, Australia.

Boyd, I.L., D.J. McCafferty, K. Reid, R. Taylor and T.R. Walker. 1998. Dispersal of male and female Antarctic fur seals (*Arctocephalus gazella*). *Can. J. Fish. Aquat. Sci.*, 55: 845–852.

MacLennan, D.N. and P. Fernandez. 2000. Definitions, units and symbols in fisheries acoustics. Draft 03/04/00. Contr. FAST Working Group Meeting, Haarlem, USA, April 2000: 6 pp.

Trathan P.N., F.H.J. Daunt and E.J. Murphy. 1996. *South Georgia: an Ecological Atlas*. British Antarctic Survey, Cambridge, UK.

Trathan, P.N., I. Everson, E.J. Murphy and G.B. Parkes. 1998. Analysis of haul data from the South Georgia krill fishery. *CCAMLR Science*, 5: 9–30.

Vincent, C., B.J. McConnell, M.A. Fedak and V. Ridoux. 2002. Assessment of ARGOS location accuracy from satellite tags deployed on captive grey seals. *Mar. Mamm. Sci.*, 18 (1): 301–322.

Woehler, E. 1993. *The Distribution and Abundance of Antarctic and Sub-Antarctic Penguins*. SCAR, Cambridge, UK.

Wood, A.G., B. Naef-Daenzer, P.A. Prince and J.P. Croxall. 2001. Quantifying habitat use in satellite-tracked pelagic seabirds: application of kernel estimation to albatross locations. Document *WG-EMM-01/67*. CCAMLR, Hobart, Australia.

Worton, B.J. 1989. Kernel methods for estimating the utilisation distribution in home-range studies. *Ecology*, 70: 164–168.

Table 1: Summary details of data for penguin species tracked in Subarea 48.1, including site of colonies, number of replicates, year of sampling and season of tracking. KGI = King George Island, LI = Livingston Island.

Species	Site	N	Year	Period
Adélie penguin	Copa, KGI	8	1996	Oct–Nov
Adélie penguin	Copa, KGI	8	1997	Oct–Nov
Adélie penguin	Copa, KGI	3	2001	Feb–Apr
Adélie penguin	Copa, KGI	3	2002	Jan–Jul
Chinstrap penguin	Copa, KGI	3	2000	Mar–Jul
Chinstrap penguin	Cape Shirreff, LI	6	1999	Jan
Chinstrap penguin	Cape Shirreff, LI	2	2000	Feb–July
Chinstrap penguin	Cape Shirreff, LI	4	2000	Nov
Chinstrap penguin	Cape Shirreff, LI	3	2001	Jan–Feb
Chinstrap penguin	Cape Shirreff, LI	10	2002	Jan
Gentoo penguin	Cape Shirreff, LI	4	2002	Feb

Table 2: Number of ARGOS satellite uplinks by quality class code for Antarctic fur seals breeding at Cape Shirreff, South Shetland Islands.

Year	Season	Female	Total Uplinks	Quality 3	Quality 2	Quality 1	Quality 0	Quality A	Quality B
1999	Jan–Feb	35	3 122	13	62	463	1 325	511	748
2000	Jan–Feb	34	2 797	27	113	404	1 095	496	662
2001	Jan–Feb	25	5 237	149	321	852	1 567	836	1 512
2002	Jan–Feb	13	1 885	54	98	280	440	386	627

Table 3: Trip durations, foraging range, and total distance travelled by 95 female Antarctic fur seals foraging from Cape Shirreff, Livingston Island, from 1999 to 2002.

Parameter	1999	2000	2001	2002	All years
Female (N)	35	50	25	12	95
Trip (N)	39	42	55	34	170
Trip duration (days):					
Mean	4.5	4.4	3.8	3.3	4.0
SE	1.3	0.3	1.0	1.0	0.1
Min.	2.6	0.8	1.8	1.6	0.8
Max.	8.8	9.1	6.0	5.9	9.1
Foraging range (maximum distance travelled – km):					
Mean	106	83	78	67	83
SE	46	5	19	14	3
Min.	47	37	45	48	37
Max.	369	217	136	111	369
Total distance travelled (km):					
Mean	504	374	351	253	372
SE	197	25	95	86	14
Min.	154	99	164	109	99
Max.	1 258	814	561	448	1 258

Table 4: Deployment locations and PTT devices used for land-based predator species tracked in Subareas 48.2 and 48.3.

Species	Year	Period	Location	Device
Adélie penguin	1999	Summer	Signy Is	ST-10, ST-18
	2000	Summer	Signy Is	ST-10, ST-18
Chinstrap penguin	1999	Summer	Signy Is	ST-10, ST-18
	2000	Summer	Signy Is	ST-10, ST-18
Macaroni penguin	1999	Summer	Bird Is	ST-10, ST-18
	2000	Summer	Bird Is	ST-10, ST-18
	2001	Summer	Bird Is	ST-10, ST-18
Black-browed albatross	1992	Summer	Bird Is	Microwave, Toyocom
	1993	Summer	Bird Is	Microwave, Toyocom
	1994	Summer	Bird Is	Microwave, Toyocom
	1997	Summer	Bird Is	Microwave, Toyocom
Antarctic fur seal	1996	Summer	Bird Is	ST-10
	1997	Summer	Bird Is	ST-10
	1998	Summer	Bird Is	ST-10
	1998	Summer	Husvik	ST-10
	1999	Summer	Bird Is	ST-10
	2000	Summer	Bird Is	ST-10
	2001	Summer	Bird Is	ST-10

Table 5: Number of ARGOS satellite uplinks by quality class for Adélie penguins breeding at Signy Island, South Orkney Islands.

Year	Season	Male	Female	Male Uplinks	Female Uplinks	Quality 3	Quality 2	Quality 1	Quality 0	Quality A	Quality B	Quality Z
2000	Chick rearing*	3	6	349	498	18	70	260	175	155	166	3
2001	Chick rearing*	7	3	886	467	38	138	351	272	287	258	9

* Chick rearing is defined as 6 December to 20 February

Table 6: Number of ARGOS satellite uplinks by quality class for chinstrap penguins breeding at Signy Island, South Orkney Islands.

Year	Season	Male	Female	Male Uplinks	Female Uplinks	Quality 3	Quality 2	Quality 1	Quality 0	Quality A	Quality B	Quality Z
2000	Chick rearing*	3	7	179	487	15	44	174	109	172	149	3
2001	Chick rearing*	6	8	395	589	14	51	153	162	250	348	6

* Chick rearing is defined as 31 December to 20 February

Table 7: Number of ARGOS satellite uplinks by quality class for macaroni penguins breeding at Bird Island, South Georgia.

Year	Season	Male	Female	Male Uplinks	Female Uplinks	Sex not Known Trips	Sex not Known Uplinks	Quality 3	Quality 2	Quality 1	Quality 0	Quality A	Quality B	Quality Z
1999	Incubation[1]	-	-	-	-	-	-	-	-	-	-	-	-	-
	Chick rearing[2]	8	15	637	1 899	5	735	50	96	786	1 364	476	484	15
	Premoult[3]	1	-	433	-	-	-	4	4	84	208	70	59	2
2000	Incubation[1]	4	7	1 165	992	-	-	24	115	748	849	202	204	15
	Chick rearing[2]	6	18	585	1 238	-	-	17	75	443	759	243	274	12
	Premoult[3]	-	-	-	-	-	-	-	-	-	-	-	-	-
2001	Incubation[1]	3	3	1 552	682	-	-	29	113	665	817	302	302	6
	Chick rearing[2]	4	13	212	973	-	-	13	45	208	407	230	271	11
	Premoult[3]	2	3	574	1 497	-	-	16	62	369	775	389	440	20

[1] Incubation is defined as 1 November to 31 December [2] Chick rearing is defined as 1 January to 17 February [3] Premoult is defined as 18 February to 21 March

Table 8: Number of ARGOS satellite uplinks by quality class for black-browed albatrosses breeding at Bird Island, South Georgia.

Year	Season	Number Trips	Number Uplinks	Quality 3	Quality 2	Quality 1	Quality 0	Quality A	Quality B	Quality Z
1992	Incubation[1]	-	-	-	-	-	-			
	Brood guard[2]	-	-	-	-	-	-			
	Chick rearing[3]	1	184	-	12	57	115			
1993	Incubation[1]	-	-	-	-	-	-			
	Brood guard[2]	3	17	-	-	5	12			
	Chick rearing[3]	66	2 098	11	191	392	1 504			
1994	Incubation[1]	-	-	-	-	-	-			
	Brood guard[2]	1	46	-	-	-	-			
	Chick rearing[3]	-	-	-	2	6	38			
1997	Incubation[1]	10	750	2	10	36	323	177	158	44
	Brood guard[2]	-	-	-	-	-	-	-	-	-
	Chick rearing[3]	-	-	-	-	-	-	-	-	-

1 Incubation is defined as 1 November to 31 December
2 Brood guard is defined as 1 January to 24 January
3 Chick rearing is defined as 25 January to 15 April

Table 9: Number of ARGOS satellite uplinks by quality class for Antarctic fur seals breeding at Bird Island, South Georgia.

Year	Season	Female	Pup	Female Uplinks	Pup Uplinks	Quality 3	Quality 2	Quality 1	Quality 0	Quality A	Quality B	Quality Z
1996	Breeding season[1]	19	-	670	-	11	46	100	137	126	227	23
1997	Breeding season[1]	18	-	1 595	-	18	51	289	571	269	382	15
1998	Breeding season[1]	72	-	3 430	-	29	129	732	1 112	614	772	42
1999	Breeding season[1]	51	-	5 708	-	36	180	1 055	1 780	1 123	1 463	71
2000	Breeding season[1]	19	-	1 813	-	11	38	280	693	308	450	33
2001	Breeding season[1]	50	-	8 023	-	109	497	1 873	1 697	1 547	2 200	100

1 Breeding season is defined as 1 December to 31 March

Table 10: Details of characteristic summer foraging areas for land-based predators in Subareas 48.1, 48.2 and 48.3.

(a) Subareas from which data originated to estimate the characteristic area for each species (rows) in each subarea (columns).

Species	Subarea		
	48.1	48.2	48.3
Adélie	48.2	48.2	
Chinstrap	48.1	48.2	
Gentoo	48.1	48.1	48.1
Macaroni			48.3
Antarctic fur seals	48.1		48.3

(b) Maximum foraging distance, in nautical miles, estimated for five predators in Area 48.

Species	Subarea		
	48.1	48.2	48.3
Adélie	96	96	
Chinstrap	20	46	
Gentoo	15	15	15
Macaroni			191
Antarctic fur seals	48		115

(c) Characteristic foraging densities estimated for each species in each region. Each row is the characteristic foraging density as a function of distance for each of the species in each of the subareas. The values are distances (n miles) from the centre of the foraging distribution to the percentile for that column. For example, 75% of the foraging done by Adélie penguins in Subarea 48.1 occurs within 87.2 n miles of the centre of the foraging distribution.

Subarea/Species	Density as Proportion of Maximum Intensity					
	0.9	0.75	0.5	0.25	0.1	0.05
Subarea 48.1						
Adélie	87.2	87.2	87.5	91.4	95.7	95.7
Chinstrap	2.8	6.9	10.9	13.7	17.5	19.7
Gentoo	2.8	2.8	6.2	10.3	13.9	15.1
Antarctic fur seal	2.8	10.3	17.8	30.4	43.0	48.7
Subarea 48.2						
Adélie	87.2	87.2	87.5	91.4	95.7	95.7
Chinstrap	42.2	42.2	45.9	45.9	45.9	45.9
Gentoo	2.8	2.8	6.6	10.3	13.9	15.1
Subarea 48.3						
Gentoo	2.8	2.8	6.6	10.3	13.9	15.1
Macaroni	0	6.0	9.3	12.0	184.9	191.3
Antarctic fur seal	0	30.8	55.2	68.2	105.9	114.8

Table 11: Coordinates of central points of foraging areas for colonies that did not have this central point located at the site of the colony.

Subarea/Species	Colony Location		Centre of Foraging	
	Longitude	Latitude	Longitude	Latitude
Subarea 48.1				
Chinstrap	-59.70	-62.32	-59.75	-62.04
Chinstrap	-55.11	61.13	-55.12	-61.27
Chinstrap	-58.00	-61.90	-58.05	-61.63
Chinstrap	-58.37	-61.93	-58.42	-61.66
Chinstrap	-57.67	-61.90	-57.72	-61.64
Chinstrap	-60.18	-62.43	-60.23	-62.15
Chinstrap	-60.80	-62.47	-60.85	-62.18
Subarea 48.2				
Adélie	-45.58	-60.73	-45.58	-62.30

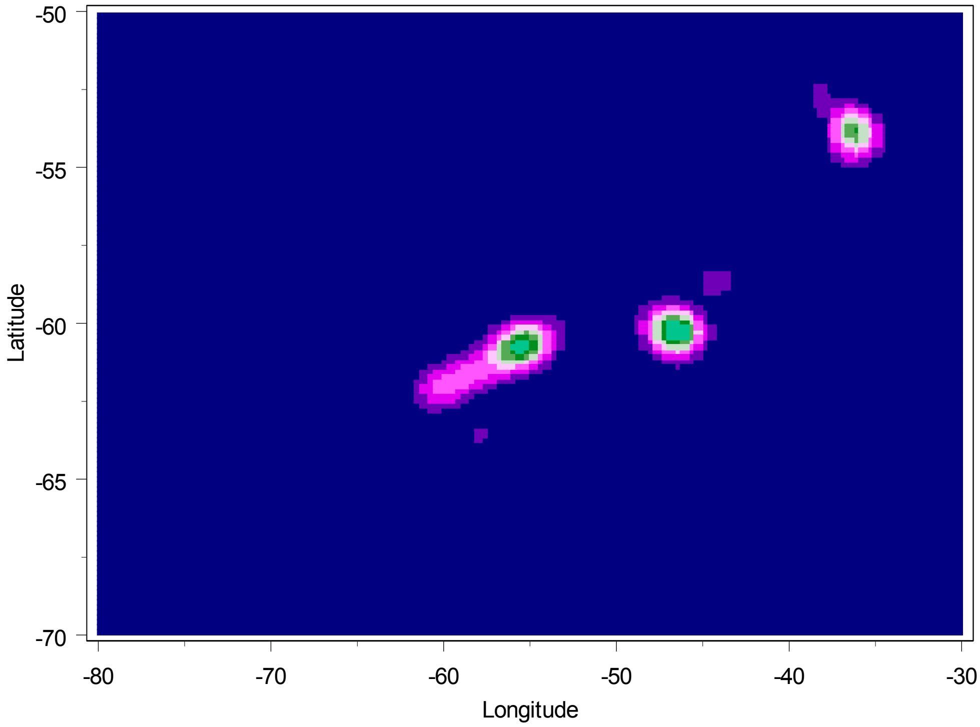

Figure 1*: Average importance of 10 x 10 n mile areas to the krill fishery from 1986 to 1990.

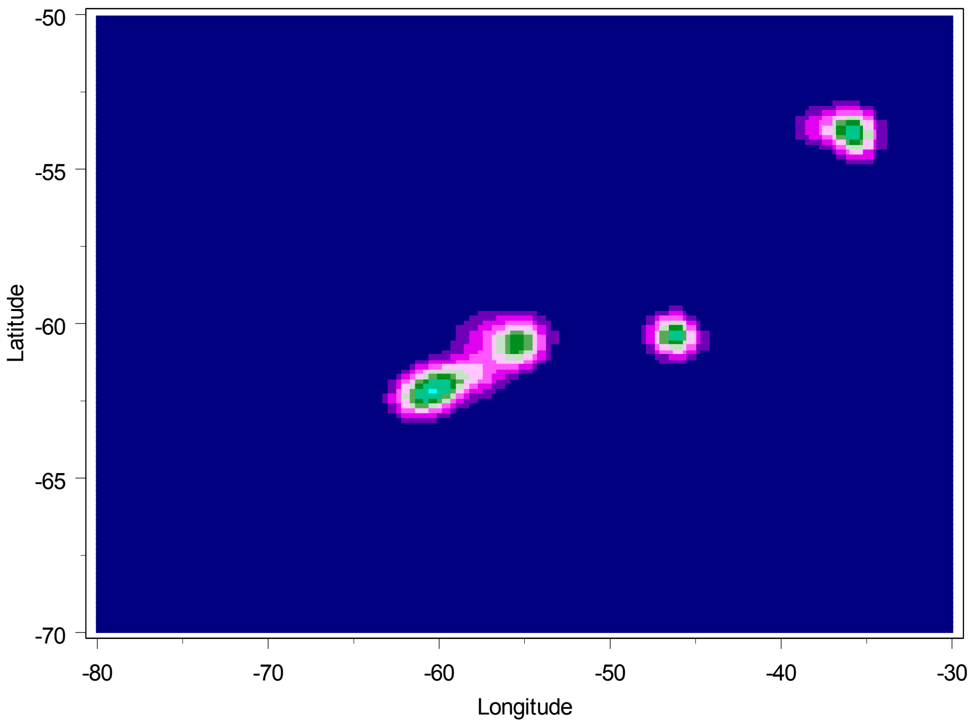

Figure 2: Average importance of 10 x 10 n mile areas to the krill fishery from 1996 to 2000.

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* Figures 1 to 5 are presented in this publication in colour to ensure full representation of the dynamic range of data available. It should be noted that figures in working group reports are not customarily published in colour.

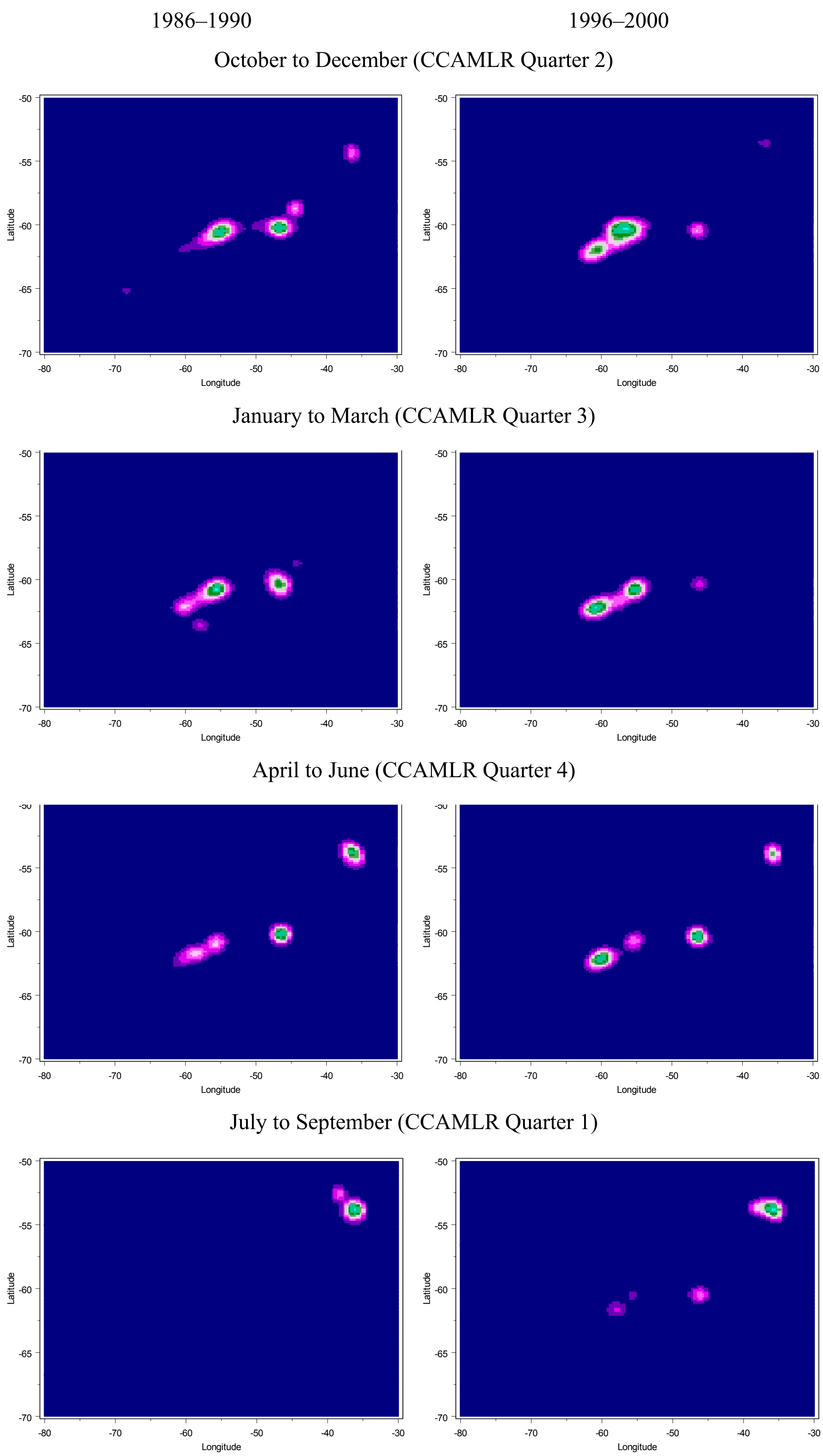


Figure 3: Average importance of 10 x 10 n mile areas for each quarter of two fishing periods.

(a)

(b)

(c)

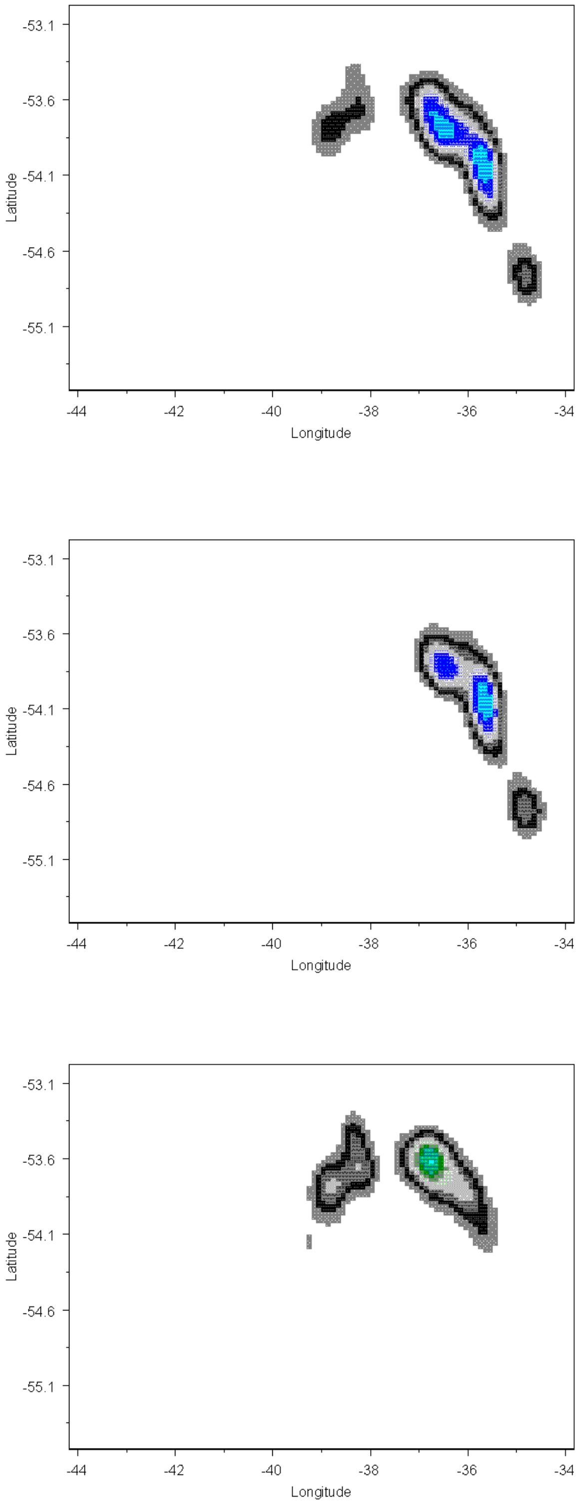


Figure 4: Average importance of 3 x 1.5 n mile areas to the USSR krill fishery: (a) from 1986 to 1990, (b) from 1986 to 1990 for the fourth quarter – April to June, and (c) from 1986 to 1990 for the first quarter – July to September. Grey indicates low importance, while light blue indicates high importance.

