CCAMLR SCIENTIFIC ABSTRACTS
1994

Commission for the Conservation of
Antarctic Marine Living Resources

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PREFACE

CCAMLR Scientific Abstracts provides a comprehensive record of all scientific papers presented for the consideration of the annual meetings of the CCAMLR Commission and Scientific Committee and of their subsidiary bodies.

This volume contains abstracts of scientific papers presented in 1994. It corresponds to the Thirteenth Meetings of the CCAMLR Commission and Scientific Committee and is published only in English.

There are four categories of papers:

(i) Scientific papers published elsewhere, for which the full reference and published abstract are given;

(ii) Scientific papers submitted for publication, i.e., in *CCAMLR Science* or elsewhere, which are listed as 'in press' with details of the publisher, if known;

(iii) Scientific papers not intended for publication, which are listed as 'unpublished'; and

(iv) Supplementary scientific papers (i.e., listing of data submitted, summary of analyses performed, etc.) not intended for publication, for which the title alone is listed.

All abstracts are listed in groups by respective CCAMLR bodies at meetings of which these papers were submitted. Each abstract is preceded with a unique CCAMLR document number, e.g. SC-CAMLR-XII/BG/11 (background document number 11 submitted at the Twelfth Meeting of the Scientific Committee); or WG-Krill-92/8 (document number 8 submitted at the 1992 meeting of the Working Group on Krill).

Unpublished papers must not be cited without written permission of the author(s). Addresses of principal authors are given for this purpose.

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SC-CAMLR-XIII/BG/1 Rev. 1
Status of catches in the Convention Area 1993/94 season. CCAMLR Secretariat, 10 pp. (English).

SC-CAMLR-XIII/BG/3
Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Bird Island, South Georgia during the 1993 winter and 1993/94 pup-rearing season. J.P. Croxall, K. Reid, A. Walker and J.P.Y. Arnould (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, Untied Kingdom), 24 pp. (English, unpublished).

Surveys of Antarctic fur seals entangled in man-made marine debris were carried out for the fourth consecutive winter and sixth consecutive summer at Bird Island, South Georgia. In the 1993 winter the number of entangled seals was only 39% of the record 1992 total, but still 5-times the numbers in 1990 and 1991. Nearly all animals were juveniles, half with severe injuries and the proportion of females (40%) was the highest yet reported. The proportion of animals entangled in packaging bands was the lowest ever (24%) and less than one-half that in 1992. Fishing net fragments and especially string and bags were important as entangling materials. In the 1993/94 summer the number of seals entangled (23) was the lowest ever and a 70% reduction on the previous year, thereby reversing the upward trend since 1990. For the first time more animals were entangled in net fragments (35%) than in packaging bands (30%), the decrease in the latter mirroring the records of the preceding winter. However, 68% of animals affected were female (previous highest 40%); combined with the highest proportion of adults and of severe injury yet reported, grounds still remain for concern.

SC-CAMLR-XIII/BG/4
Fishing gear, oil and marine debris associated with seabirds at Bird Island, South Georgia, 1993/94. N. Huin and J.P. Croxall (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, Untied Kingdom), 18 pp. (English, unpublished).

We record the first observations of oiled albatrosses at South Georgia, provide data on ingestion of plastics by albatrosses and giant petrels and report a 6-fold increase over the previous year of the incidence of fishing line and hooks associated with, regurgitated by and impaled in seabirds. Although the ingestion of oil, plastics and fishing gear are probably causing only minor problems for South Georgia seabirds at present, the increase in number and variety of environmental threats is a cause for concern. Members of CCAMLR are urged to do everything possible to eliminate or minimise these problems.

SC-CAMLR-XIII/BG/5
Report on CCAMLR's participation at the FAO *ad hoc* consultation on the role of regional fisheries agencies in relation to high seas statistics. CCAMLR Secretariat, 4 pp. (English, unpublished).

SC-CAMLR-XIII/BG/6
Observer's report from the 1994 meeting of the Scientific Committee of the International Whaling Commission. CCAMLR Observer's report (W.K. de la Mare), Australia, 2 pp. (English, unpublished).

SC-CAMLR-XIII/BG/7
Report on CCAMLR's participation at the SCAR Sixth Biology Symposium 'Antarctic communities, structure and survival'. CCAMLR Secretariat, 2 pp. (English, unpublished).

SC-CAMLR-XIII/BG/9 Rev. 1
CCAMLR scheme of International Scientific Observation: preliminary report of the scientific observer FV *Maksheevo*, 7 February to 18 April 1994. (USA designated scientific

observer) USA, 18 pp. (English, unpublished).