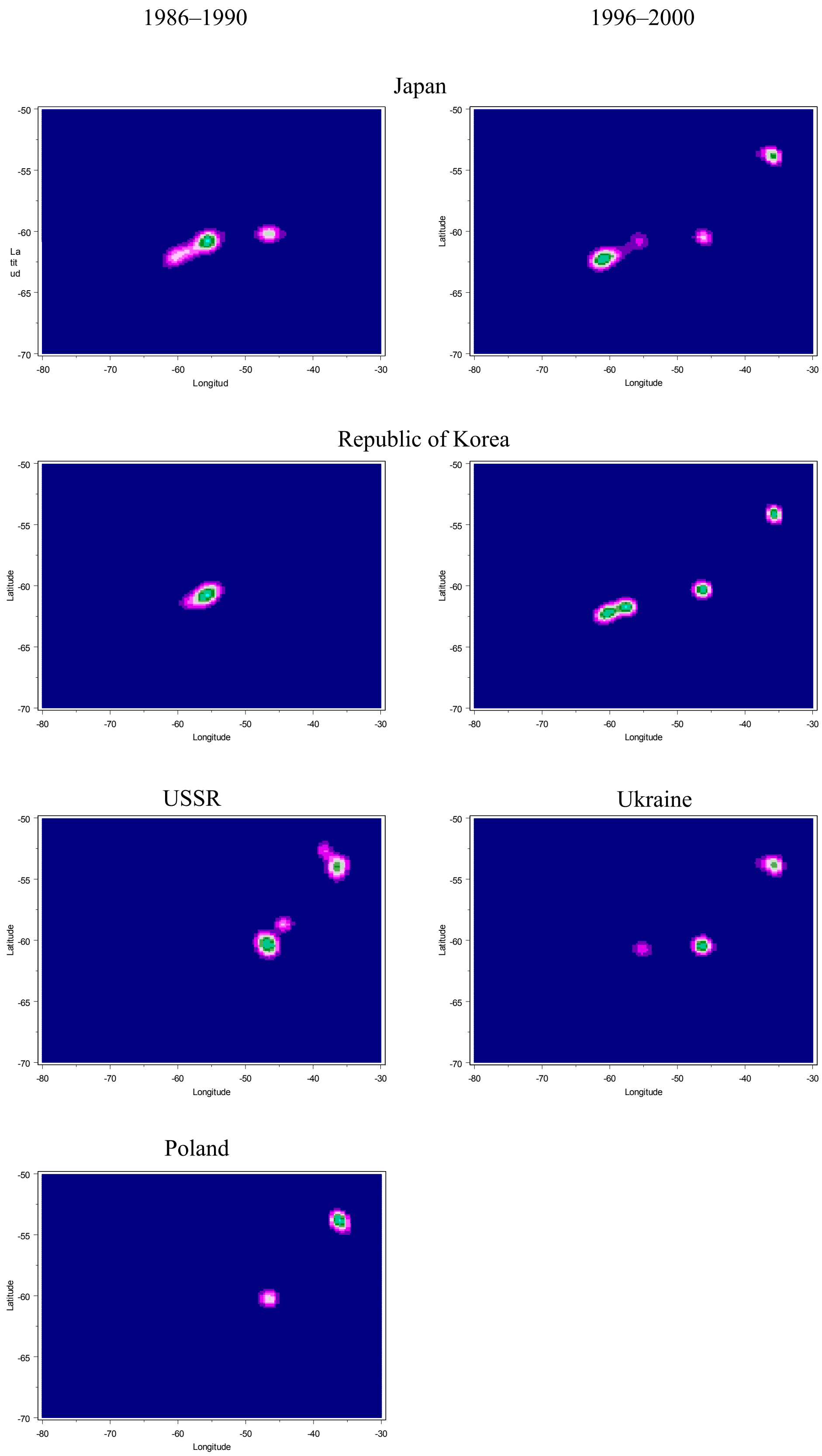


Figure 5: Average importance of 10 x 10 n mile areas for major krill-fishing countries during each of two fishing periods.

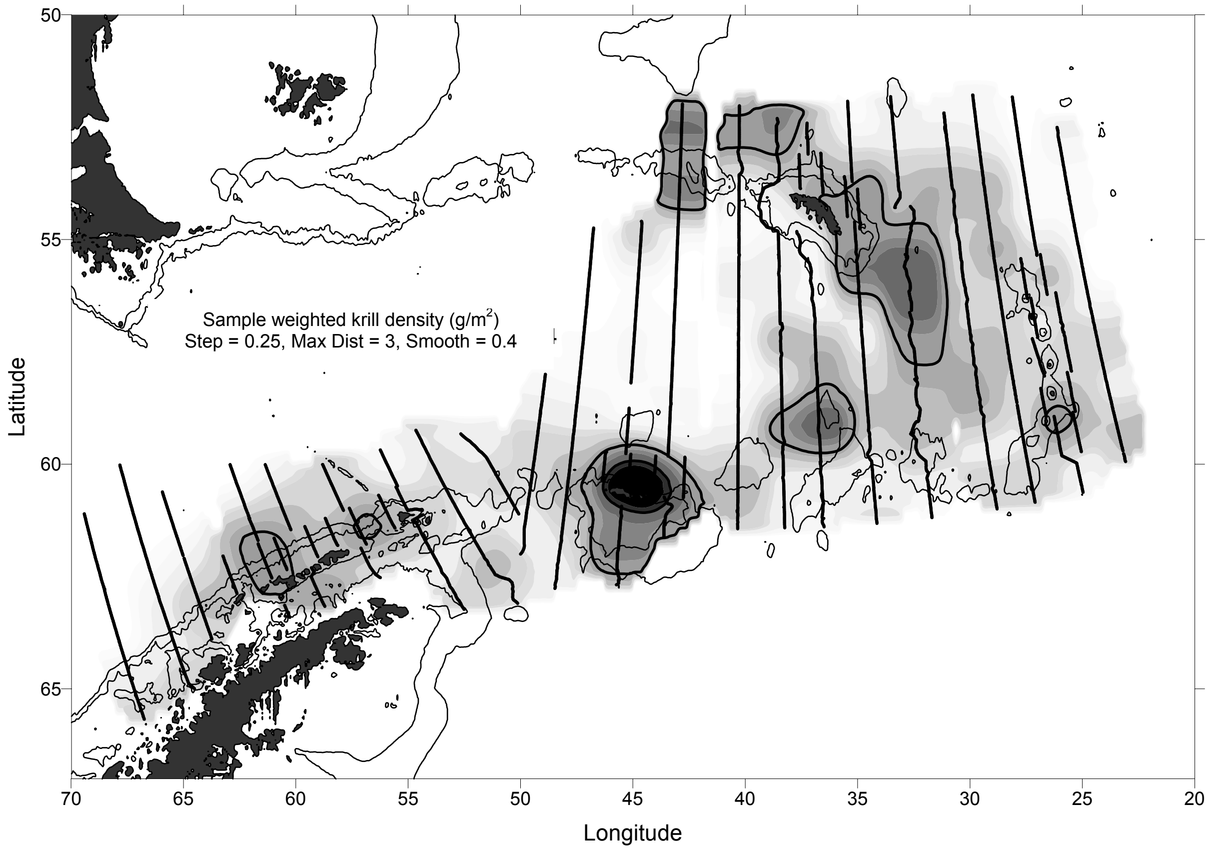


Figure 6: Sample weighted krill density (g m^{-2}) in Area 48 estimated from the CCAMLR-2000 Survey. Scale indicates relative density. Parameters show the values used in 'Tracks and Fields' for smoothing the data. Thin lines show the 500 m and 2 000 m isobaths. Thick lines denote areas where density is greater than 10 g m^{-2}.

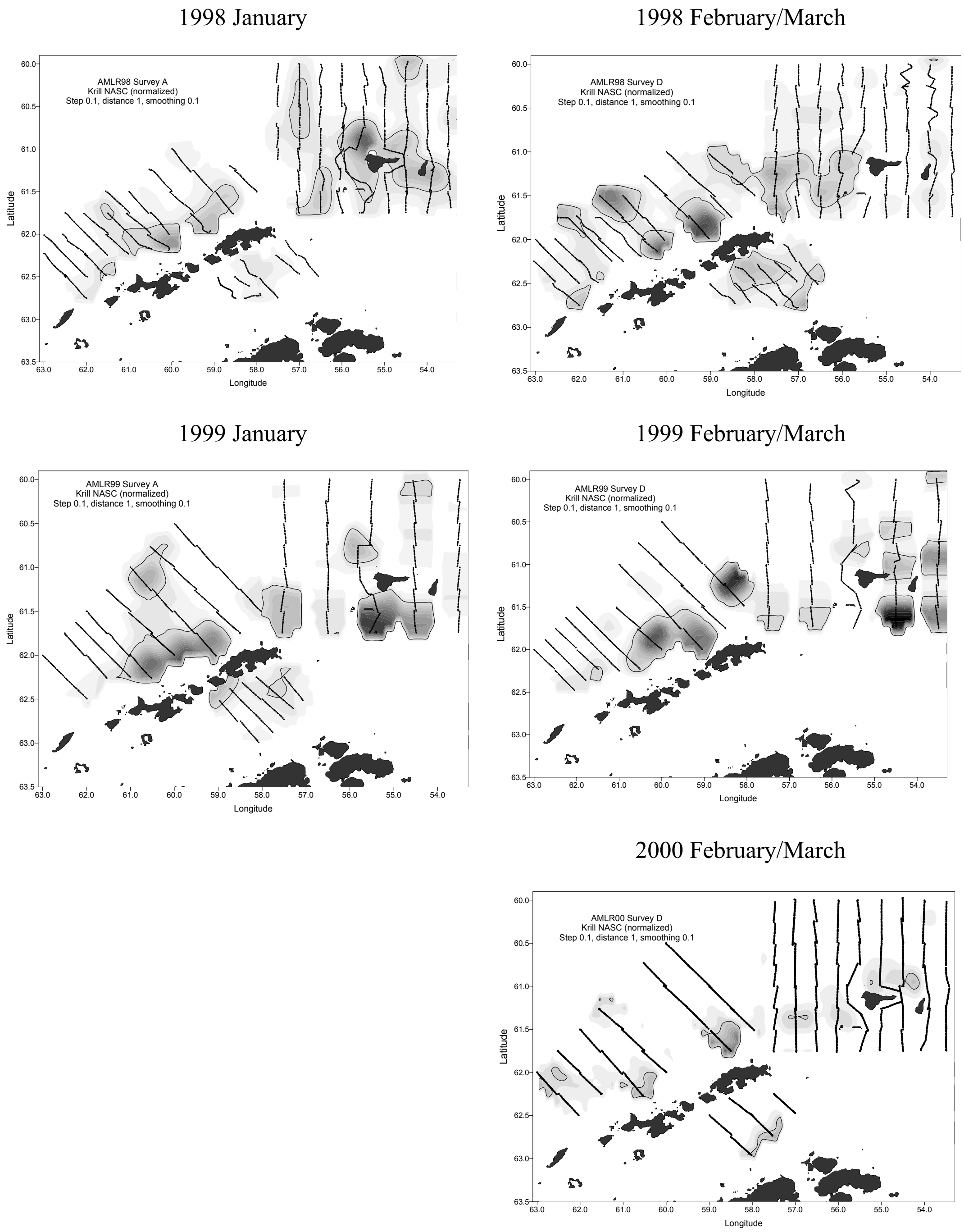
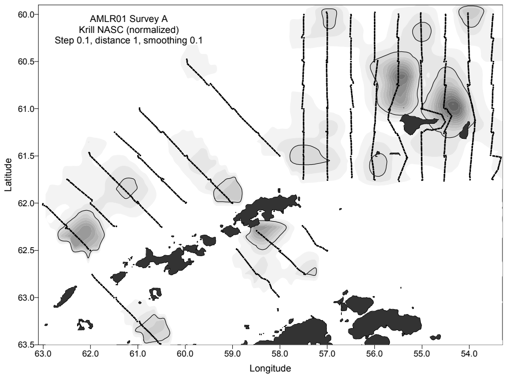


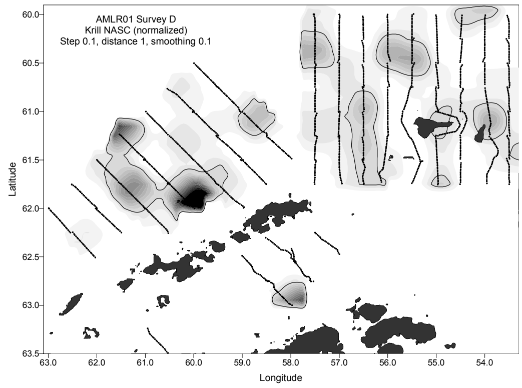
Figure 7: Relative densities of krill in Subarea 48.1 obtained from eight acoustic surveys by the US AMLR Program between 1998 and 2002. Thick lines indicate survey transects. Thin lines denote areas of relative high concentrations of krill. Parameters show the values used in 'Tracks and Fields' for smoothing and normalising the data.

Figure 7 continued

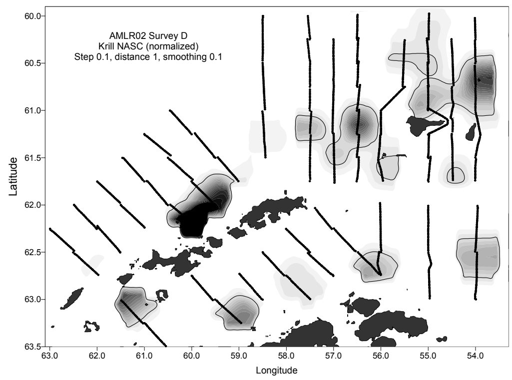
2001 January



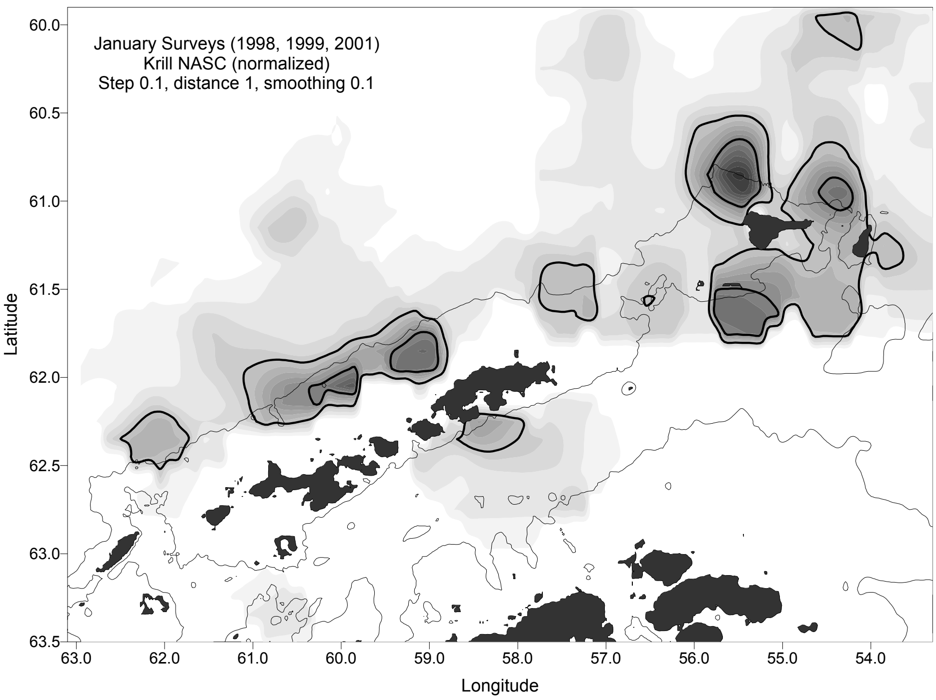
2001 February/March



2002 February/March



January (1998, 1999, 2001)



February–March (1998–2002)

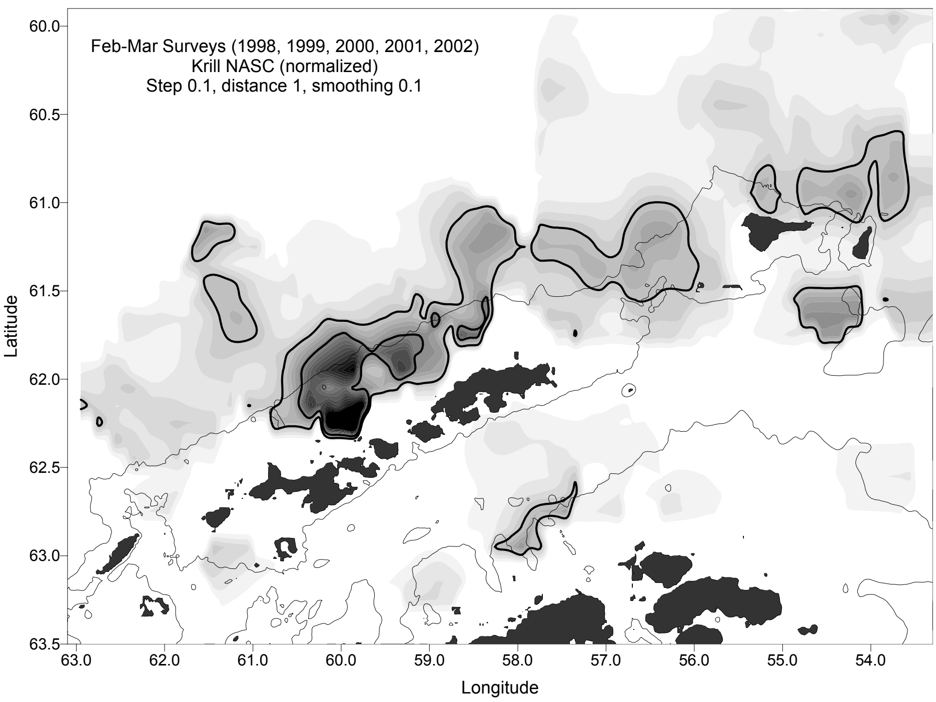


Figure 8: Relative densities of krill in Subarea 48.1 averaged over surveys by the US AMLR Program undertaken at the same time each year from 1998 to 2002. Thin lines indicate the 500 m isobath. Thick lines denote areas of relative high concentrations of krill. Parameters show the values used in 'Tracks and Fields' for smoothing and normalising the data.

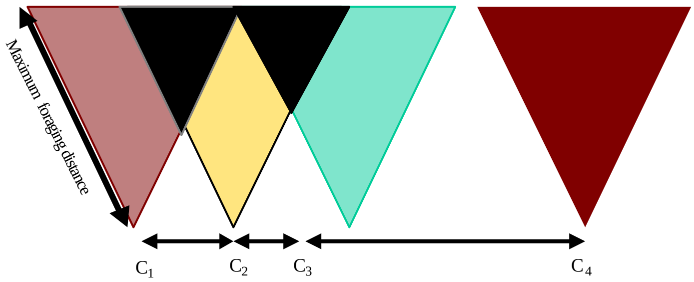


Figure 9: Colonies were considered to have a functional overlap where the distance between colonies was less than the maximum foraging distance. In this example, colonies C_1, C_2 and C_3 have a functional overlap.

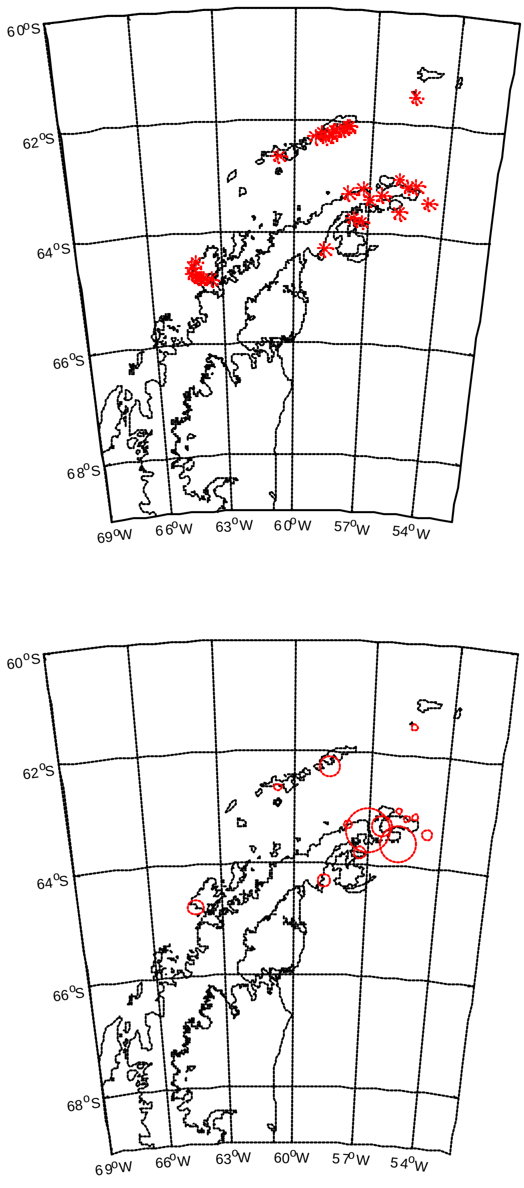


Figure 10: Adélie penguins in Subarea 48.1 – distribution of colonies and centres of biomass (stars indicate colony locations, size of circles indicates relative biomass).

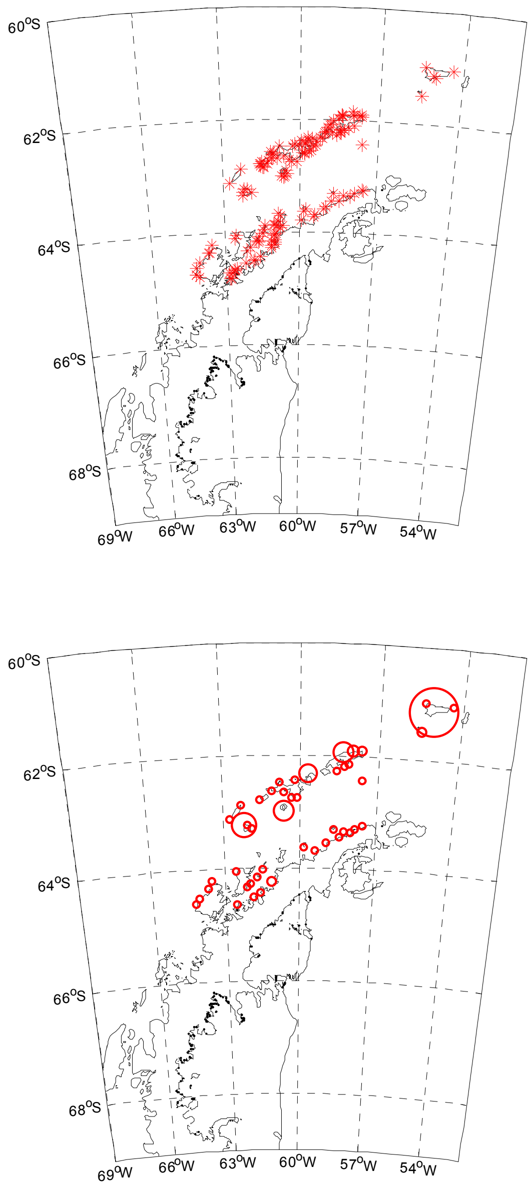
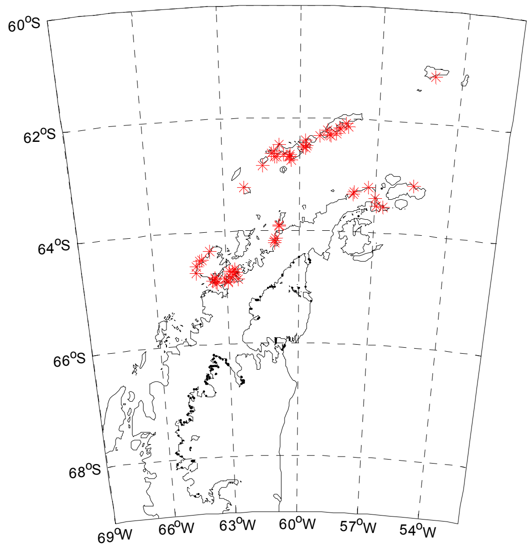


Figure 11: Chinstrap penguins in Subarea 48.1 – distribution of colonies and centres of biomass (stars indicate colony locations, size of circles indicates relative biomass).



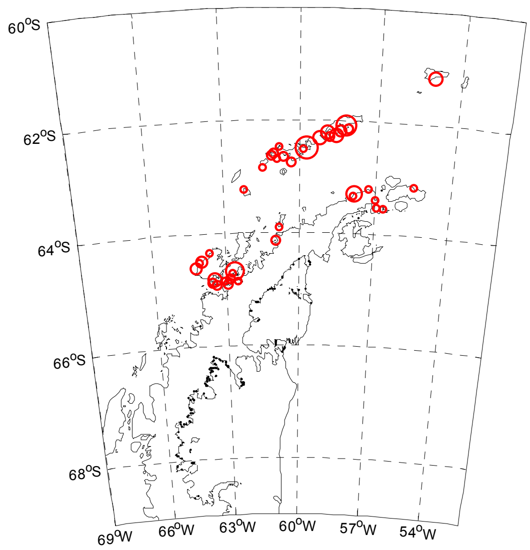


Figure 12: Gentoo penguins in Subarea 48.1 – distribution of colonies and centres of biomass (stars indicate colony locations, size of circles indicates relative biomass).

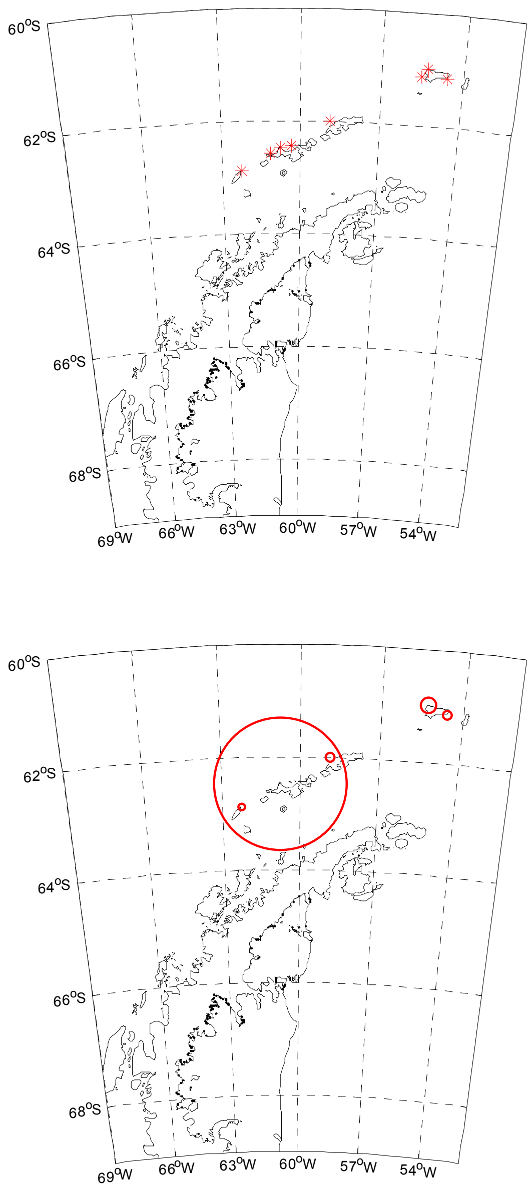


Figure 13: Antarctic fur seals in Subarea 48.1 – distribution of colonies and centres of biomass (stars indicate colony locations, size of circles indicates relative biomass).

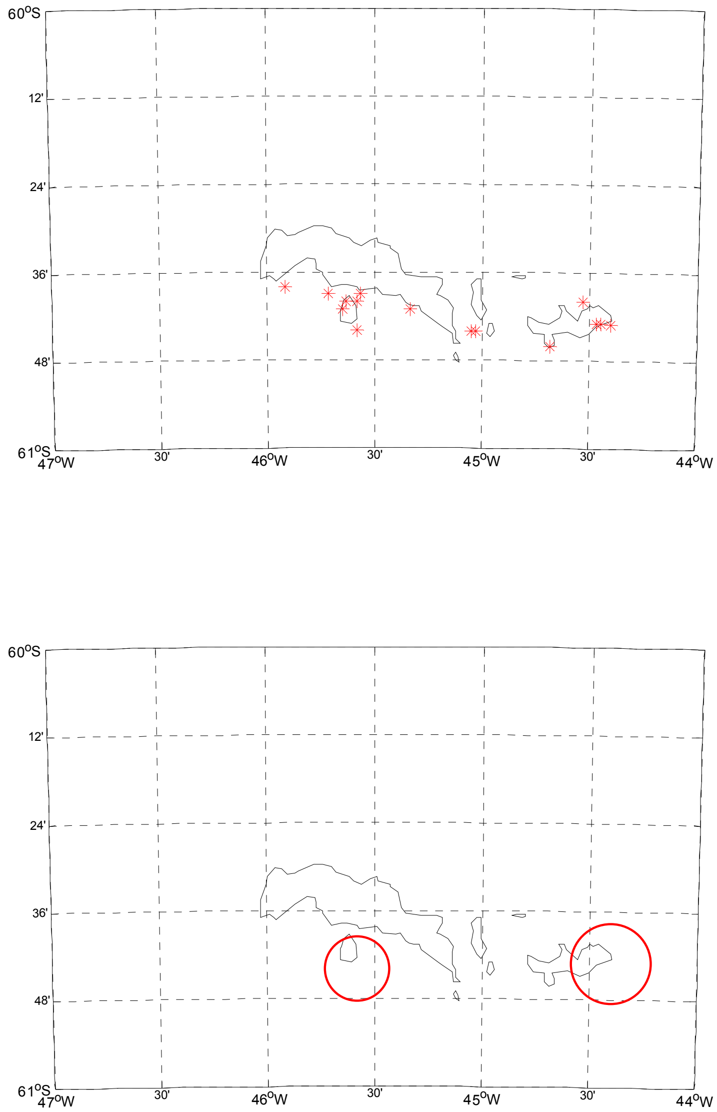


Figure 14: Adélie penguins in Subarea 48.2 – distribution of colonies and centres of biomass (stars indicate colony locations, size of circles indicates relative biomass).

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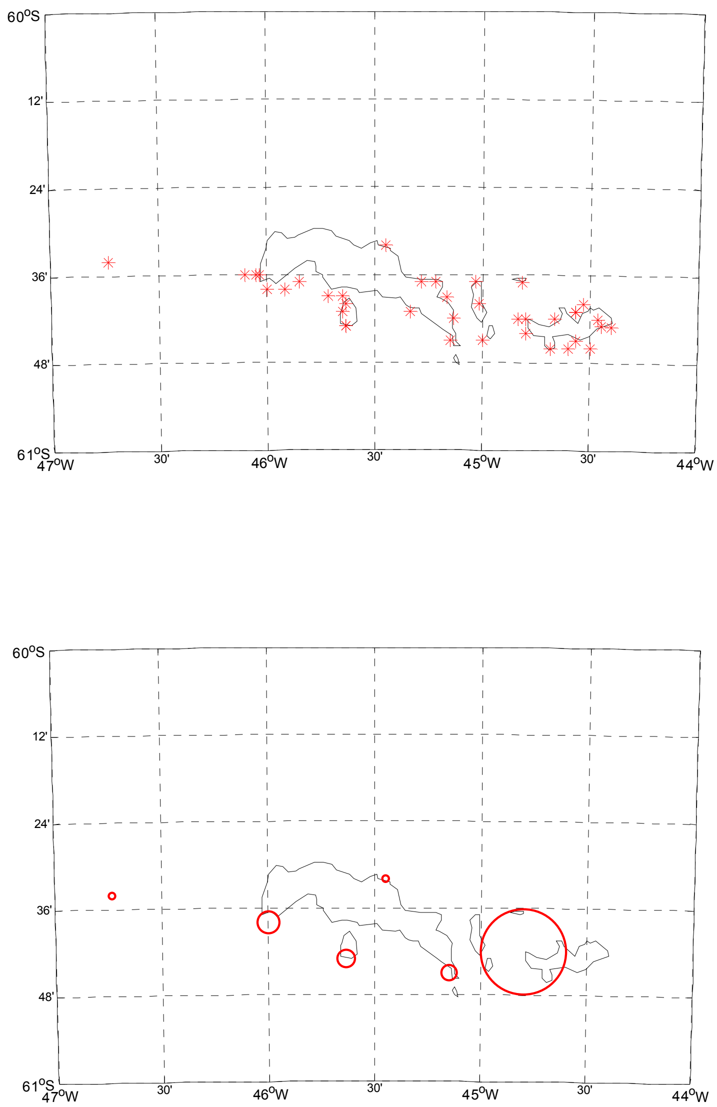


Figure 15: Chinstrap penguins in Subarea 48.2 – distribution of colonies and centres of biomass (stars indicate colony locations, size of circles indicates relative biomass).

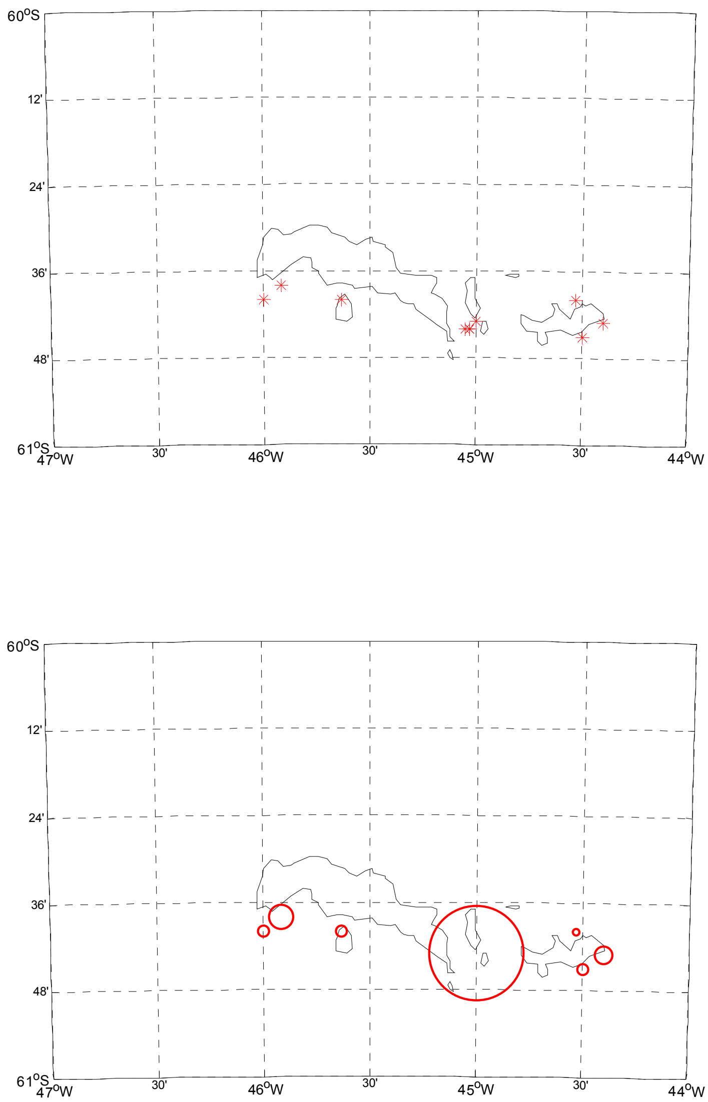


Figure 16: Gentoo penguins in Subarea 48.2 – distribution of colonies and centres of biomass (stars indicate colony locations, size of circles indicates relative biomass).

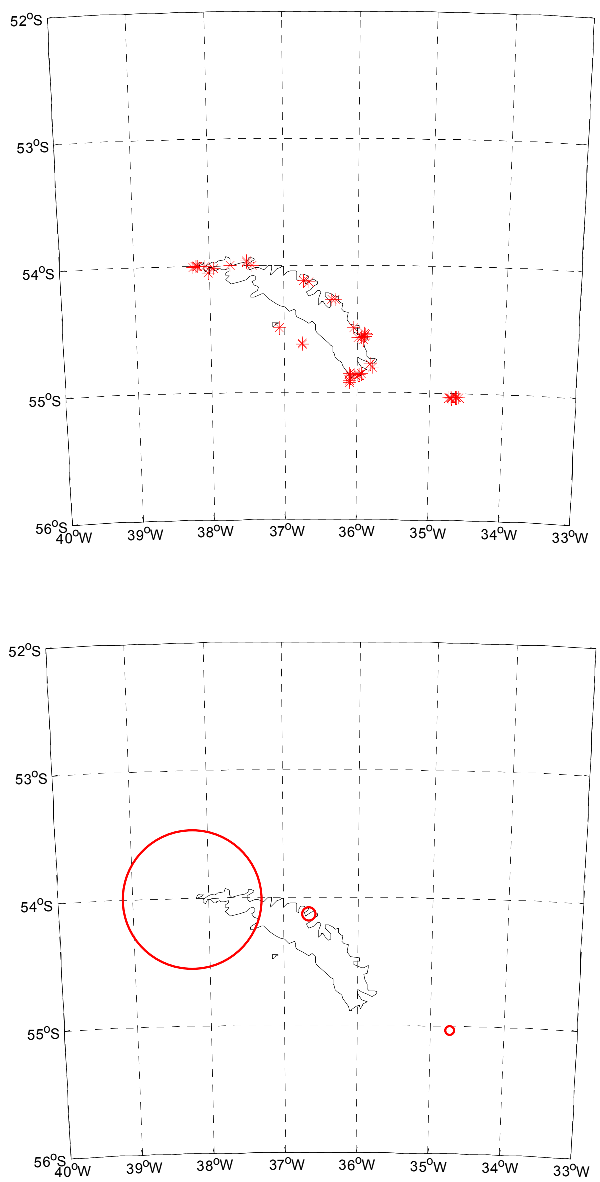


Figure 17: Macaroni penguins in Subarea 48.3 – distribution of colonies and centres of biomass (stars indicate colony locations, size of circles indicates relative biomass).

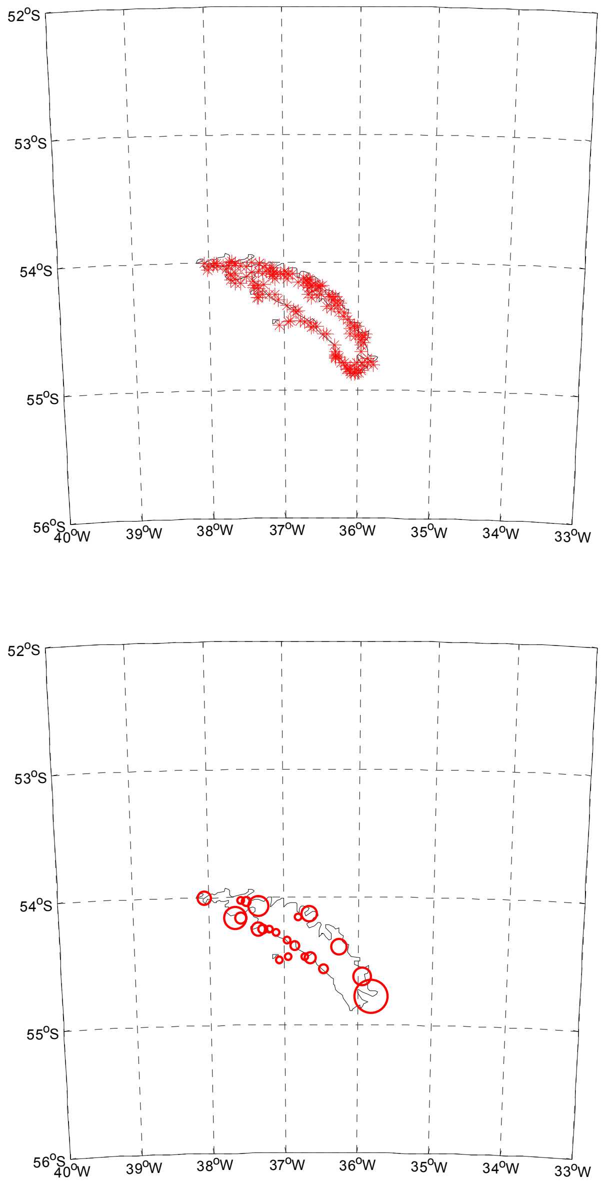
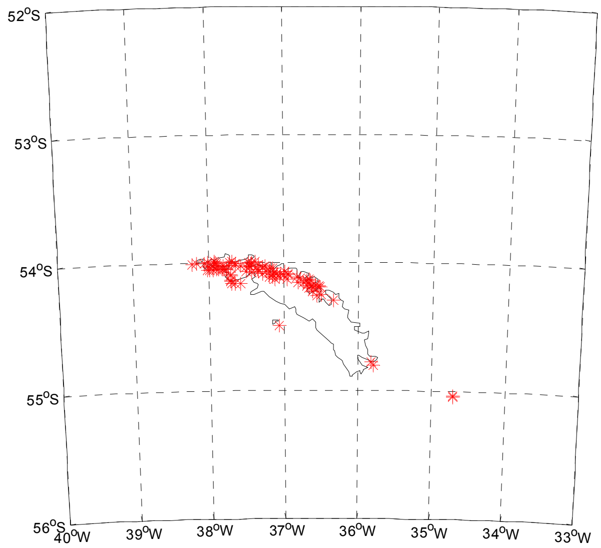


Figure 18: Gentoo penguins in Subarea 48.3 – distribution of colonies and centres of biomass (stars indicate colony locations, size of circles indicates relative biomass).



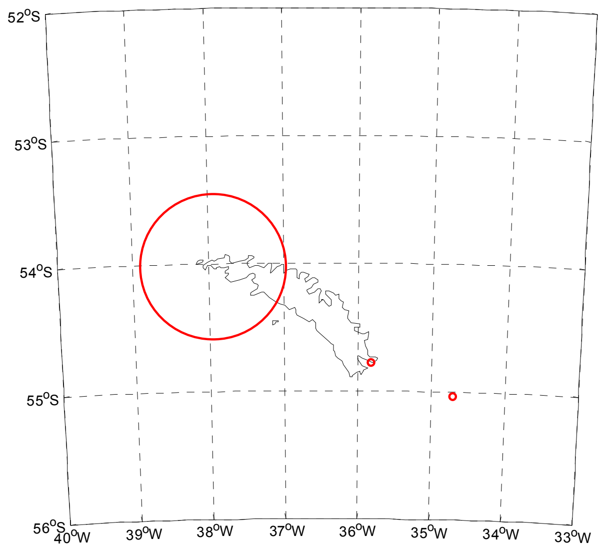


Figure 19: Antarctic fur seals in Subarea 48.3 – distribution of colonies and centres of biomass (stars indicate colony locations, size of circles indicates relative biomass).

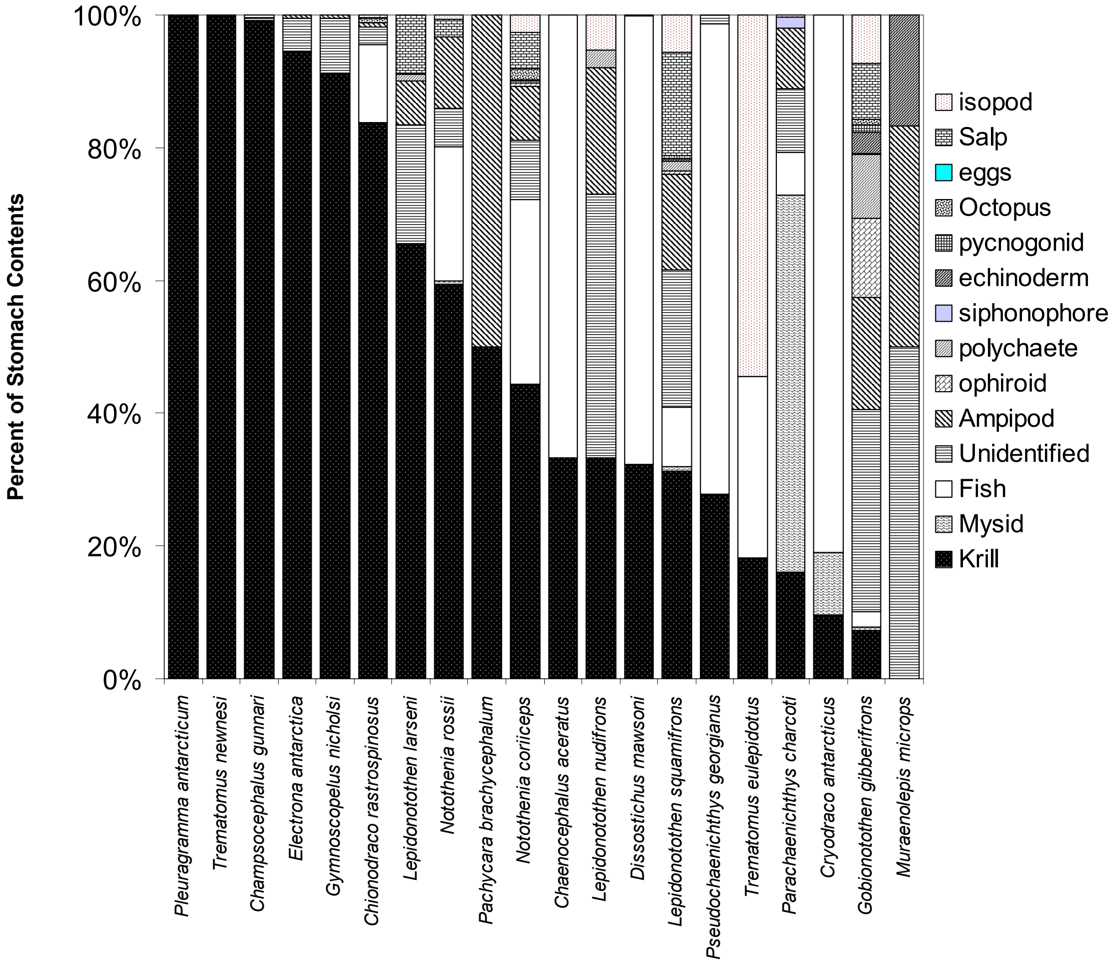
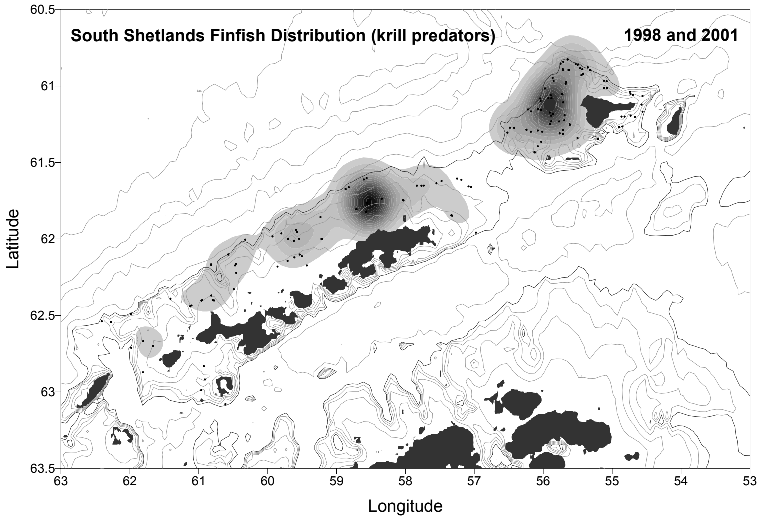
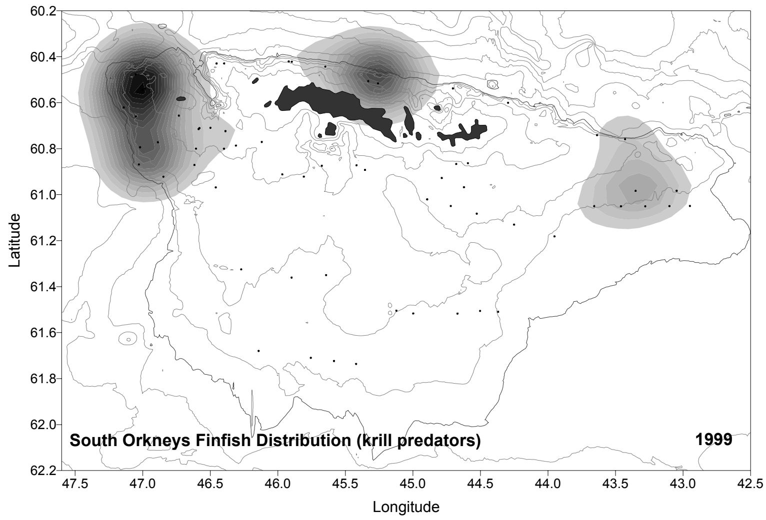


Figure 20: Summary of diet composition of 20 species of finfish, based on mean stomach content scores, from US AMLR finfish bottom trawl surveys conducted in the South Shetland Islands in 2001 (C. Jones, unpublished data).

(a)



(b)



(c)

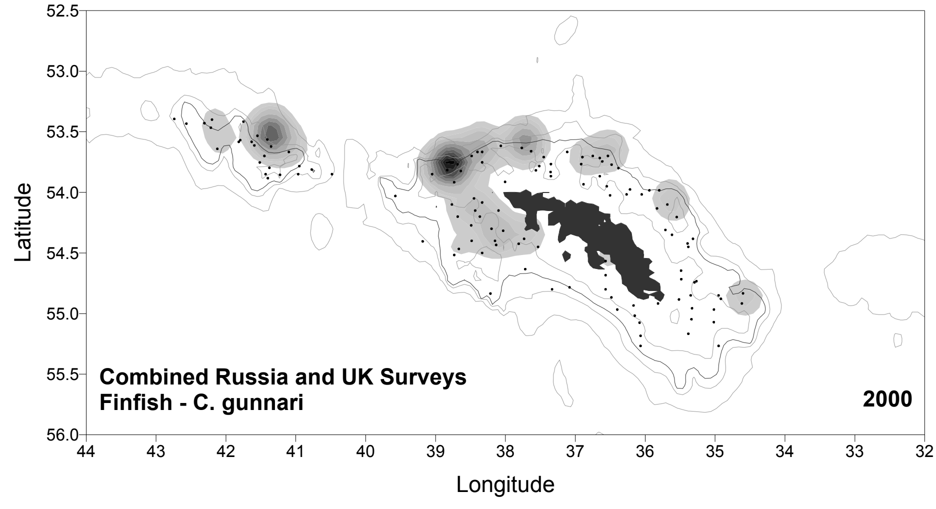


Figure 21: Spatial distribution of normalised krill-eating finfish around (a) South Shetland Islands (C. Jones, unpublished data), (b) the South Orkney Islands (C. Jones, unpublished data), and (c) South Georgia (CCAMLR database). Solid bathymetric line is the 500 m contour.