SC-CAMLR-XIII/BG/10
CCAMLR sea ice data project. CCAMLR Secretariat, 5 pp. (English, unpublished).

SC-CAMLR-XIII/BG/11
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SC-CAMLR-XIII/BG/14
Summary report of the UK nominated scientific observers on FV *Ihn Sung 66*, 15 December 1993 to 7 February 1994. (C. Jones, M. Wharton and I. Liggett) UK, 10 pp. (English, unpublished).

SC-CAMLR-XIII/BG/15
Information on squid relevant to CCAMLR area, 1993/94. P.G. Rodhouse (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 4 pp. (English, unpublished).

SC-CAMLR-XIII/BG/16
International data management. CCAMLR Secretariat, 5 pp. (English, unpublished).

Workshop on Evaluating Krill Flux Factors

WS-Flux-94/4
Analysis of acoustic and oceanographic data for the 1994 krill flux workshop. D.J. Agnew, (CCAMLR Secretariat, 25 Old Wharf, Hobart, Tasmania, 7000 Australia), 13 pp. (English, unpublished).

A methodology is described which, when applied to data from an acoustic survey, will yield mean krill density along an arbitrary section through the survey area, giving results compatible with the specifications given in SC-CAMLR-XII, Annex 4, Appendix D. A program written to calculate such sections is also described and example output displayed. A similar program calculates current speeds normal to a section given an oceanographic dataset of current direction and speed. The two programs produce compatible vectors of krill density and current speed along specified sections.

WS-Flux-94/5
Use of current velocity data from FRAM to investigate the large-scale transport of krill in the Scotia Sea. E.J. Murphy (British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom), 10 pp. (English, unpublished).

Current velocity data from a single time realisation of the FRAM model are presented for particular areas of the Scotia Sea. The regions are based on the CCAMLR subareas and also include a more detailed area around South Georgia. Mean current velocities have been calculated for region boundaries over the upper 250 m of the water column. These have been combined with estimates of krill density and standing stock in order to study the large-scale flux of krill through the regions and to estimate residence times.

WS-Flux-94/6
Large-scale circulation in the South Atlantic: estimates from giant iceberg drift rates. P.N. Trathan and C. Symon (British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom), 11 pp. (English, unpublished).

The paper reports work currently in progress and presents estimates of ocean circulation in the Scotia Sea. The estimates are derived from the drift rates of giant icebergs calved in the Weddell Sea since 1974. Comparison with other estimates is

limited by the lack of studies reported in the literature; however, efforts to make these comparisons are in hand.

WS-Flux-94/7
Comparison of geostrophic velocities from Subarea 48.1. W. de la Mare (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia), 4 pp. (English, unpublished).

WS-Flux-94/8
Reference materials on Statistical Area 48 for krill flux workshop. M. Naganobu (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, Shizuoka, 424 Japan), 9 pp. (English, unpublished).

WS-Flux-94/9
Stream lines in the FRAM velocity field: speeds and directions from passive tracers. E.J. Murphy (British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom), 4 pp. (English, unpublished).

A single time realisation of the FRAM model has been used to obtain trajectories of passive tracers. This note presents some of the analyses undertaken in order to provide background information on the potential transfers of krill in the Scotia Sea. A more detailed presentation of the stream lines in the South Georgia region is also given.

WS-Flux-94/10
Tracer trajectories from the western shelf of South Georgia: ship displacement data. E.J. Murphy, I. Everson and C. Goss (British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom), 5 pp. (English, unpublished).

Corrected ship's heading data were used to calculate drift data for the shelf area to the west of South Georgia. The data were collected over a six-week period during 1986. A distance-weighted interpolation was used to obtain tracer trajectories in this irregular data grid. The vector field is complex with no simple flow field. These data include a lot of complex process interactions. Particles getting onto the shelf are retained with little chance of escape after a run of 100 days. Some of the trajectories are extremely complex. Particles to the north of the shelf can be transported up onto the shelf. Only those particles released very close to the shelf break in the south are transported up onto the shelf. Further south, particles are transported to the west along the shelf.

Working Group on Krill

WG-Krill-94/4
Parameters for the stochastic krill dynamics model (SKDM): selectivity and maturity. D.J. Agnew (CCAMLR Data Manager, 25 Old Wharf, Hobart, Tasmania 7000, Australia), 3 pp. (English, unpublished).

The parameters used to model gear selectivity and maturity at length in the SKDM were derived from data available at the CCAMLR Data Centre or in documents submitted to past meetings of the Scientific Committee. In the SKDM, if ℓ_{50} for selectivity and maturity is to be sampled from a uniform distribution and applied to a standard function width, then these should be:

$\ell_{r\,50}$ = U[30,39] w_r = 9 mm
(for gear selectivity)
$\ell_{m\,50}$ = U[32,37] w_m = 6 mm
(for maturity).