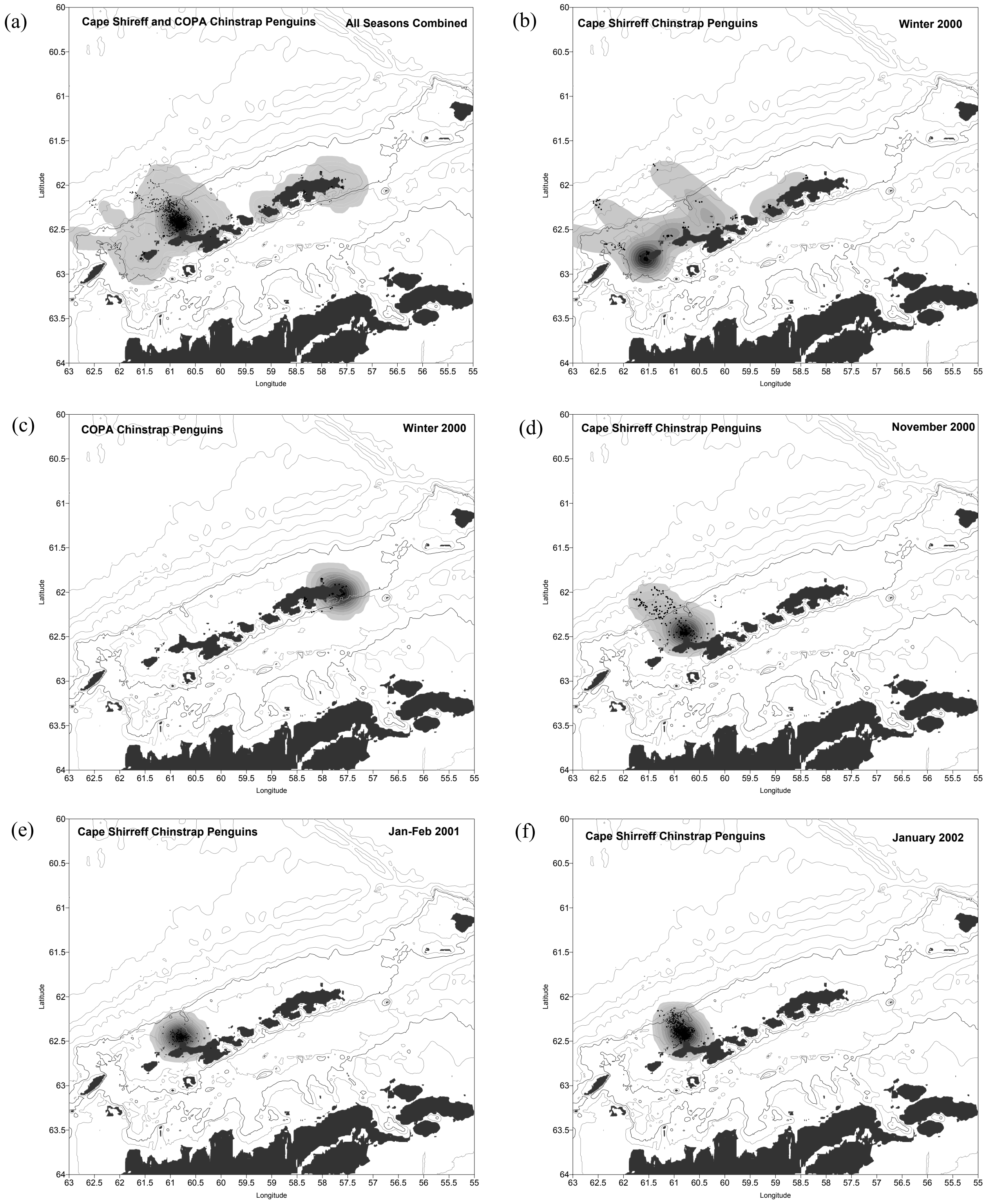


Figure 22: Foraging locations of chinstrap penguins in the South Shetland Islands (W. Trivelpiece, unpublished data): (a) Composite foraging distribution of penguins monitored at Cape Shirreff and Copa over the breeding and winter seasons from 2000 to 2002, (b) winter distribution (February to May 2000) of penguins tagged at Cape Shirreff, (c) winter foraging distribution of penguins from the Copa colony on King George Island from February to May 2000, (d) foraging distribution of penguins from Cape Shirreff during the incubation period in November 2000, (e) foraging distribution of penguins from Cape Shirreff during the chick-rearing stage in 2001, and (f) as for (e) but in 2002. Solid bathymetric line is the 500 m contour.

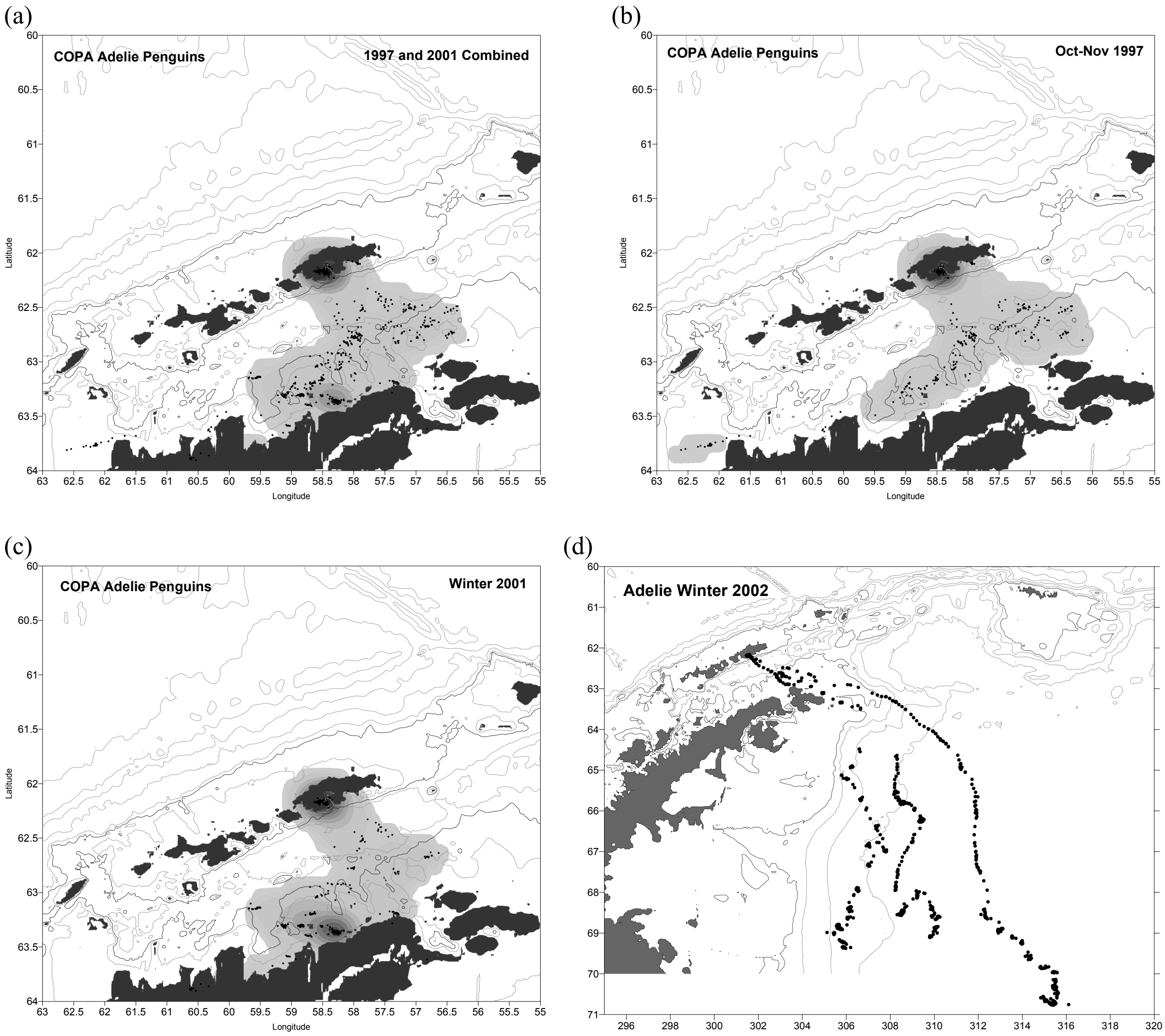


Figure 23: Foraging locations of Adélie penguins in the South Shetland Islands (W. Trivelpiece, unpublished data): (a) Combined winter and incubation period data for penguins at the Copa colony, King George Island, (b) foraging distributions of Adélie penguins from the Copa colony following clutch completion in November 1997, (c) early winter foraging distributions of penguins tagged at the Copa colony in 2001, (d) as for (c) but in 2002. Solid bathymetric line is the 500 m contour.

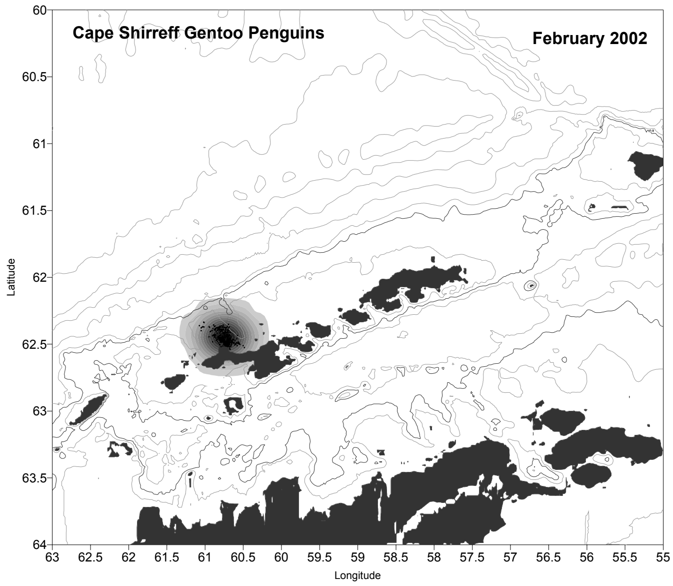


Figure 24: Foraging distribution of gentoo penguins in the South Shetland Islands during the chick-rearing period in 2002. Solid bathymetric line is the 500 m contour (W. Trivelpiece, unpublished data).

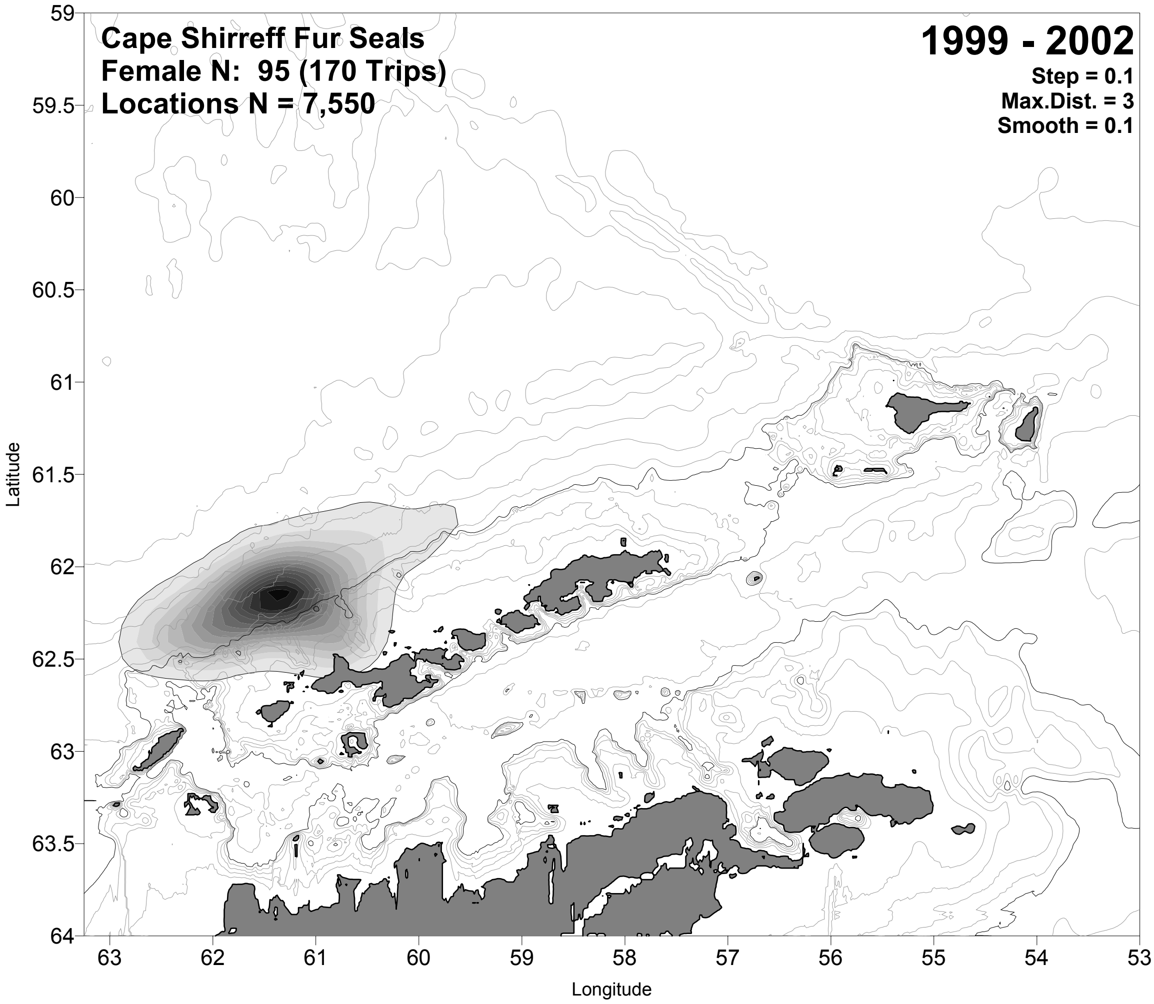


Figure 25: A shaded smoothed density plot for all at-sea locations of female Antarctic fur seals from 1999 to 2002 (N = 7 550 locations). The South Shetland Islands and the Antarctic Peninsula (lower right) are shaded dark grey. Isobaths are plotted for every 100 m up to 500 m and from every 1 000 m thereafter. The continental shelf break at 500 m is plotted with a heavier line. Fur seal locations were centred at the continental shelf slope and the highest densities of locations were found approximately 40 km northwest of Cape Shirreff. A line is drawn around the smoothed density plot at the 95 percentile.

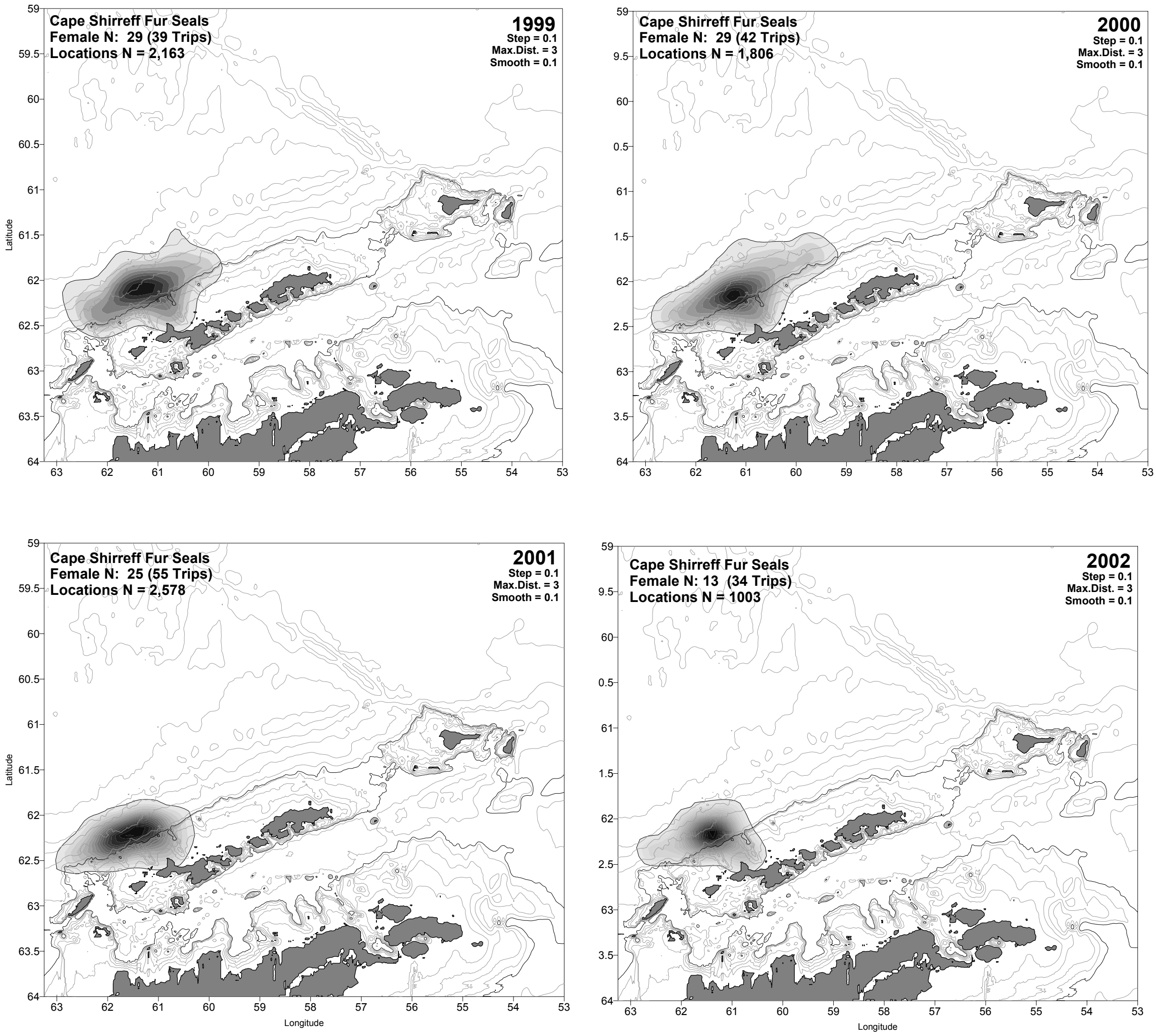


Figure 26: Shaded smoothed density plots of foraging areas as in Figure 25 for Antarctic fur seals tagged at Cape Shirreff in each year of the study. The year is identified at the top right in each plot. Although distributions and mean ranges varied by year, all four years had their highest densities of fur seal locations in the same general area (i.e. the continental shelf slope area) ~40 km northwest of Cape Shirreff.

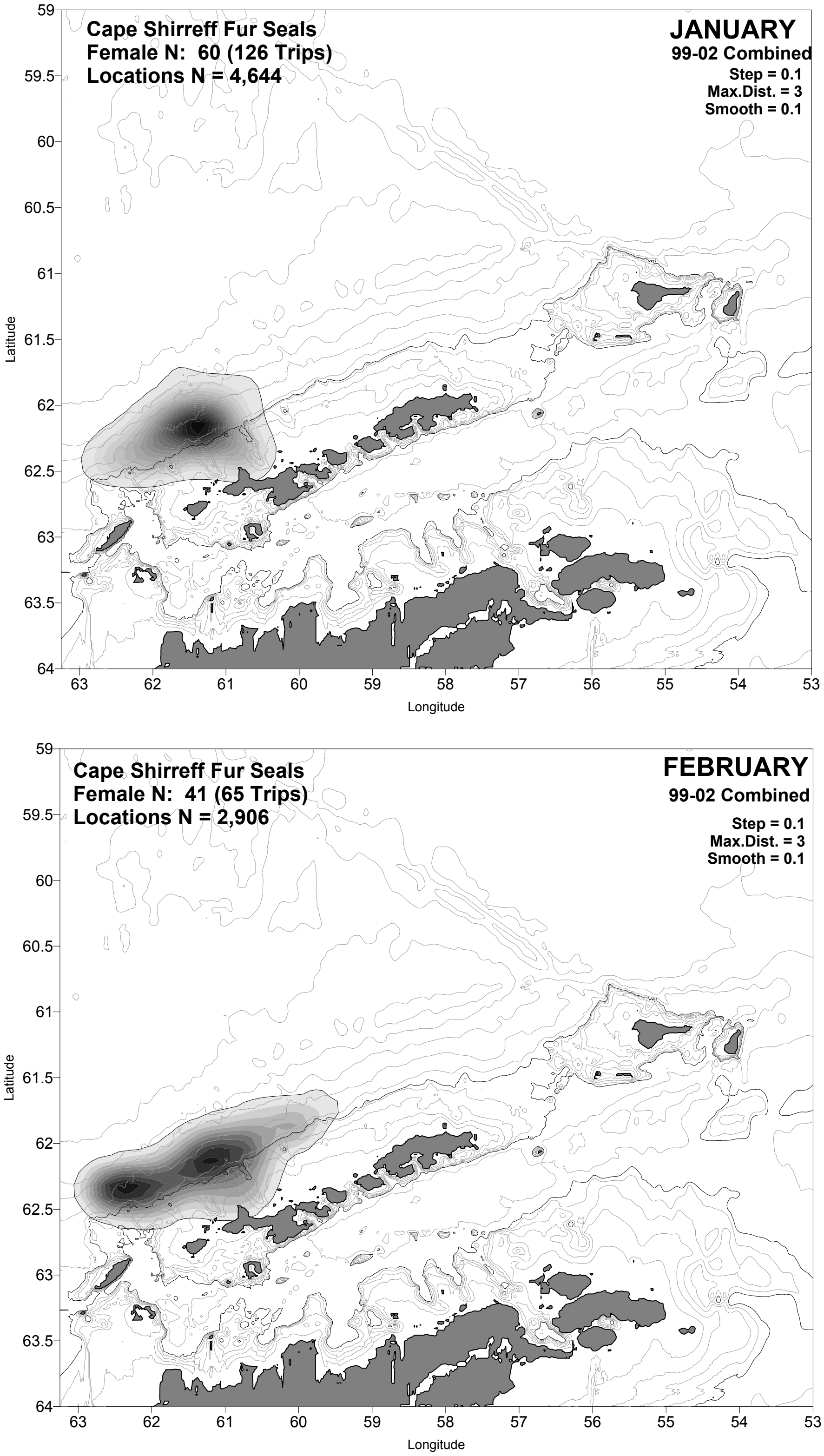


Figure 27: An intra-seasonal comparison of foraging fur seal locations at sea from seals tagged at Cape Shirreff, Livingston Island. All years (1999–2002) are combined; data for each year are normalised. The month is identified at the top right in each plot. The distribution of locations in February was broader than in January, was bimodal and was on average further west. However in both months the highest densities of fur seal locations were centred over the continental shelf slope area.

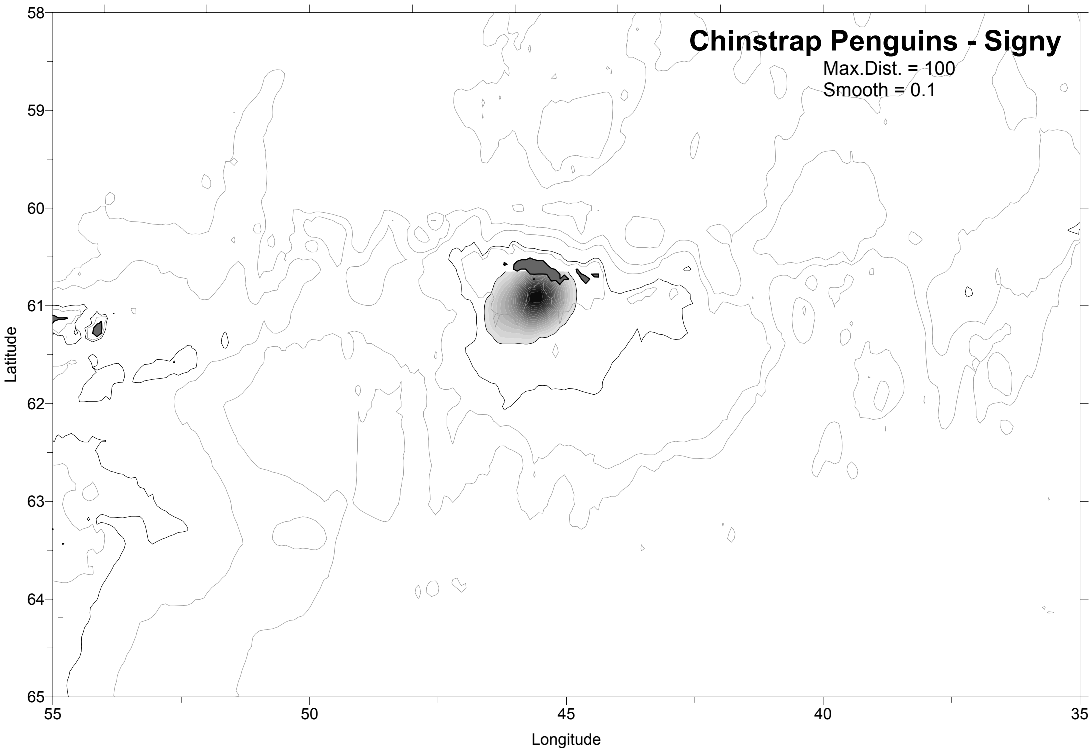


Figure 28: Average summer foraging distribution of chinstrap penguins tagged at Signy Island between 2000 and 2001 (see Table 6). The solid bathymetric line is the 500 m contour. A line is drawn around the smoothed density plot at the 95 percentile.

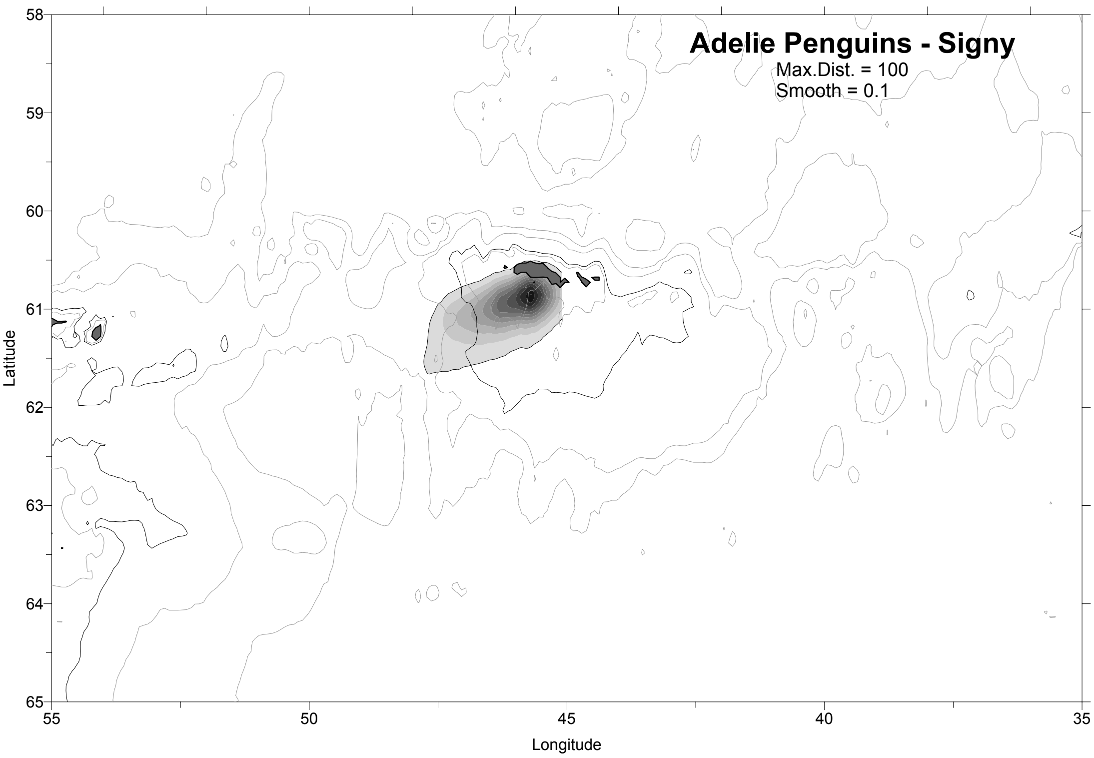


Figure 29: Average summer foraging distribution of Adélie penguins tagged at Signy Island between 2000 and 2001 (see Table 5). The solid bathymetric line is the 500 m contour. A line is drawn around the smoothed density plot at the 95 percentile.

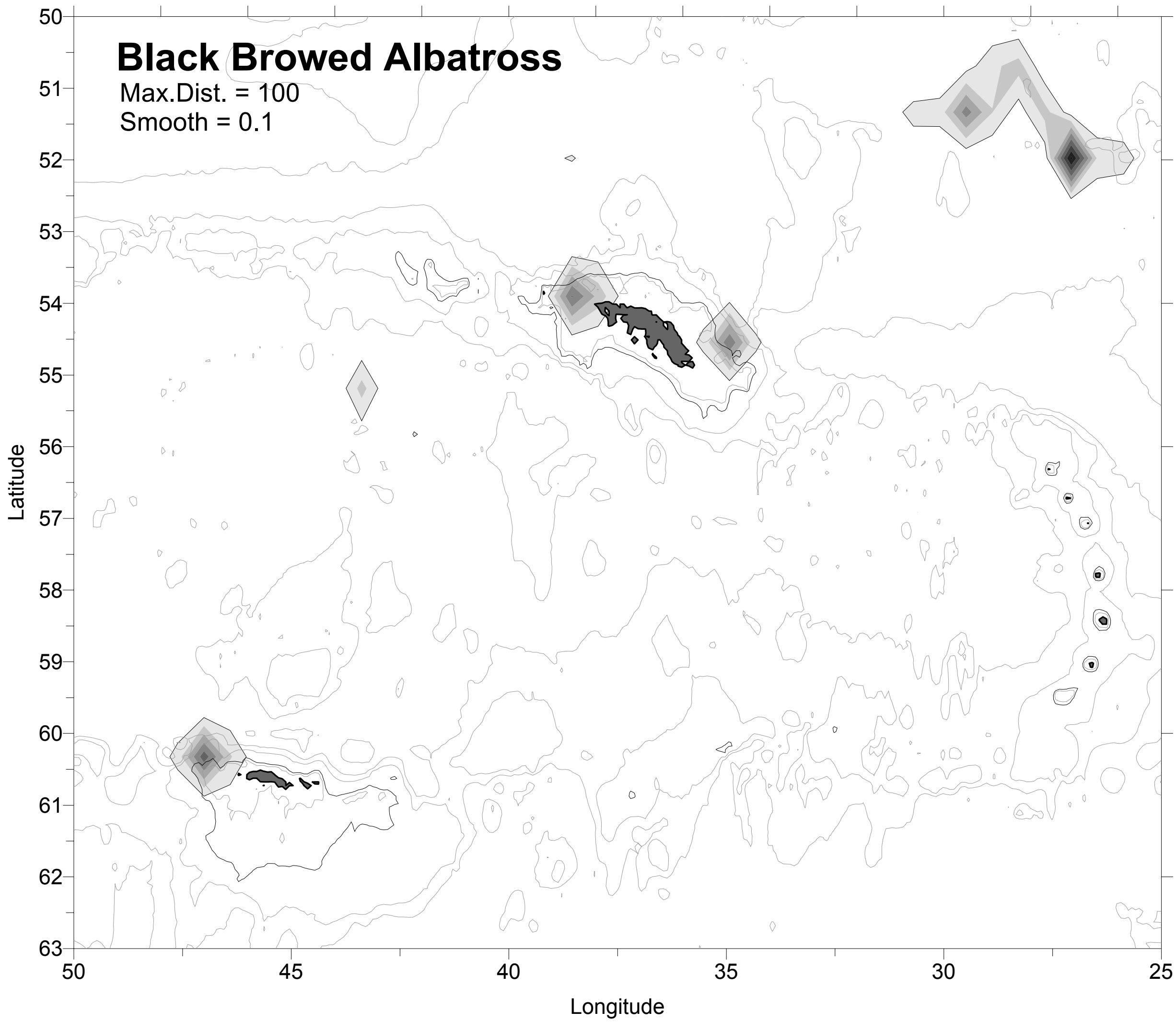


Figure 30: Average summer foraging distribution of black-browed albatrosses tagged at Bird Island during the breeding season between 1992 and 1997 (see Table 8). The solid bathymetric line is the 500 m contour. A line is drawn around the smoothed density plot at the 95 percentile.

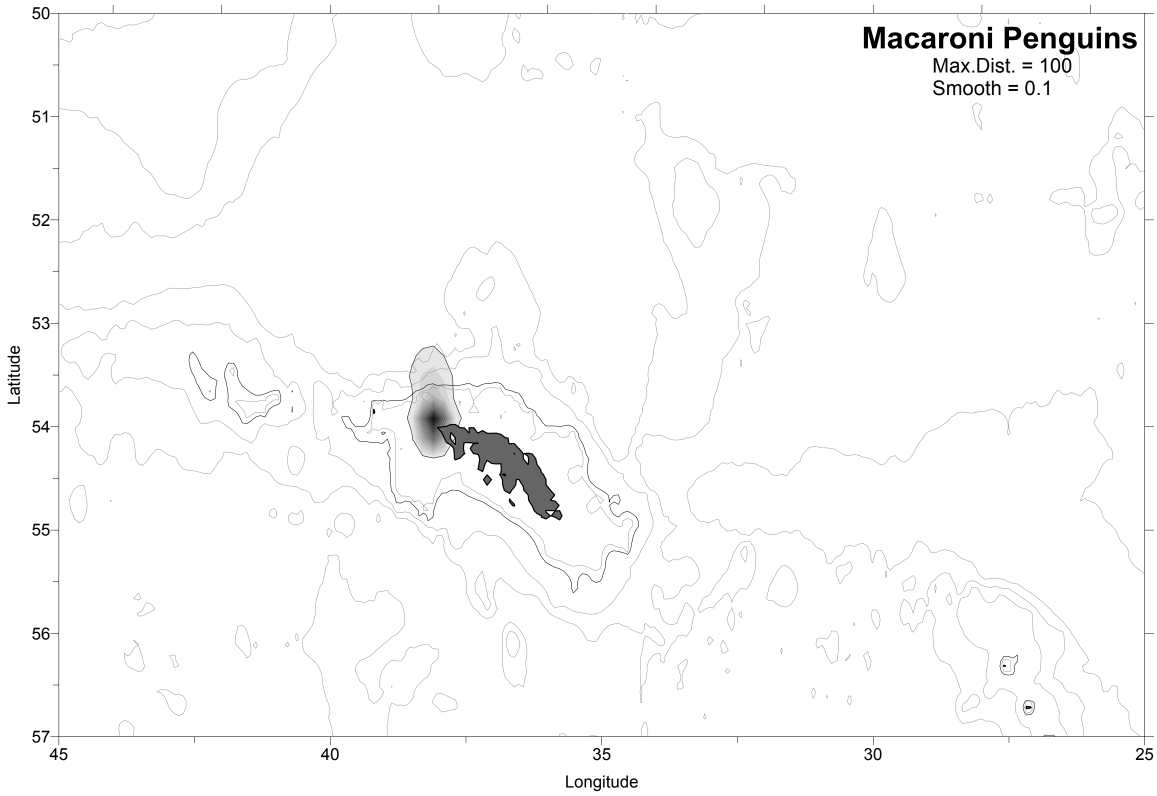


Figure 31: Average summer foraging distribution of macaroni penguins tagged at Bird Island between 1999 and 2001 (see Table 7). The solid bathymetric line is the 500 m contour.

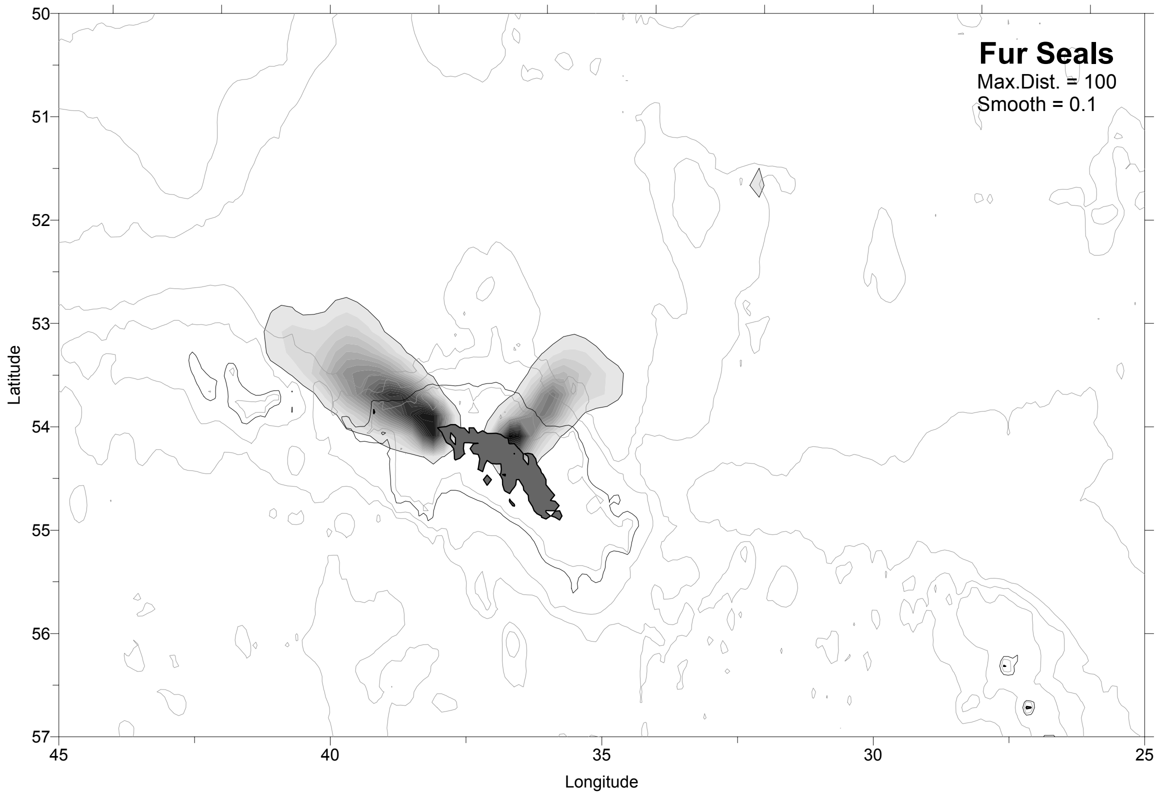


Figure 32: Average summer foraging distribution of Antarctic fur seals tagged at South Georgia between 1996 and 2001 (see Tables 4 and 9). The solid bathymetric line is the 500 m contour.

Overlap of foraging ranges (uniform weight across range)

Biomass-weighted foraging areas (each foraging range weighted by centre of biomass and foraging density within range)

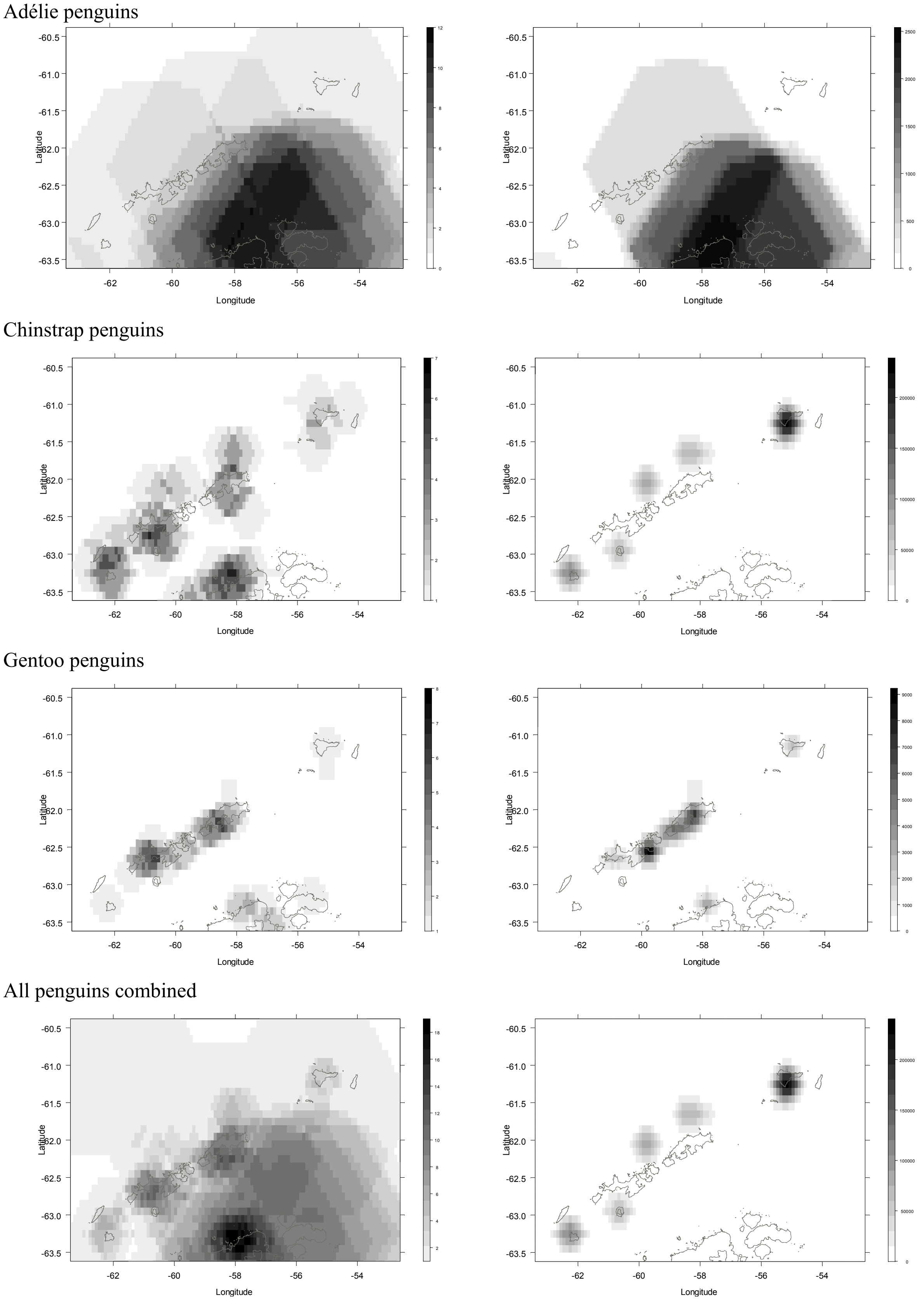


Figure 33: Extrapolated foraging areas for three land-based predator species in Subarea 48.1.

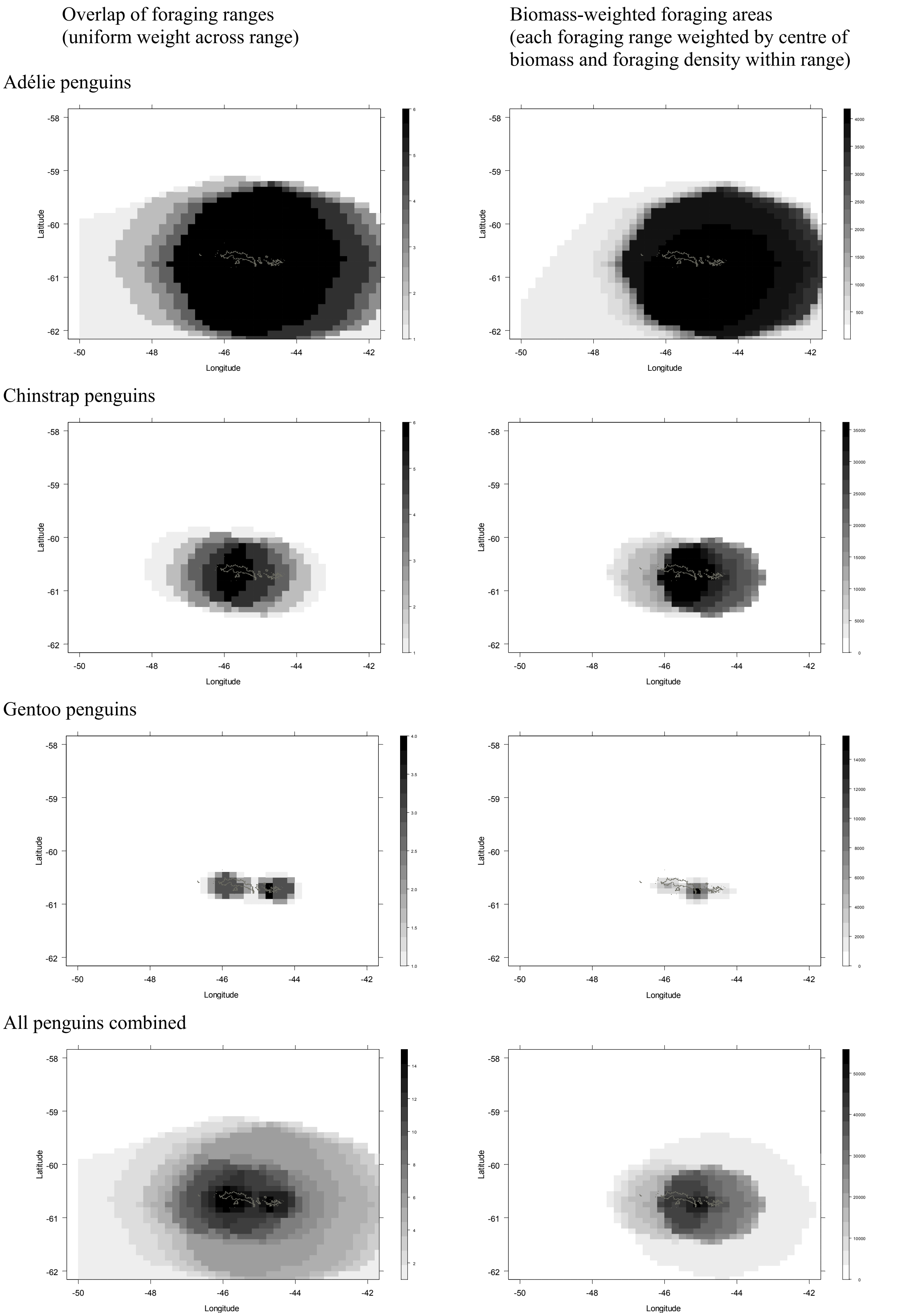
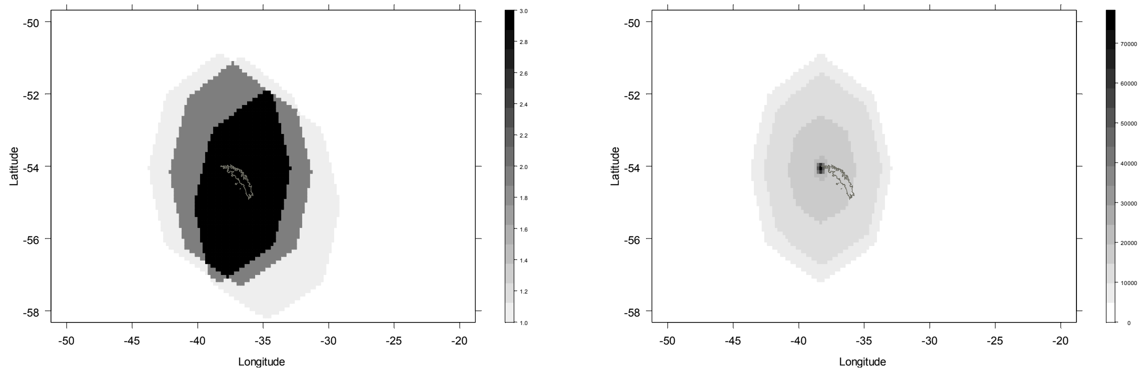


Figure 34: Extrapolated foraging areas for three land-based predator species in Subarea 48.2.