WG-Krill-94/5
Incorporation of a model of krill recruitment into the Butterworth *et al.* stochastic krill dynamics model (SKDM). D.J. Agnew (CCAMLR Data Manager, 25 Old Wharf, Hobart, Tasmania 7000, Australia), 6 pp. (English, unpublished).

The method of simulating recruitment variability using observed ratios of 0-year krill to the total population is validated and tested. The method links natural mortality to krill recruitment. Incorporation of the krill dynamics model into the SKDM increases the variability of the krill population dynamics predicted by the latter model, although median escapement is

similar to the previous formulation of the SKDM model.

WG-Krill-94/6
Fine-scale catches of krill in Area 48 reported to CCAMLR for the 1992/93 fishing season. CCAMLR Secretariat, 37 pp. (English, unpublished).

WG-Krill-94/7 Rev. 1
Assessing the probability of detecting krill concentrations in Division 58.4.2. V.N. Yakovlev, V.A. Bibik and L.M. Kokoz (Southern Scientific Research Institute of Marine Fisheries and Oceanography (YugNIRO), 2 Sverdlov Street, Kerch 334500, Crimea Ukraine), 17 pp. (English, unpublished).

In 1994 the first stage was completed on the creation of a model describing krill distribution and the process of searching for krill concentrations in the area of Antarctica between 30° and 80°E. During the course of this work several tasks were performed, including the analysis and classification of krill echograms according to the primary characteristics of aggregations (length, volume, frequency of occurrence and temporal stability). In addition, algorithms have been developed for the automatic processing of data on the distribution of krill concentrations, as well as catch data. Data have been obtained on the frequency of occurrence of krill swarms - these data are discussed in detail for large spatial scales. A series of algorithms has been calculated and approaches to the construction of the model are presented.

WG-Krill-94/9
Polish krill fishery in the 1991/92 and 1992/93 seasons: catches and results of biological investigations. J. Sosinski and Z. Cielniaszek (Sea Fisheries Institute, ul. Kollataja 1, 81-332 Gdynia, Poland), 15 pp. (English, unpublished).

Poland began krill fishing operations in the 1976/77 season. It has been engaged in the commercial krill fishery since the 1986/87 season. A maximum catch of 15.9 thousand tonnes was taken in the 1992/93 season. This paper presents an analysis of Polish krill catches in the 1991/92 and 1992/93 seasons. CPUEs by month and subarea of the Atlantic sector of Antarctica were calculated. The results of biological investigations of krill on the fishing grounds of the South Orkney and South Georgia subareas are also given.

WG-Krill-94/10 Rev. 1
Analysis of krill fishing by Soviet fishing vessels in the Cooperation Sea (Division 58.4.2) in 1978 by fine-scale data. V.N. Yakovlev and V.A. Bibik (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine), 3 pp. (English, unpublished).

WG-Krill-94/11
Towards a distribution of M/K for krill (*Euphausia superba*) required for the stochastic krill yield model. M. Basson (Northeast Fisheries Center, Water Street, Woods Hole, Ma. 02543, USA), 16 pp. (English, unpublished).

WG-Krill-94/12
***In situ* target strength measurements of Antarctic zooplankton (*Euphausia superba* and *Salpa thompsoni*) at 120 kHz and 200 kHz, corroboration of scattering models, and a statistical technique for delineating species.** D.A. Demer and R.P. Hewitt (Scripps Institution of Oceanography, University of Ca. at San Diego, La Jolla, California 92038-0203, USA), 35 pp. (English, unpublished).

In situ measurements of target strength (TS) were made of Antarctic zooplankton (*Euphausia superba* and *Salpa thompsoni*) at 120 kHz and 200 kHz. Concurrently, a two-metre Isaacs-Kidd midwater trawl was used to sample the zooplankton populations and animal length-frequency data were recorded. The TS and length-frequency data were combined to corroborate theoretical scattering models for both species. The individual TS measurements were collected at 120 kHz with a split-beam echosounder and a single-target detection algorithm. Because the two transducers were essentially collocated, range-bin and off-axis angles from the 120 kHz detections were used to extract the corresponding TS from the 200 kHz single-beam data. The backscattering cross-sectional areas $\left(\sigma_{bs}\right)$ of salps are shown to fit a fluid sphere model [V.C. Anderson, (1950) *J. Acoust. Soc. Am.*, 22: 426-431]; presumably,