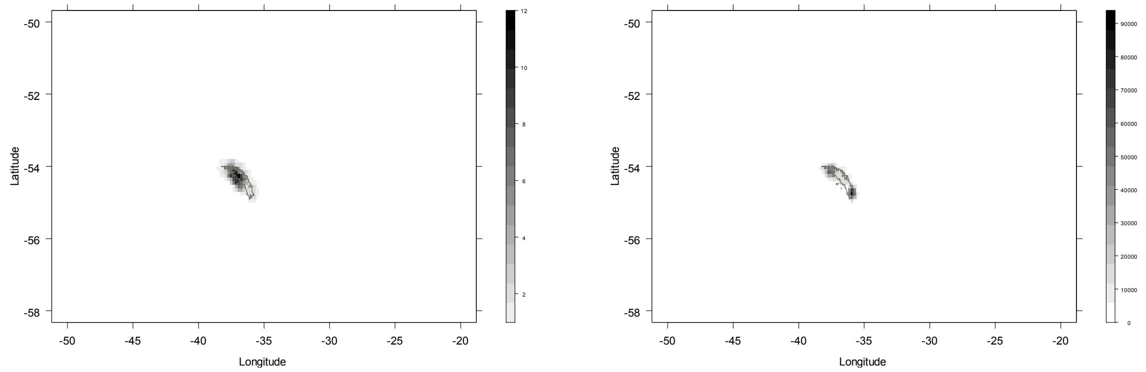
Overlap of foraging ranges
(uniform weight across range)

Biomass-weighted foraging areas
(each foraging range weighted by centre of biomass and foraging density within range)

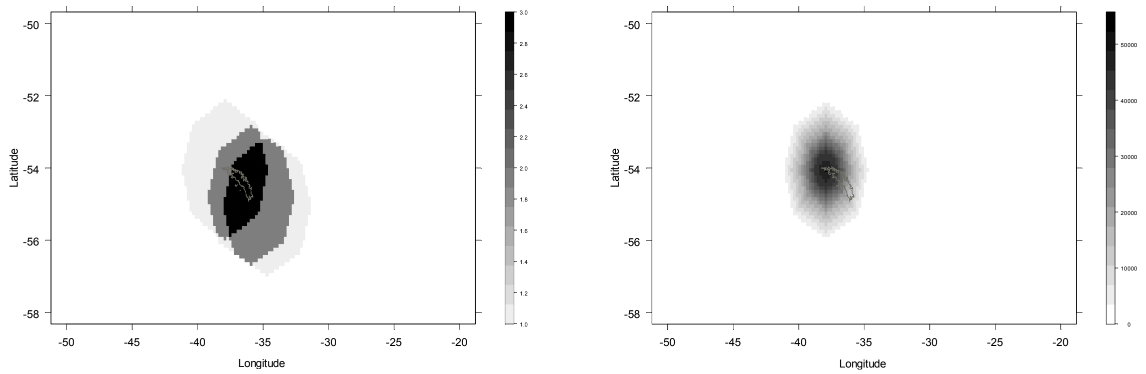
Macaroni penguins



Gentoo penguins



Antarctic fur seals



All species combined

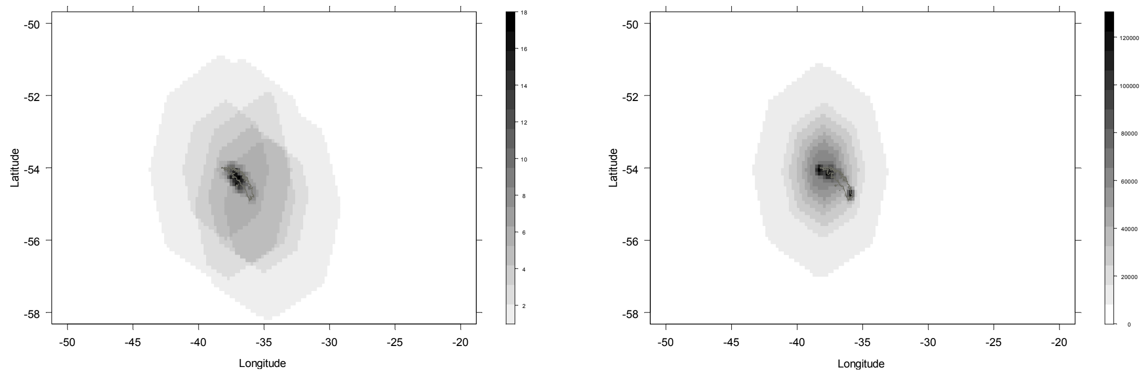


Figure 35: Extrapolated foraging areas for three land-based predator species in Subarea 48.3.

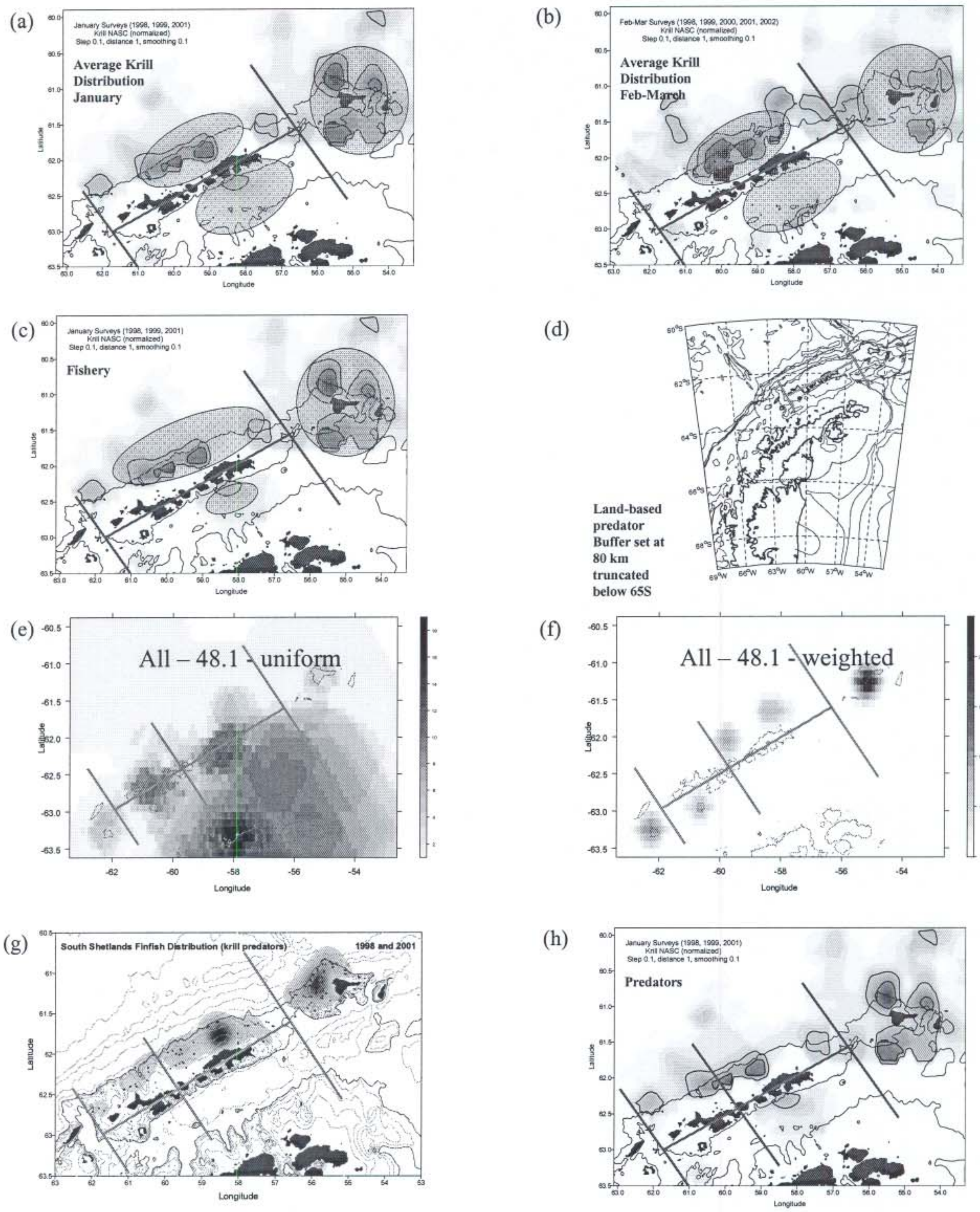


Figure 36: Subdivision of Subarea 48.1 based on: (a,b) krill aggregations (ovals show primary areas of aggregation), (c) the krill fishery (ovals show the primary locations of the krill fishery), (d) the maximum foraging distance and buffer for land-based predators around the land areas in Subarea 48.1, (e) the combined foraging ranges of land-based predators, (f) the aggregated foraging grounds of land-based predators (noting that known dominance of Cape Shirreff is not shown in this figure), (g) the aggregations of krill-eating finfish, and (h) the combined predator divisions and the krill distribution. Solid lines indicate divisions.

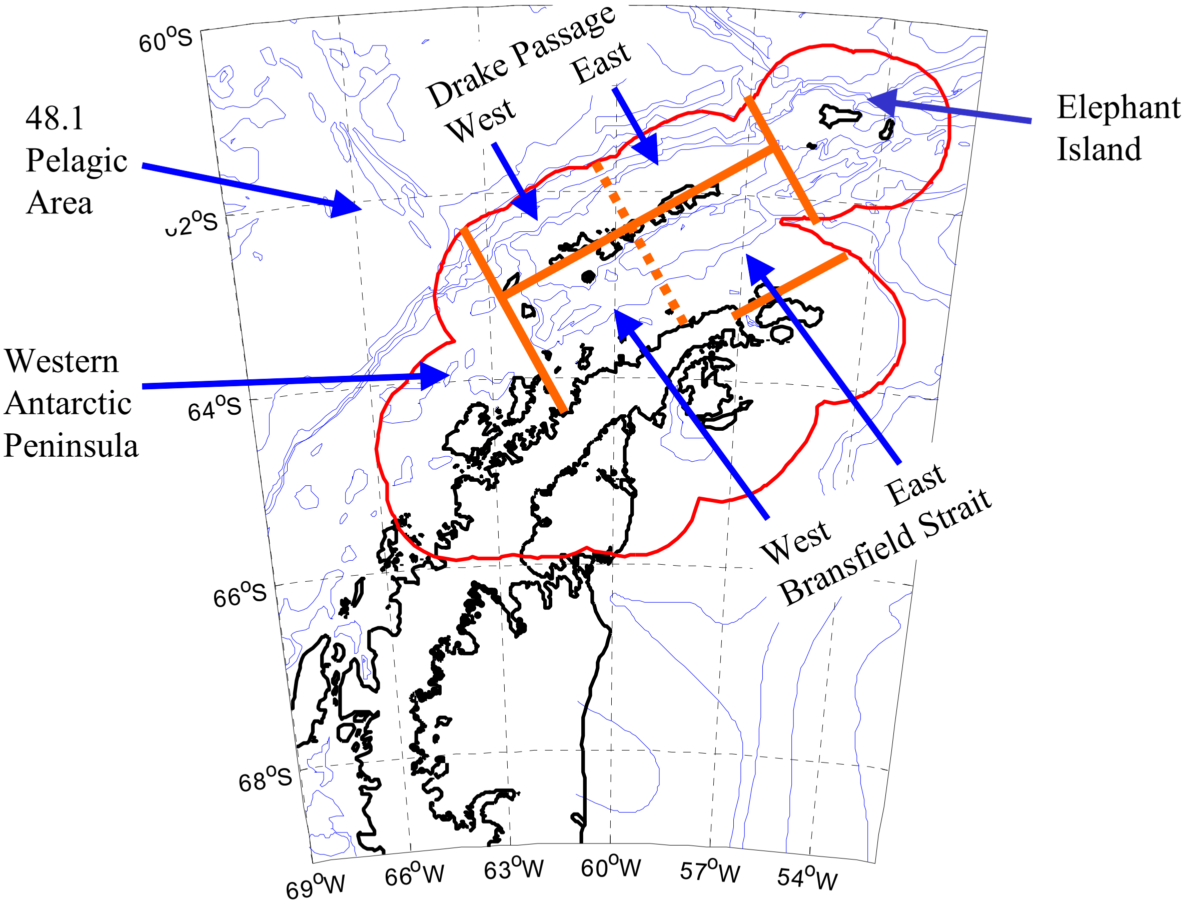


Figure 37: Proposed small-scale management units for Subarea 48.1. The subarea is divided between a pelagic area and the land-based predator area, with the latter area divided into four main units: Drake Passage, Elephant Island, Bransfield Strait and the Western Antarctic Peninsula. The Drake Passage and Bransfield Strait units are proposed to be divided into east and west components to delineate different foraging grounds of land-based predators.

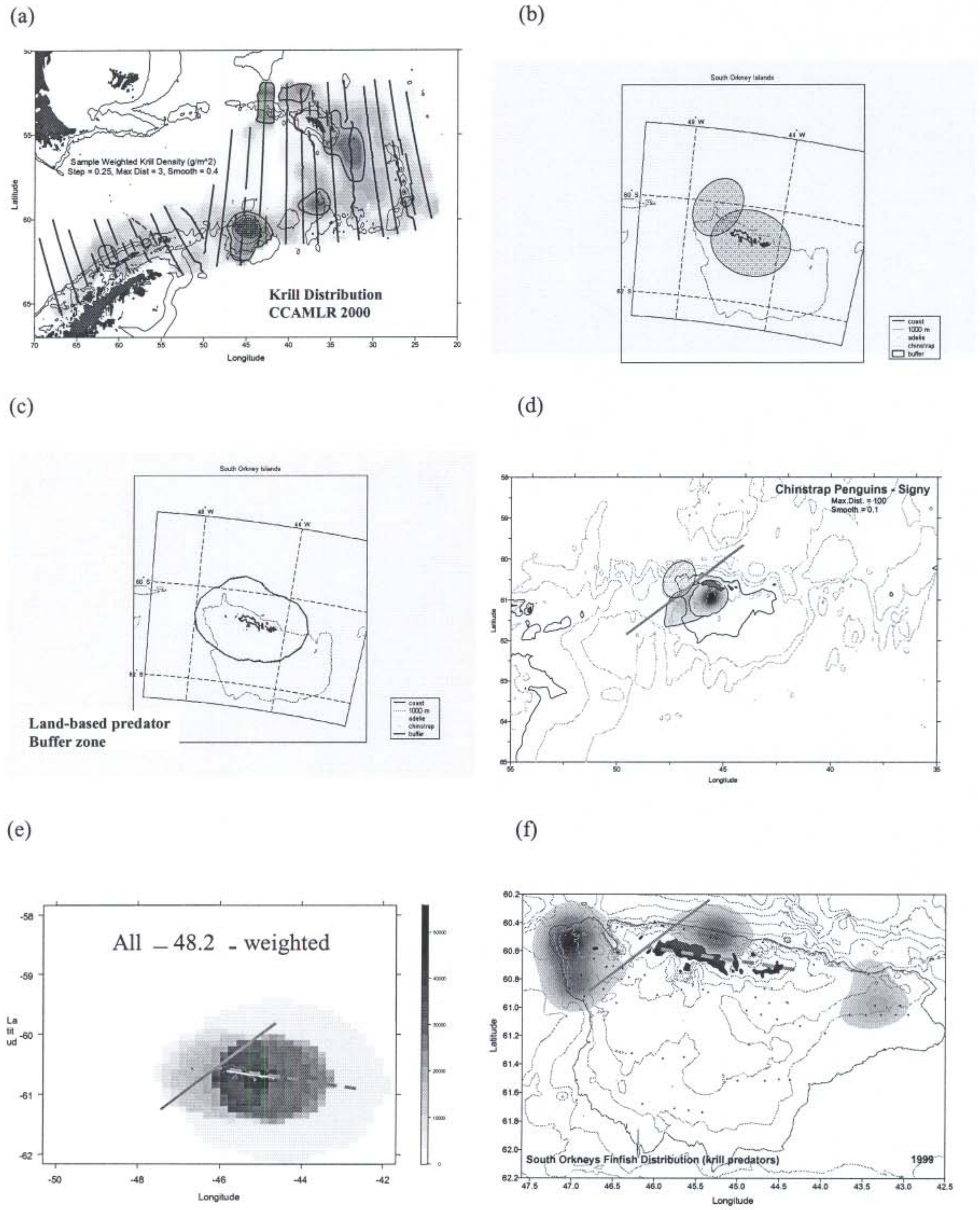


Figure 38: Subdivision of Subarea 48.2 based on: (a) krill aggregations (oval shows primary area of aggregation), (b) the krill fishery (right oval shows the observed krill aggregation while the left oval shows the primary location of the krill fishery), (c) the maximum foraging distance and buffer for land-based predators around the land areas in Subarea 48.2, (d) the combined known foraging ranges of land-based predators, including black-browed albatrosses, and chinstrap and Adélie penguins, (e) the aggregated extrapolated foraging grounds of land-based predators, and (f) the aggregations of krill-eating finfish. Solid lines indicate divisions.

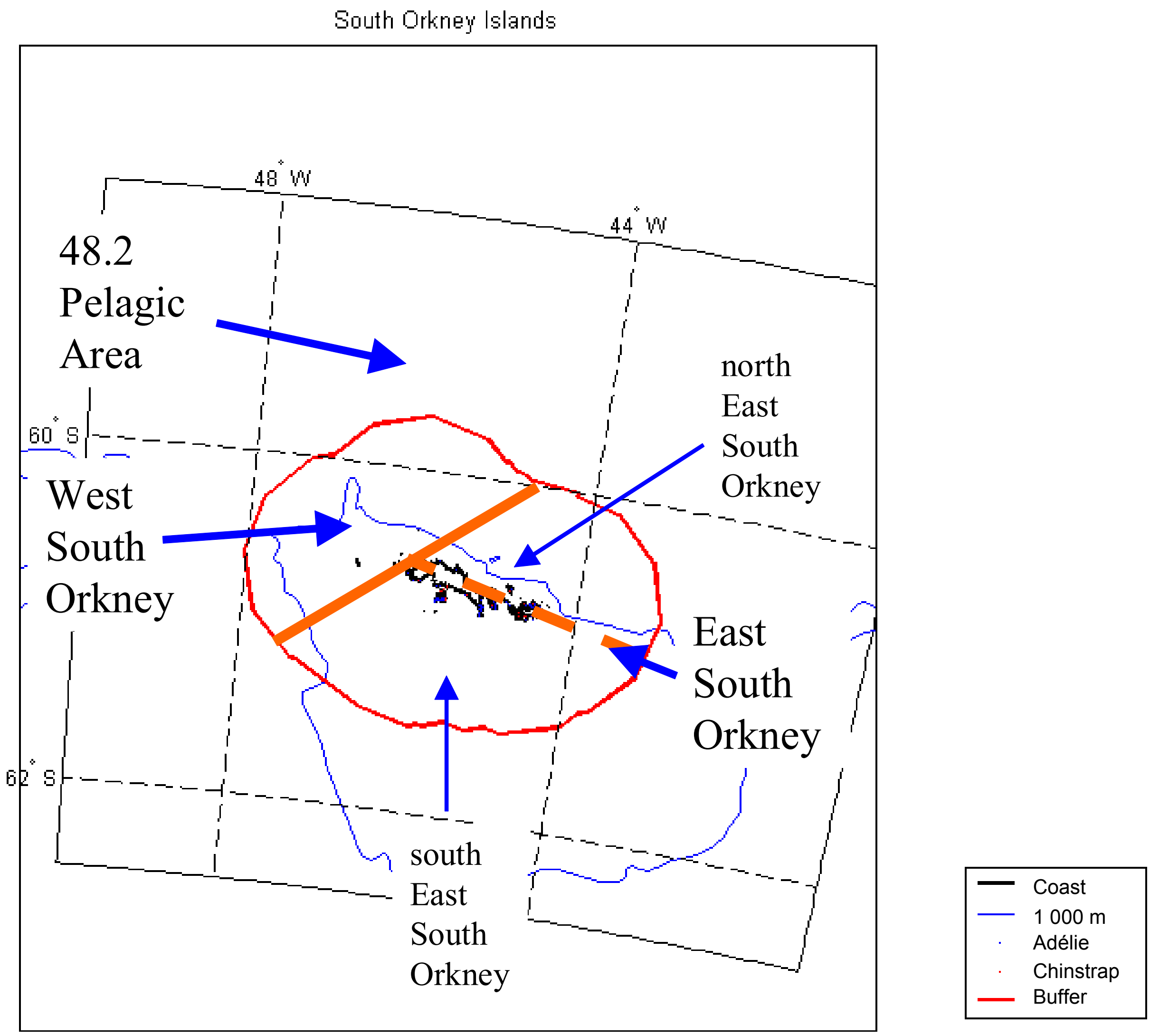


Figure 39: Proposed small-scale management units for Subarea 48.2. The subarea is divided between a pelagic area and the land-based predator area, with the latter area divided into two main units – West South Orkney and East South Orkney. The division between north and south East South Orkney areas is proposed in the interim, pending further information on foraging of penguins from the Laurie and Powell Islands.

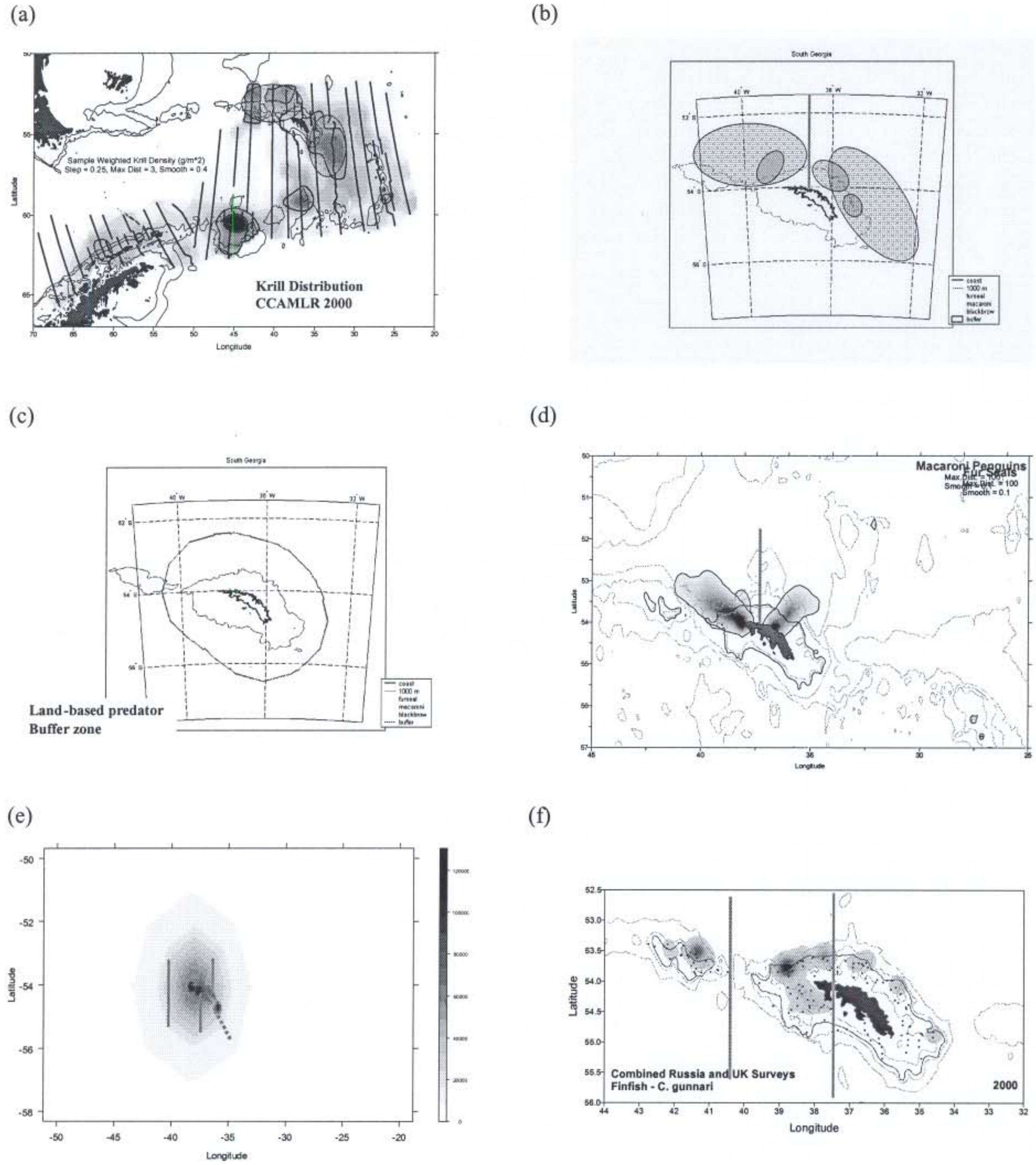


Figure 40: Subdivision of Subarea 48.3 based on: (a) krill aggregations approximated from the CCAMLR-2000 Survey (ovals show primary areas of aggregation), (b) krill aggregations approximately located according to CCAMLR-2000 Survey and experience from UK surveys (large ovals show expected primary areas of aggregation) and the winter krill fishery from 1986 to 1990 (small ovals show the primary locations of the krill fishery), (c) the maximum foraging distance and buffer for land-based predators around the land areas in Subarea 48.3, (d) the combined known foraging ranges of Antarctic fur seals and macaroni penguins (noting that black-browed albatrosses have foraging areas to the east and west of South Georgia), (e) the aggregated extrapolated foraging grounds of land-based predators, and (f) the observed aggregations of *Champsocephalus gunnari* in the 2002 surveys. Solid lines indicate divisions.

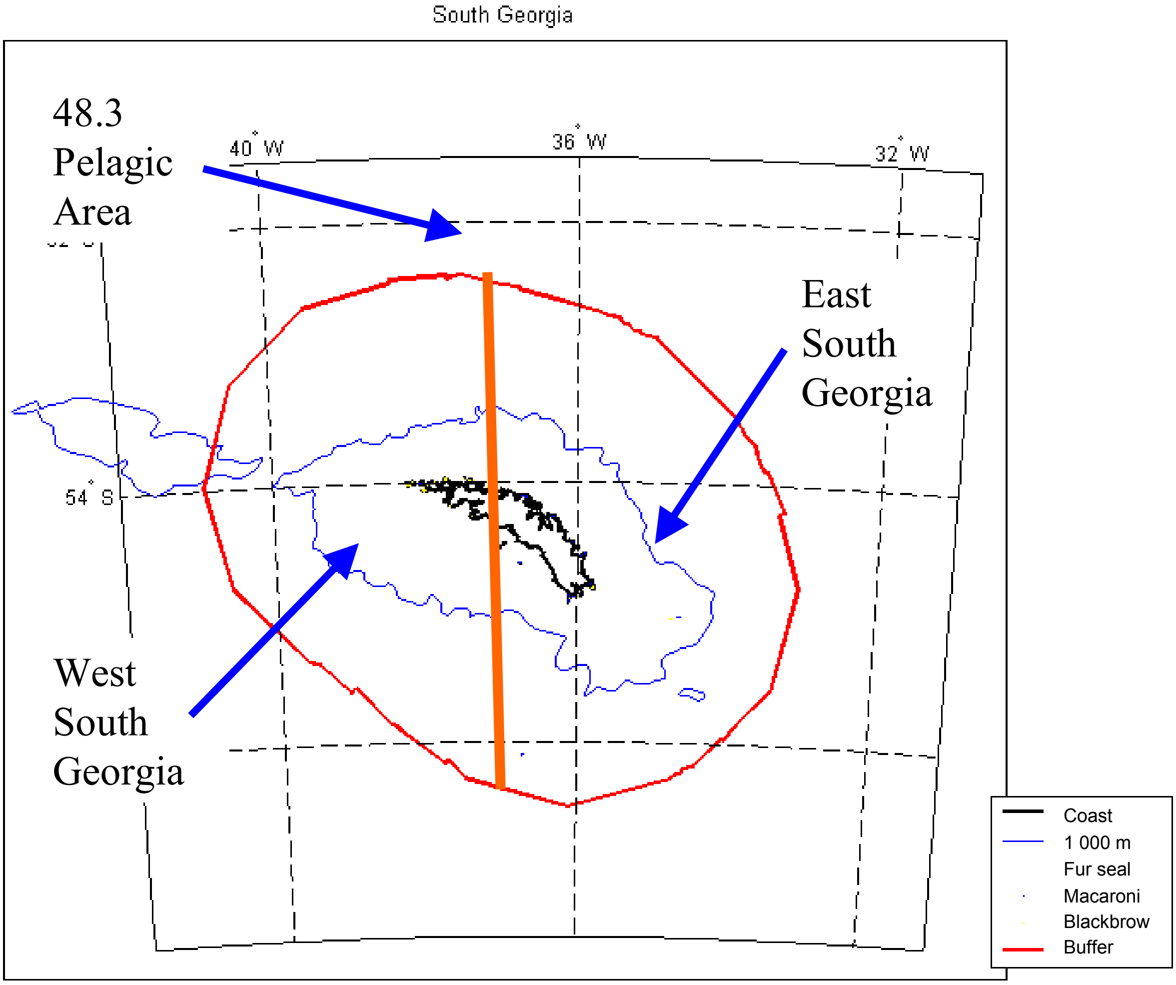


Figure 41: Proposed small-scale management units for Subarea 48.3. The subarea is divided between a pelagic area and the land-based predator area, with the latter area divided into two main units: East South Georgia and West South Georgia.

ATTACHMENT 1

AGENDA

Workshop on Small-scale Management Units, such as Predator Units
(Big Sky, Montana, USA, 7 to 15 August 2002)

1. Opening
   (a) Agenda
   (b) Work plan
   (c) Rapporteurs

2. Principles on the development of predator units

3. Krill predators
   (a) Patterns of distribution and abundance
   (b) Spatial patterns of foraging
       (i) Penguins
       (ii) Flying birds
       (iii) Seals
       (iv) Other species including whales, fish and squid
   (c) Seasonal and interannual variation
   (d) Criteria for defining foraging/feeding grounds
   (e) Analysis and methods

4. Krill fishery
   (a) Patterns of fishing
   (b) Interannual variation
   (c) Criteria for defining fishing grounds
   (d) Analysis and methods

5. Krill
   (a) Patterns of abundance
   (b) Dynamics of distribution
   (c) Criteria for defining spatial distribution
   (d) Analysis and methods

6. Environment
   (a) Spatial patterns of the physical environment
   (b) Interannual variability
   (c) Points to be considered in the development of integrated units
   (d) Analysis and methods

7. Synthesis
   (a) Spatial relationships between predators and the krill fishery
   (b) Methods for determining integrated predator units
   (c) Development of a proposal

8. Advice to WG-EMM.

BIOMASS CENTRES FOR LAND-BASED PREDATORS IN SUBAREAS 48.1, 48.2 AND 48.3

Subarea	Species	Centre No.	Long.	Lat.	Number*	Biomass
48.1	Adélie penguin	1	-57.8333	-63.3000	1 100	9 900
		2	-56.4833	-63.3000	35 000	315 000
		3	-55.8333	-63.0000	100	900
		4	-55.5167	-63.1333	1 000	9 000
		5	-55.1667	-63.1000	25	225
		6	-54.6333	-63.4000	15 000	135 000
		7	-57.0000	-63.3833	124 150	1 117 350
		8	-55.4833	-61.5000	2	18
		9	-64.0667	-64.7667	43 921	395 289
		10	-58.6167	-62.2667	55 691	501 219
		11	-55.7667	-63.5833	100 000	900 000
		12	-58.7500	-64.3000	21 954	197 586
		13	-60.6167	-62.6500	2	18
		14	-57.2833	-63.8000	10 320	92 880
	Chinstrap penguin	15	-61.0833	-62.6333	8 115	64 920
		16	-59.7000	-62.3167	214 636	1 717 088
		17	-58.6667	-63.3000	3 445	27 560
		18	-57.5333	-63.2333	930	7 440
		19	-55.1167	-61.1333	571 230	4 569 840
		20	-54.4000	-61.0167	2 200	17 600
		21	-55.4833	-61.5000	40 890	327 120
		22	-58.0000	-61.9000	62 158	497 264
		23	-58.1333	-62.1333	10	80
		24	-58.3000	-62.1833	2 083	16 664
		25	-58.3667	-61.9333	149 082	1 192 656
		26	-57.6167	-62.4333	16 278	130 224
		27	-57.6667	-61.9000	41 034	328 272
		28	-62.5667	-64.0500	5 250	42 000
		29	-62.5667	-64.6333	7 276	58 208
		30	-61.1333	-64.2333	16 882	135 056
		31	-64.2500	-64.6000	7 199	57 592
		32	-64.1167	-64.5000	24	192
		33	-61.9833	-64.2667	25	200
		34	-61.4667	-64.0167	1 620	12 960
		35	-61.7000	-64.1500	2 510	20 080
		36	-60.3333	-62.7500	10 260	82 080
		37	-60.6167	-62.9833	164 610	1 316 880
		38	-60.6167	-62.6500	1 500	12 000
		39	-60.1833	-62.4333	7 000	56 000
		40	-60.8000	-62.4667	3 000	24 000
		41	-58.9667	-63.5500	1 010	8 080
		42	-59.3833	-63.6833	152	1 216
		43	-59.8333	-63.6333	515	4 120
		44	-62.7333	-63.1167	5 000	40 000
		45	-62.1167	-64.3333	425	3 400
		46	-62.2167	-63.2333	285 000	2 280 000
		47	-62.3000	-62.8667	2 500	20 000
		48	-61.9167	-63.3000	10 000	80 000

Subarea	Species	Centre No.	Long.	Lat.	Number*	Biomass
48.1	Chinstrap penguin (continued)	49	-61.5833	-62.7833	6 550	52 400
		50	-62.0833	-63.2333	50	400
		51	-61.6000	-64.4333	40	320
		52	-60.1167	-62.7500	3	24
		53	-58.6167	-62.2667	495	3 960
		54	-55.4167	-60.9833	1 000	8 000
		55	-61.8500	-64.5167	550	4 400
		56	-63.5500	-64.2167	800	6 400
		57	-63.7000	-64.3500	8 500	68 000
		58	-58.0167	-63.3500	1 280	10 240
		59	-58.2833	-63.3500	15 000	120 000
		60	-58.4500	-63.4333	35	280
		61	-57.8333	-63.3000	9 400	75 200
	Gentoo penguin	62	-59.7500	-62.5000	9 257	111 084
		63	-60.8667	-62.6833	400	4 800
		64	-55.5167	-63.1333	200	2 400
		65	-57.0000	-63.3833	86	1 032
		66	-61.0000	-62.6000	904	10 848
		67	-61.0833	-62.6333	750	9 000
		68	-58.2500	-62.0833	5 944	71 328
		69	-59.8500	-62.5167	45	540
		70	-57.2833	-63.2000	50	600
		71	-55.0000	-61.1667	2 600	31 200
		72	-63.6000	-64.8833	1 500	18 000
		73	-62.8667	-64.8167	900	10 800
		74	-60.8083	-63.9083	600	7 200
		75	-60.9667	-64.1500	1 180	14 160
		76	-64.2500	-64.6000	1 600	19 200
		77	-58.9333	-62.2167	3 105	37 260
		78	-62.6333	-64.6833	7 918	95 016
		79	-62.7667	-64.7167	200	2 400
		80	-62.9500	-64.9000	740	8 880
		81	-58.8500	-62.2833	850	10 200
		82	-58.1333	-62.1333	1 105	13 260
		83	-60.3333	-62.7500	776	9 312
		84	-63.4333	-64.9167	1 200	14 400
		85	-60.8000	-62.4667	300	3 600
		86	-62.5333	-64.8500	250	3 000
		87	-61.4333	-62.8500	150	1 800
		88	-62.2167	-63.2333	250	3 000
		89	-60.6167	-62.6500	1 016	12 192
		90	-58.6167	-62.2667	2 584	31 008
		91	-63.5167	-64.8167	2 663	31 956
		92	-58.4500	-62.1833	2 254	27 048
		93	-63.0833	-64.8500	150	1 800
		94	-57.9000	-63.3333	6	72
		95	-57.8333	-63.3000	3 500	42 000
		96	-63.6833	-64.3500	42	504
		97	-64.1167	-64.5000	61	732
		98	-59.2333	-62.3167	3 347	40 164
		99	-56.6667	-63.5500	300	3 600
		100	-56.9167	-63.5333	200	2 400
		101	-64.0000	-64.5000	2 000	24 000

Subarea	Species	Centre No.	Long.	Lat.	Number*	Biomass
48.1	Antarctic fur seal	F1	-60.7417	-62.4680	9 131	319 585
		F2	-55.3422	-60.9908	562	19 670
		F3	-54.6332	-61.1274	188	6 580
		F4	-58.8577	-62.0045	158	5 530
		F5	-62.2836	-62.8840	7	245
48.2	Adélie penguin	102	-45.5833	-60.7333	95 675	861 075
		103	-44.4000	-60.7167	119 062	1 071 558
	Chinstrap penguin	108	-44.8000	-60.7000	420 877	3 367 016
		109	-45.6333	-60.7167	88 544	708 352
		110	-45.1500	-60.7500	76 230	609 840
		111	-45.4500	-60.5333	5 000	40 000
		112	-46.0000	-60.6333	111 244	889 952
		113	-46.7333	-60.5667	1 000	8 000
	Gentoo penguin	114	-44.4000	-60.7167	1 000	12 000
		115	-44.5000	-60.7500	430	5 160
		116	-46.0000	-60.6667	320	3 840
		117	-45.0000	-60.7167	7 907	94 884
		118	-45.6333	-60.6667	378	4 536
		119	-45.9167	-60.6333	2 185	26 220
		120	-44.5333	-60.6667	10	120
48.3	Macaroni penguin	121	-36.6636	-54.1304	144 960	1 304 640
		122	-34.7383	-55.0352	33 700	303 300
		123	-38.2128	-54.0038	3 166 805	28 501 245
	Gentoo penguin	127	-37.6443	-54.1575	21 344	256 128
		128	-37.3452	-54.2502	6 877	82 524
		129	-38.0516	-54.0042	5291	63 492
		130	-37.3437	-54.0701	12 784	153 408
		131	-37.4960	-54.0359	3 032	36 384
		132	-37.5722	-54.0254	752	9 024
		133	-36.6636	-54.1304	8 579	102 948
		134	-36.8087	-54.1602	376	4 512
		135	-37.2800	-54.2476	1 504	18 048
		136	-37.5746	-54.1578	4 500	54 000
		137	-37.0988	-54.2726	752	9 024
		138	-37.1918	-54.2469	752	9 024
		139	-36.2687	-54.3941	7 969	95 628
		140	-36.9616	-54.3354	926	11 112
		141	-36.8571	-54.3805	1 576	18 912
		142	-35.9507	-54.6175	16 363	196 356
		143	-36.6529	-54.4742	4 481	53 772
		144	-36.7200	-54.4656	407	4 884
		145	-36.9413	-54.4673	202	2 424
		146	-37.0685	-54.4890	376	4 512
		147	-36.4746	-54.5591	1 528	18 336
		148	-35.8239	-54.7779	30 979	371 748
	Antarctic fur seal	124	-37.9375	-54.0220	457 540	16 013 900
		125	-35.8239	-54.7779	4 500	157 500
		126	-34.7148	-55.0356	60	2 100

* For penguins – number of breeding pairs; for fur seals – number of pups

APPENDIX E

MEETING OF THE INTERIM STEERING COMMITTEE
FOR THE CEMP REVIEW
(Big Sky, Montana, USA, 3 August 2002)

CONTENTS

MEETING OF THE INTERIM STEERING COMMITTEE
FOR THE CEMP REVIEW

(Big Sky, Montana, USA, 3 August 2002)

OPENING OF THE MEETING

1. The Convener, Prof. J. Croxall (UK), welcomed participants (Attachment 1) and thanked the US hosts and the local organiser, Dr W. Trivelpiece, for their assistance with the arrangements for the meeting, and the CCAMLR Secretariat for support during intersessional planning and at the meeting itself.

2. The draft agenda was adopted (Attachment 2).

3. The materials available for the meeting are listed in Attachment 3. They comprise:

(i) reports of the first three meetings of WG-CEMP, at which the CCAMLR Ecosystem Monitoring Program was developed;

(ii) papers selected from those tabled for the current meeting of WG-EMM; and

(iii) the papers by Drs A. Constable (Australia), I. Everson (UK) and D. Miller (South Africa), arising from the presentations invited for the 2001 meeting of WG-EMM.

In addition, lists of relevant publications prepared by Prof. Croxall, Dr M. Naganobu (Japan) and Dr S. Nicol (Australia) were available. The documents referenced in these lists, supplemented by additional relevant material, will be made available for intersessional consultation at an appropriate part of the CCAMLR website. Other important reference and source documents include Agnew (1997) and the Report of the Workshop on Area 48 (SC-CAMLR-XVII, Annex 4, Appendix D).

4. In opening the meeting the Convener remarked that the development and implementation of CEMP represented an outstanding achievement of CCAMLR. Major new programs of monitoring and directed research in support of CEMP had been initiated by Australia, Japan, South Africa, UK and the USA, together with significant additional contributions by Argentina, Chile, Germany, New Zealand and the former USSR. The value of these programs and of the time series of data collected in consistent fashion as part of CEMP was recognised worldwide.

5. Nevertheless, a review of CEMP was timely, particularly to take account of issues such as:

(i) the extent to which data from CEMP sites were representative of the areas in which they are located;

(ii) the ability (power) of CEMP data to distinguish between changes due to environmental variation and those due to commercial fishing;

(iii) the appropriateness of maintaining the focus on krill which characterises the current scope of CEMP; and

(iv) the ability to develop management advice based on CEMP data.

6. The aims of the workshop to be held in 2003 would, therefore, include:

(i) assessment of the strengths and weaknesses of the existing program and the limitations these might impose for meeting the original objectives;

(ii) potential additions and improvements to the existing program; and

(iii) identification of ways of using CEMP data to develop management advice.

7. The aim of the present meeting is to review the terms of reference and to prepare detailed plans for the workshop in 2003. A thorough discussion of the terms of reference was deemed essential in order to identify the intersessional preparations to address them adequately at the 2003 workshop.

REVIEW OF TERMS OF REFERENCE

8. The terms of reference (SC-CAMLR-XX, Annex 4, paragraphs 5.16 and 5.17) are:

(i) Are the nature and use of the existing CEMP data still appropriate for addressing the original objectives?

(ii) Do these objectives remain appropriate and/or sufficient?

(iii) Are additional data available which should be incorporated in CEMP or be used in conjunction with CEMP data?

(iv) Can useful management advice be derived from CEMP or be used in conjunction with CEMP data?

9. The original objectives of CEMP (SC-CAMLR-IV, paragraph 7.2) were to:

(i) detect and record significant changes in critical components of the ecosystem to serve as a basis for the conservation of Antarctic marine living resources; and

(ii) distinguish between changes due to the harvesting of commercial species and changes due to environmental variability, both physical and biological.

10. The original terms of reference for this work were (SC-CAMLR-III, paragraph 9.27):

(a) Review the objectives of ecosystem monitoring and review the life history characteristics of indicator species that are potentially suitable for monitoring studies, bearing in mind potential relationships between selected indicator species and harvested resources (especially krill).

(b) Consider sampling and data collection procedures, including the collection of baseline data, required to detect any effect of fisheries activities on components of the Antarctic marine ecosystem.

(c) Describe the types of studies that would be necessary to evaluate natural variation of relevant variables.

(d) Evaluate and recommend potential monitoring sites and areas.

(e) Consider the utility, feasibility, and design of controlled experiments undertaken in collaboration with fisheries activities to test hypotheses concerning cause/effect relationships and the possible effects of different methods and intensities of fisheries activities on components of the Antarctic marine ecosystem.

(f) Formulate and recommend specific actions for planning and implementing multi-national ecosystem monitoring programs to establish data baselines, monitor indicator species, and undertake controlled experiments.

Are the Nature and Use of the Existing CEMP Data Still Appropriate for Addressing the Original Objectives?

11. It was agreed that most of the CEMP data were likely to be appropriate for detecting and recording significant change in critical components of the ecosystem. However, they were unlikely to be sufficiently comprehensive to serve on their own as an adequate basis for the conservation of Antarctic marine living resources. Furthermore, critical evaluation of the nature, magnitude and statistical significance of the changes indicated by the CEMP data is required.

12. The design of CEMP also needs evaluation, especially in terms of modern approaches to the construction of monitoring programs designed to assess changes before and after potential environmental perturbations or impacts. Particular concern was expressed at the extreme difficulty of designing a monitoring program, such as CEMP, which tried to address both the detection and measurement of change and also to understand the causes of this change.

13. In respect of the ability to distinguish between changes due to the harvesting of commercial species and changes due to environmental variability, both physical and biological, it was agreed that the design of CEMP and the nature of the data currently available to it was such that it was extremely unlikely that this would be feasible, at least at current levels of harvesting.

14. The intersessional work should include provision of appropriate documentation on the design of monitoring programs with analogous objectives to CEMP in order to facilitate the evaluation of this objective of the original CEMP Program. Dr Nicol agreed to coordinate this.

Do These Objectives Remain Appropriate and/or Sufficient?

15. It was agreed likely that the original objectives remained appropriate. However, it was suggested that the workshop should consider including an additional objective, directed at the development of appropriate management advice from CEMP and related data.

Are Additional Data Available which should be Incorporated in CEMP or be Used in Conjunction with CEMP Data?

16. It was agreed that there were a number of important types and sources of data which had either already been identified as important to incorporate in CEMP or which needed evaluation in this regard. There were also other data of potential high value for use in conjunction with CEMP data. These data, which would need to be investigated, assembled or analysed as part of the program of intersessional work, are reviewed in paragraphs 36 to 56.

17. In respect of expanding the scope of CEMP to include, for example, species dependent on commercially harvestable resources other than krill (e.g. squid, fish), it was felt that insufficient time would be available at the 2003 workshop to develop appropriate proposals.

18. It was suggested that a request be made for the submission to the workshop of outline proposals for appropriate monitoring programs in relation to predator–prey interactions involving squid or fish resources. The workshop would review all such proposals and identify those which it believed should be developed into more detailed descriptions of the nature and scope of potentially appropriate monitoring programs.

Can Useful Management Advice be Derived from CEMP or be Used in Conjunction with CEMP Data?

19. It was agreed that there were encouraging signs that useful management advice might be derived from CEMP, or that CEMP data could contribute to appropriate management advice. However, it was recognised that further progress would depend on critical evaluation (including modelling initiatives) and development of some or all of the proposed management procedures.

20. To assist in this process, the five examples of the proposed management procedures for krill fisheries (Constable, 2002) were evaluated from the standpoint of which were best suited to further (intersessional) development in terms of the variables to be monitored.

21. It was agreed that no further progress in this regard could be envisaged in respect of example 1 (precautionary catch limit for target species) or example 2 (target population size for predators). Consideration of example 5 (no interference by fisheries near colonies with land-based predators) would not be undertaken in the preparations for the CEMP review as further development, if desirable, would arise out of the deliberations following the Workshop on Small-scale Management Units, such as Predator Units (SSMU Workshop).

Nevertheless, it was recognised that this procedure offered considerable potential, for which experiences within CEMP would be valuable for developing appropriate monitoring procedures relevant to the management system adopted.

22. Example 3 (average fitness of predators maintained) and example 4 (maintaining median predator productivity arising from harvested species at above 80% of pre-exploitation level) were felt to be appropriate for further development during the intersessional period in order to improve consideration of this item at the workshop.

23. For example 3, Drs K. Reid (UK) and P. Trathan (UK) agreed to consider, with appropriate colleagues, how best to arrange further developments.

24. For example 4, the three main groups working on food-web and production issues (Australia, UK and the USA) agreed to develop these concepts further in relation to the areas and species of their particular interest. Drs R. Hewitt (USA), Nicol and Trathan agreed to coordinate this initiative.

PLANNING FOR THE 2003 WORKSHOP ON THE REVIEW OF CEMP

Intersessional Work Plan

25. A work plan, based on the tasks identified in this report, is appended as Attachment 4.

Workshop Arrangements

26. The UK offered to host this workshop as part of next year's WG-EMM meeting in Cambridge, UK, from 15 to 29 August 2003, for which it is extending an invitation. Detailed arrangements for the conduct of the meeting and for data submission and analysis would be developed by the workshop steering committee in consultation with the Secretariat, Data Manager and the local organisers of the Cambridge meeting.

Availability and Analysis of Data

CEMP Data

27. Recent work at the Secretariat had resolved a number of issues of validation and consistency with the CEMP data. The outstanding issues would be resolved by the Data Manager in consultation with the appropriate data holders.

28. All data would be analysed in terms of overall trends, together with levels of confidence and statistical significance. This would be undertaken by the Data Manager in consultation with the workshop steering committee.

29. To clarify understanding of the potential for additional analyses, matrices illustrating the availability of data in terms of species, sites, variables and duration of time series would be prepared by the Data Manager in consultation with Dr C. Southwell (Australia) (Attachment 5).

30. Issues relating to potential methodological differences between sites would be discussed as soon as possible by a subgroup comprising Mr M. Goebel (USA) and Drs Reid and Southwell. This group would also consider the extent to which potential fundamental biases inherent in the different standard methods could be evaluated or categorised.

31. Issues relating to the sensitivity and power of the data collected under each of the standard methods would be evaluated by appropriate statisticians. Drs Hewitt and Southwell undertook to investigate this further. This work should be able to develop the analyses commissioned for an earlier meeting of WG-CEMP (see WG-CEMP-91/8 and 91/36).

32. Notwithstanding the work to be undertaken in respect of paragraphs 29 to 31, it was envisaged that the following types of analysis would be undertaken:

(i) intersite variation –
this would involve consideration of both CEMP data and comparable data collected outside CEMP, to investigate both inter- and intra-regional variation, the latter with a view to assessing the extent to which local sites are representative of processes at regional scales;

(ii) interannual variation; and

(iii) correlation amongst indices –
this would involve further investigation of CSIs (see SC-CAMLR-XIX, Annex 4, paragraphs 3.50 to 3.52) and assessment of potential redundancy amongst indices integrating at similar spatial and temporal scales.

33. It was felt potentially less important for the moment to undertake intersessional work on topics relating to the identification of anomalies and missing values, though further work would be advantageous at some stage (see SC-CAMLR-XVI, Annex 4, Appendix D, paragraphs 2.5 to 2.23 and 5.1 to 5.8).

34. It was agreed that similar analytical approaches should be applied to other time-series data, collected by consistent methods, that could be made available to the meeting (see paragraphs 36 to 56).

35. Details of the nature of the analyses to be undertaken in respect of CEMP and appropriate non-CEMP data will need to be considered by a specialist subgroup. Members of the steering committee would propose appropriate members of this subgroup, who should be invited to hold early discussions by correspondence.

Other Data

36. To guide discussion in respect of relevant data currently not available within CEMP (see paragraph 16), a list of potentially relevant types of data was prepared (Table 1).

Krill

37. Priority data required for the workshop and derived from biological samples would include:

(i) indices of krill availability;
(ii) recruitment indices from at-sea surveys;
(iii) demographic data from predator samples; and
(iv) demographic data from fishery samples.

Valuable demographic data are collected by the US LTER Program and these should be incorporated as available.

38. A subgroup to coordinate the provision of these data and to consider appropriate analyses and comparisons between datasets would be set up following consultations between Drs Hewitt, Nicol and Trathan.

39. CPUE data from krill fishing operations would also be desirable. Papers tabled at recent and current WG-EMM meetings seem to indicate that an index based on catch per days fishing might serve as an appropriate interim indicator. WG-EMM was invited to advise on this, taking into account discussions during the SSMU Workshop.

Cetaceans

40. Data on the status and trends of baleen whales, especially minke whales, in the CCAMLR Convention Area were of obvious relevance to CCAMLR, including in the context of CEMP. It was agreed that Dr Hewitt should discuss with Dr S. Reilly (IWC) how the workshop might acquire the most relevant and appropriate data for its purposes.

41. Other time-series data from cetaceans in the Convention Area, some of which had been made available to the Workshop on Area 48, would also be valuable. Data holders were invited to make appropriate data available to the workshop.

Seals

42. It was agreed that the data on the status and trends of Antarctic seals recently supplied to CCAMLR by the SCAR Group of Specialists on Seals would be appropriate background information for the workshop. Dr Southwell indicated that the results of the Antarctic Pack-Ice Seal (APIS) survey program would be unlikely to be available in time for the 2003 workshop.

43. Holders of time-series data on Antarctic fur seals, additional to those already held in the CEMP database, were requested to make these available to the workshop at the earliest opportunity.

Seabirds

44. A recent review of the status and trends of Antarctic seabirds by the SCAR Bird Biology Sub-committee (Woehler et al., 2001) would be appropriate background information, particularly for populations and species not covered by CEMP.

45. Long time-series data, mainly on non-CEMP seabird species, were also available from studies carried out by French scientists working at sites in the sub-Antarctic Indian Ocean and in Adélie Land, Antarctica. Several recent publications from these researchers had evaluated fluctuations in breeding population size and performance of a range of seabird species in relation to physical environmental data (e.g. ENSO, sea-surface temperature, pack-ice extent). It was agreed that the relevant publications should be referenced on the CCAMLR website and made available to the workshop. Appropriate French scientists should also be specifically invited to participate in the workshop.

46. Data from South African research on seabirds at Marion Island (see WG-EMM-02/26) would also be valuable to the workshop and should be requested.

47. Holders of time-series data on any of the CEMP seabird indicator species (Adélie penguin, chinstrap penguin, gentoo penguin, macaroni penguin, Antarctic petrel, cape petrel, black-browed albatross) additional to those already held in the CEMP database were requested to make these available to the workshop at the earliest opportunity.

Icefish

48. Long-term data on icefish, particularly from studies in the South Georgia region, would be a valuable contribution to the workshop. Prof. Croxall would consult with Dr Everson, the author of the WG-FSA species profile of this species, to determine which were the most useful data to have available for analysis at the workshop.

Biological Environment

49. The utility and feasibility of analysing data on primary productivity (derived from SeaWiFS) in conjunction with CEMP or CEMP-related data on krill or dependent species, would be investigated by a subgroup comprising Drs Hewitt, Nicol and Trathan.

50. Appropriate time series data on former CEMP indicator species such as *Pleuragramma* and on other taxa potentially important as competitors or alternate prey to krill (e.g. salps, myctophids) were requested to be submitted to the workshop by appropriate data holders.

Physical Environment

51. It was agreed that it was important to have available at the workshop time-series data on key features of the physical environment for analysis in conjunction with data on krill and dependent species.

52. Data on sea-ice distribution, concentration and extent, sea-surface temperature (including measurements in relation to the heat content of Antarctic Surface Water) and appropriate composite indices (e.g. ACW, DPOI and ENSO) were likely to be of particular importance.

53. It was recognised, however, that particular attention should be given to matching the physical data to the scales at which the biological data are collected and/or integrated and to ensure that appropriate analyses of the physical environmental data are feasible in relation to workshop objectives.

54. A subgroup to evaluate the most important physical environmental data for the purposes of the 2003 workshop would be established following consultation between Drs Hewitt, Naganobu, Nicol and Trathan. Subgroup members should include individuals with expertise in analysis of physical datasets in biological contexts.

Data from Fisheries for Species other than Krill

55. Data derived from non-krill fisheries on variations in biological characteristics of stocks might proof useful for analysis at the workshop.

56. It was agreed to request WG-FSA to recommend any time-series data which might be suitable for the purposes of the 2003 workshop.

Availability of Reference Material

57. A listing of relevant publications (together with a pdf version wherever possible) and other material will be maintained by the Secretariat on part of the CCAMLR website. Potentially useful material should be submitted to the Website and Information Services Officer who will process the material in consultation with the steering committee.

Additional Attendees at the 2003 Workshop

58. Noting the particular need to develop and link appropriate ecological and statistical models (SC-CAMLR-XIX, Annex 4, paragraph 5.20), it was recommended that:

(i) Members be requested to assist the attendance at the workshop of appropriately qualified scientists; and

(ii) additional international experts in these fields be invited to attend.

59. WG-EMM was invited to suggest potential candidates for invitation, from which the steering committee would draw up a short list to approach with respect to availability. It was noted that the attendance of some experts could have budget implications.

ANY OTHER BUSINESS

60. It was recommended that the available members of the steering committee should hold a meeting to evaluate progress during the forthcoming meeting of the Scientific Committee.

REFERENCES

Agnew, D.J. 1997. Review: the CCAMLR Ecosystem Monitoring Program. *Ant. Sci.*, 9 (3): 235–242.

Constable, A.J. 2002. CCAMLR ecosystem monitoring and management: future work. *CCAMLR Science,* 9: 233–253.

Woehler, E., J. Cooper, J.P. Croxall, W.R. Fraser, G.L. Kooyman, G.D. Miller, D.C. Nel, D.L. Patterson, H.-U. Peter, C.A. Ribic, K. Salwicka, W.Z. Trivelpiece and H. Weimerskirch. 2001. *A Statistical Assessment of the Status and Trends of Antarctic and SubAntarctic Seabirds*. SCAR, Cambridge.

Table 1: Types of data of known or potential utility in relation to CEMP.

KRILL	METEOROLOGY AT CEMP SITE
Abundance	Precipitation
Distribution	Air temperature
Demographics	
Condition	PREDATOR PARAMETERS (non-CEMP)
Fisheries performance	Demographics
	Diet composition
PELAGIC PREDATORS	
Whales	DATA FROM OTHER BODIES/PROGRAMS
Crabeater seals	IWC
Icefish	SCAR
	France
BIOLOGICAL ENVIRONMENT	LTER
Primary productivity	
Other prey species	DATA FROM 'NON-KRILL' FISHERIES
Salps	IMAF
	Icefish
PHYSICAL ENVIRONMENT	Squid
Sea-ice	Myctophids
Frontal positions	
ENSO	
DPOI	
SST	
Surface-layer temperature	

ATTACHMENT 1

LIST OF PARTICIPANTS

Interim Steering Committee for the CEMP Review
(Big Sky, Montana, USA, 3 August 2002)

CROXALL, John (Prof.)	British Antarctic Survey High Cross, Madingley Road Cambridge CB3 0ET United Kingdom j.croxall@bas.ac.uk
GOEBEL, Michael (Mr)	US AMLR Program Southwest Fisheries Science Center 8604 La Jolla Shores Drive La Jolla, CA 92037 USA michael.goebel@noaa.gov
HEWITT, Roger (Dr)	US AMLR Program 8604 La Jolla Shores Drive La Jolla, CA 920378 USA roger.hewitt@noaa.gov
NAGANOBU, Mikio (Dr)	National Research Institute of Far Seas Fisheries Orido 5-7-1, Shimizu Shizuoka 424-8633 Japan naganobu@affrc.go.jp
NICOL, Steve (Dr)	Australian Antarctic Division Channel Highway Kingston Tasmania 7050 Australia steve.nicol@aad.gov.au
REID, Keith (Dr)	British Antarctic Survey High Cross, Madingley Road Cambridge CB3 0ET United Kingdom k.reid@bas.ac.uk

SOUTHWELL, Colin (Dr)	Australian Antarctic Division Environment Australia Channel Highway Kingston Tasmania 7050 Australia colin.southwell@aad.gov.au
TRATHAN, Philip (Dr)	British Antarctic Survey High Cross, Madingley Road Cambridge CB3 0ET United Kingdom p.trathan@bas.ac.uk

Secretariat:

Denzil MILLER (Executive Secretary) David RAMM (Data Manager)	CCAMLR PO Box 213 North Hobart 7002 Tasmania Australia ccamlr@ccamlr.org

ATTACHMENT 2

AGENDA

Interim Steering Committee for the CEMP Review
(Big Sky, Montana, USA, 3 August 2002)

1. To review the terms of reference for the review of CEMP.

2. To prepare detailed plans for the workshop in 2003, including:

   (a) an appropriate program of intersessional preparatory work;

   (b) identification and ensuring availability of appropriately validated data, together with arrangements for analysis of such data as required;

   (c) identification and ensuring availability of appropriate reference material for the meeting; and

   (d) suggestions as to additional attendees at the 2003 meeting, taking particular account of the potential need to develop and link appropriate ecological and statistical models.

ATTACHMENT 3

MATERIAL AVAILABLE FOR THE MEETING

Interim Steering Committee for the CEMP Review
(Big Sky, Montana, USA, 3 August 2002)

Reports of first three meetings of WG-CEMP:

SC-CAMLR-IV, Annex 7	Report of the Ad Hoc Working Group on Ecosystem Monitoring, Seattle, Washington USA, 6 to 11 May 1985
SC-CAMLR-V, Annex 6	Report of the Working Group for the CCAMLR Ecosystem Monitoring Program, Hamburg, Federal Republic of Germany, 2 to 7 July 1986
SC-CAMLR-VI, Annex 4	Report of the Working Group for the CCAMLR Ecosystem Monitoring Program, Dammarie-les-lys, France, 10 to 15 June 1987

WG-EMM-2002 papers:

WG-EMM-02/5	CEMP indices 2002: analysis of anomalies and trends CCAMLR Secretariat
WG-EMM-02/7	A review and preliminary analysis of CEMP data CCAMLR Secretariat
WG-EMM-02/19	Combined standardised indices of predator performance at Bird Island, South Georgia, 1973–2002 K. Reid (United Kingdom)
WG-EMM-02/20	Are krill recruitment indices from meso-scale survey representative for larger areas? V. Siegel (Germany), R.M. Ross and L.B. Quetin (USA)
WG-EMM-02/26	Conserving seabirds competing with fisheries for food – observations from southern Africa and Marion Island R.J.M. Crawford, C.M. Duncombe Rae and D.C. Nel (South Africa)

WG-EMM-02/46	An assessment of temporal variability and interrelationships between CEMP parameters collected on Adélie penguins at Béchervaise Island L.M. Emmerson, J. Clarke, K. Kerry and C. Southwell (Australia) (*CCAMLR Science*, submitted)

WG-EMM-2001 presentation papers:

Miller, D.G.M. (2002)	Antarctic krill and ecosystem management – from Seattle to Siena *CCAMLR Science*, 9: 175–212
Everson, I. (2002)	Consideration of major issues in ecosystem monitoring and management *CCAMLR Science*, 9: 213–232
Constable, A.J. (2002)	CCAMLR ecosystem monitoring and management: future work *CCAMLR Science*, 9: 233–253

ATTACHMENT 4

INTERSESSIONAL WORK PLAN FOR THE WORKSHOP ON THE REVIEW OF CEMP

	Task/Topic	Paragraphs of Report	Responsibility	Start/ Completion Deadlines[1]	Priority[2]	Action
1.	Review of design of monitoring programs	14	Nicol		1	
2.	Submission of proposals for monitoring in respect of non-krill based interactions	18	Secretariat	After Scientific Committee	2	Request to Members
3.	Development of krill management model 3	22, 23	Reid, Trathan		2	
4.	Development of krill management model 4	22, 24	Hewitt, Nicol, Trathan		2	
5.	Workshop arrangements, including data submission and analysis	26	Steering Committee		1	
6.	CEMP data validation	27	Ramm		1	Interaction with data owners
7.	Basic analysis of CEMP data	28	Ramm, Steering Committee		1	
8.	Matrices of CEMP data availability	29	Ramm, Southwell	Immediate	1	
9.	Intersite methodological differences and biases	30	Goebel, Reid, Southwell		1	
10.	Standard method data: sensitivity and power analysis evaluation	31	Hewitt, Southwell		1	Find appropriate statisticians
11.	Establish subgroup for advising on and coordinating analysis of CEMP and non-CEMP data	35	Steering Committee		1	
12.	Establish subgroup for acquisition and analysis of krill data	38	Steering Committee		1	
13.	Acquire time-series data on krill fishery CPUE	39	Steering Committee		2	Discuss during WG-EMM

	Task/Topic	Paragraphs of Report	Responsibility	Start/ Completion Deadlines[1]	Priority[2]	Action
14.	Acquire IWC data on status and trends of baleen whales	40	Hewitt		2	Dialog with Dr S. Reilly (IWC)
15.	Acquire other indicator data on cetaceans	41	Secretariat	After Scientific Committee	2	Request to Members
16.	Acquire non-CEMP time-series data on Antarctic fur seals	43	Secretariat, Steering Committee	After Scientific Committee	2	Request to Members Steering Committee to approach data holders direct
17.	Acquire non-CEMP time-series data on seabirds	45–47	Secretariat, Steering Committee	After Scientific Committee	2	Request to Members Steering Committee to approach data holders direct Specific approach to French scientists
18.	Availability of relevant icefish data	48	Croxall		2	Dialog with Dr I. Everson (UK)
19.	Feasibility of using appropriate data on primary productivity	49	Hewitt, Nicol, Trathan		2	
20.	Acquire time-series data on e.g. *Pleuragramma*, myctophids, salps	50	Secretariat	After Scientific Committee	2	Request to Members
21.	Establish subgroup for evaluating relevant physical environment data	54	Hewitt, Naganobu, Nicol, Trathan		1	
22.	Advice on appropriate biological data from fisheries	56	Steering Committee	At WG-FSA	2	Request to WG-FSA
23.	Creation of workshop information area on CCAMLR website	57	WIS Officer, Steering Committee		1	
24.	Attendance of invited experts	59	Steering Committee	During WG-EMM After WG-EMM	1	Develop long list Create short list Establish availability and potential budget considerations
25.	Next meeting of Steering Committee	60	Steering Committee	During Scientific Committee	1	

	Task/Topic	Paragraphs of Report	Responsibility	Start/ Completion Deadlines[1]	Priority[2]	Action
26.	Inform all CEMP data holders of analyses planned and invite collaboration as appropriate	WG-EMM 6.7	Secretariat		1	
27.	Summary of spatial and temporal scales at which CEMP indices integrate and of degree to which CEMP parameters vary with consumption of krill	WG-EMM 6.11	Steering Committee		1	

[1] All start deadlines are as soon as possible, unless otherwise indicated.

[2] 1 – essential for CEMP review; 2 – very valuable for CEMP review.

SPECIES BY SITE BY YEAR MATRIX OF CEMP DATA AVAILABLE FROM 1976 TO 2002

***Pygoscelis adeliae* (Adélie penguin)**

A1 Weight (g) of adult penguin on arrival

Site					1980										1990										2000		
Stranger Point (King George Island)	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Esperanza Station (Hope Bay)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	-	-	X	-
Laurie Island	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-
Verner Island (Mawson Station)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Béchervaise Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X

A2 Duration (day) of penguin incubation shift

Site					1980										1990										2000		
Admiralty Bay	-	-	-	-	-	-	X	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-	X	X
Esperanza Station (Hope Bay)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	-	X	-
Béchervaise Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X
Magnetic Island (Prydz Bay)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
Edmonson Point	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	X	-	-	-

A3 Penguin breeding population size (number of pairs)

Site					1980										1990										2000		
Anvers Island (Antarctic Peninsula)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	-	-	-
Admiralty Bay	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-	X	X
Stranger Point (King George Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X	X	X	X	X
Esperanza Station (Hope Bay)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	-	X	X
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	-	X	X	X	X
Laurie Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X	X	X	-	X
Shirley Island (Casey Station)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-
Verner Island (Mawson Station)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X
Syowa Station	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Béchervaise Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X
Magnetic Island (Prydz Bay)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
Edmonson Point	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X
Ross Island	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

A5a Duration (h) of penguin foraging

Site					1980										1990										2000		
Anvers Island (Antarctic Peninsula)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	-	-	-
Shirley Island (Casey Station)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-

***Pygoscelis adeliae* (Adélie penguin) – continued**

A5a Duration (h) of penguin foraging – continued

Site					1980										1990										2000		
Béchervaise Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	-
Edmonson Point	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-

A6a Penguin breeding success (chicks fledged per egg laid)

Site					1980										1990										2000		
Admiralty Bay	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
Stranger Point (King George Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X	X	X	X	X
Esperanza Station (Hope Bay)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	-	X	X
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	-	X	X	X	X
Laurie Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X	X	X	-	X
Shirley Island (Casey Station)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-
Béchervaise Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X
Edmonson Point	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	-	X	X	X	-

A6c Penguin breeding success (chicks fledged per chicks hatched)

Site					1980										1990										2000		
Anvers Island (Antarctic Peninsula)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	-	-	-
Shirley Island (Casey Station)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-
Béchervaise Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X
Magnetic Island (Prydz Bay)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
Edmonson Point	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	X	X	X	-

A7 Penguin chick weight (g) at fledging

Site					1980										1990										2000		
Anvers Island (Antarctic Peninsula)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	-	-	-
Admiralty Bay	-	-	-	-	-	-	X	X	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	-	X	X
Esperanza Station (Hope Bay)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	-	X	X
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X
Béchervaise Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X
Magnetic Island (Prydz Bay)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
Edmonson Point	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-

A8a Weight (g) of stomach contents of adult penguins

Site					1980										1990										2000		
Anvers Island (Antarctic Peninsula)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	-	-	-
Admiralty Bay	-	-	X	-	-	-	X	X	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	-	X	X
Stranger Point (King George Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X
Laurie Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	-
Shirley Island (Casey Station)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-
Béchervaise Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-	X	X	X	-
Edmonson Point	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	-	X	-	X	-

Pygoscelis adeliae **(Adélie penguin) – continued**

A8b Composition (proportion) of diet of adult penguins

Site					1980										1990										2000		
Anvers Island (Antarctic Peninsula)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	-	-	-
Admiralty Bay	-	-	X	-	-	-	X	X	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	-	X	X
Stranger Point (King George Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X
Laurie Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	-
Shirley Island (Casey Station)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-
Béchervaise Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-	X	X	X	-
Edmonson Point	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	-	X	-	X	-

A8c Composition (occurrence) of diet of adult penguins

Site					1980										1990										2000		
Anvers Island (Antarctic Peninsula)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	-	-	-
Admiralty Bay	-	-	X	-	-	-	X	X	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	-	X	X
Stranger Point (King George Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X
Laurie Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	-
Shirley Island (Casey Station)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-
Béchervaise Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-	X	X	X	-
Edmonson Point	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	-	X	-	X	-

Pygoscelis antarctica **(chinstrap penguin)**

A1 Weight (g) of adult penguin on arrival

Site					1980										1990										2000		
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X	X

A2 Duration (day) of penguin incubation shift

Site					1980										1990										2000		
Admiralty Bay	-	-	-	-	-	-	-	X	-	X	X	X	X	-	-	X	X	X	X	X	X	X	X	-	-	-	-

A3 Penguin breeding population size (number of pairs)

Site					1980										1990										2000		
Cape Shirreff	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X
Admiralty Bay	-	-	X	X	X	X	X	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-	X	X
Elephant Island (Stinker Point)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	-	X	X	X	X
Bouvetoya (Bouvet Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-

A5a Duration (h) of penguin foraging

Site					1980										1990										2000		
Seal Island	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-	-	-	-	-	-	-	-
Bouvetoya (Bouvet Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-

***Pygoscelis antarctica* (chinstrap penguin) – continued**

A6a Penguin breeding success (chicks fledged per egg laid)

Site					1980										1990										2000		
Cape Shirreff	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X
Admiralty Bay	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
Elephant Island (Stinker Point)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	-	X	X	X	X
Bouvetoya (Bouvet Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-

A6c Penguin breeding success (chicks fledged per chicks hatched)

Site					1980										1990										2000		
Seal Island	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	-	-	-	-	-	-	-

A7 Penguin chick weight (g) at fledging

Site					1980										1990										2000		
Cape Shirreff	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X
Admiralty Bay	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	X	X	X	-	X	X
Seal Island	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	-	-	-	-	-
Elephant Island (Stinker Point)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X

A8a Weight (g) of stomach contents of adult penguins

Site					1980										1990										2000		
Cape Shirreff	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X
Admiralty Bay	-	-	X	-	-	-	X	X	-	-	-	-	X	X	-	X	X	X	X	X	X	X	X	X	-	X	X
Seal Island	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-	-	-	-	-	-	-	-
Elephant Island (Stinker Point)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X
Laurie Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	-
Bouvetoya (Bouvet Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-

A8b Composition (proportion) of diet of adult penguins

Site					1980										1990										2000		
Cape Shirreff	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X
Admiralty Bay	-	-	X	-	-	-	X	X	-	-	-	-	X	X	-	X	X	X	X	X	X	X	X	X	-	X	X
Seal Island	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-	-	-	-	-	-	-	-
Elephant Island (Stinker Point)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X
Laurie Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	-
Bouvetoya (Bouvet Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-

A8c Composition (occurrence) of diet of adult penguins

Site					1980										1990										2000		
Cape Shirreff	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X
Admiralty Bay	-	-	X	-	-	-	X	X	-	-	-	-	X	X	-	X	X	X	X	X	X	X	X	X	-	X	X
Seal Island	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-	-	-	-	-	-	-	-
Elephant Island (Stinker Point)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X
Laurie Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	-
Bouvetoya (Bouvet Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-

Pygoscelis papua **(gentoo penguin)**

A3 Penguin breeding population size (number of pairs)

Site					1980										1990										2000		
Cape Shirreff	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X
Admiralty Bay	-	-	X	X	X	X	X	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-	X	X
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	-	X	X	X	X
Bird Island	-	X	X	X	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Marion Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-

A6a Penguin breeding success (chicks fledged per egg laid)

Site					1980										1990										2000		
Admiralty Bay	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	-	X	X	X	X
Bird Island	-	X	X	X	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Marion Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	-	-

A6c Penguin breeding success (chicks fledged per chicks hatched)

Site					1980										1990										2000		
Marion Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-

A7 Penguin chick weight (g) at fledging

Site					1980										1990										2000		
Cape Shirreff	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X
Admiralty Bay	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	X	X
Bird Island	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	-	X	X	X	X
Marion Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-

A8a Weight (g) of stomach contents of adult penguins

Site					1980										1990										2000		
Cape Shirreff	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X
Admiralty Bay	-	-	X	-	-	-	X	X	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	-	-	-
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X
Bird Island	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Marion Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	-	-	-	-	-

A8b Composition (proportion) of diet of adult penguins

Site					1980										1990										2000		
Cape Shirreff	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X
Admiralty Bay	-	-	X	-	-	-	X	X	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	-	-	-
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X
Bird Island	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Marion Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	-	-	-	-	-

A8c Composition (occurrence) of diet of adult penguins

Site					1980										1990										2000		
Cape Shirreff	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X
Admiralty Bay	-	-	X	-	-	-	X	X	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	-	-	-
Signy Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X
Bird Island	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Marion Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	-	-	-	-	-

Eudyptes chrysolophus **(macaroni penguin)**

A1 Weight (g) of adult penguin on arrival

Site					1980										1990										2000		
Bird Island	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Marion Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-

A3 Penguin breeding population size (number of pairs)

Site					1980										1990										2000		
Elephant Island (Stinker Point)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Bird Island	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bouvetoya (Bouvet Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-
Marion Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-

A5a Duration (h) of penguin foraging

Site					1980										1990										2000		
Seal Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Bouvetoya (Bouvet Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-

A6a Penguin breeding success (chicks fledged per egg laid)

Site					1980										1990										2000		
Elephant Island (Stinker Point)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Bird Island	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bouvetoya (Bouvet Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-

A6c Penguin breeding success (chicks fledged per chicks hatched)

Site					1980										1990										2000		
Seal Island	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X	X	X	X	-	-	-	-	-	-	-
Marion Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-

A7 Penguin chick weight (g) at fledging

Site					1980										1990										2000		
Seal Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Elephant Island (Stinker Point)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Bird Island	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Marion Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-

A8a Weight (g) of stomach contents of adult penguins

Site					1980										1990										2000		
Elephant Island (Stinker Point)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-
Bird Island	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bouvetoya (Bouvet Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-
Marion Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-

A8b Composition (proportion) of diet of adult penguins

Site					1980										1990										2000		
Elephant Island (Stinker Point)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-
Bird Island	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bouvetoya (Bouvet Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-
Marion Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-

***Eudyptes chrysolophus* (macaroni penguin) – continued**

A8c Composition (occurrence) of diet of adult penguins

Site					1980										1990										2000		
Elephant Island (Stinker Point)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-
Bird Island	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bouvetoya (Bouvet Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-
Marion Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-

***Diomedea melanophrys* (black-browed albatross)**

B1a Albatross breeding population size (number of pairs)

Site					1980										1990										2000		
Bird Island	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

B1b Albatross breeding success

Site					1980										1990										2000		
Bird Island	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

***Thalassoica antarctica* (Antarctic petrel)**

B5c Petrel breeding population size (number of nests brooding)

Site					1980										1990										2000		
Svarthamaren	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	-	X	X	-	-	-	-

***Arctocephalus gazella* (Antarctic fur seal)**

C1 Duration (h) of fur seal cow foraging

Site					1980										1990										2000		
Cape Shirreff	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X
Seal Island	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X	X	X	X	-	-	-	-	-	-	-
Bird Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X
Bouvetoya (Bouvet Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-

C2b Growth rate (kg/month) of fur seal pups

Site					1980										1990										2000		
Cape Shirreff	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X
Seal Island	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	-	-	-	-	-	-	-
Bird Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X
Bouvetoya (Bouvet Island)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-