predominant scattering is from each animal's spheroidal nucleus. Consistent with the measurements of encaged krill [K.G. Foote *et al.* (1990) *J. Acoust. Soc. Am.*, 87(1): 16-24 and D. Chu *et al.* (1993) *J. Acoust. Soc. Am.*, 93(5): 2985-2988], the TS of *in situ* krill are shown to fit a deformed cylinder model [T.K. Stanton *et al.* (1993a) *J. Acoust. Soc. Am.*, 94(6): 3454-3462 and T.K. Stanton *et al.* (1993b) *J. Acoust. Soc. Am.*, 94(6): 3463-3472]. By utilising these scattering models and empirically derived distributions of animal sizes, a technique is developed for acoustically delineating the two species. The method uses non-parametric Kolmogorov-Smirnov fitness tests to evaluate cumulative distribution frequencies (CDFs) of $\Delta\sigma_{bs}$ derived from the differences in σ_{bs} measurements at two frequencies. About 15% of the tests indicated the presence of salps without krill, and about 3% revealed krill without salps. The salp/no krill echograms were characterised by diffuse scattering layers which were much higher in volume backscattering strength (S_v) at 200 kHz than at 120 kHz. Conversely, the krill/no salp echograms included dense swarms with virtually equivalent S_v at the two frequencies. The ability of this method to delineate salps from krill is highly dependent on the degree to which the two CDFs differ. A simulated combination of 200 kHz and 38 kHz resulted in highly distinguishable CDFs, indicating that these frequencies may be more useful for distinguishing salps from krill. Data were collected near Elephant Island, Antarctica, during the austral summer of 1994, as part of the United States Antarctic Marine Living Resources Program.

WG-Krill-94/13

Zooplankton target strength: volumetric or areal dependence?

D.A. Demer and L.V. Martin (Scripps Institution of Oceanography, University of California at San Diego, La Jolla, Ca. 92038-0203, USA), 21 pp. (English, unpublished).

Target strengths (TS) of various zooplankton were measured at 200 kHz, 420 kHz and 1 MHz, and the dependence of these data on animal volume versus cross-sectional area was explored. The 420 kHz and 1 MHz data were collected with a dual-beam sonar system and the 200 kHz data with a split-beam system. Experiments were conducted with live, tethered individuals in an enclosure filled with filtered seawater. The data were compared to both empirical and theoretical models of reduced target strength (TS normalised by the square of the animal length) versus *ka* (the product of wave number and equivalent cylindrical radius). The theoretical models chosen for this comparison were two versions of a high-pass bent-cylinder model (Stanton, 1989b) that indicate TS is dependent on animal volume, and the ray bent-cylinder model (Stanton, 1993a) which implies TS is dependent on the cross-sectional area. The dependence of acoustic backscattering on animal volume or area was tested by fitting regression lines for TS versus the logs of *ka*, length (L), wet weight (WW) and dry weight (DW). Contrary to an empirical model derived from similar experiments (Wiebe *et al.*, 1990), and to the high-pass models, the regressions indicated that TS is proportional to the cross-sectional area of the animal. However, neither Wiebe *et al.* (1990) nor this experiment directly accounted for animal orientations. Simulations using a Distorted Wave Born Approximation Model (Chu *et al.*, 1993) indicated that animal behaviour is an important factor in the scattering characteristics of zooplankton. Moreover, because scattering from individual zooplankton is highly non-linear, especially in the geometric scattering region ($ka>1$), linear regressions of TS versus the log of *ka*, L, WW or DW are inappropriate and misleading.

WG-Krill-94/14

An attempt to derive a composite index of abundance from acoustic surveys and fishery data.

R.P. Hewitt, V. Marín and D.A. Demer (Southwest Fisheries Science Center, La Jolla, Ca. 92038, USA). *CCAMLR Science*, (in press): 13 pp. (English).

Maps of krill (*Euphausia superba*) density derived from acoustic survey data, as well as the distribution of fishing effort

in the Chilean krill fishery, indicate an area of high krill density wrapping around the northwestern end of Elephant Island during the austral summer of 1992. In this area, the distribution of catch-per-fishing-time and krill density (measured acoustically) show similar forms. Search time could not be used to estimate other aspects of the pattern of krill distribution because fishing operations are limited by processing efficiency rather than the availability of krill. Analysis of the acoustic survey data suggested characteristic distribution pattern scales of 1.7 and 4 n miles. Estimates of a composite index of krill abundance (SC-CAMLR-VIII, 1989) were derived using these data sets for two surveys. In addition, the data suggest that the abundance of krill in the Elephant Island area can change rapidly, and when krill do come into the area they are most often found in water 100 m to 500 m deep along the shelf break north of Elephant Island, particularly in the area where it wraps around the western end of the island.

WG-Krill-94/15

Comments on WG-Krill-93/12 and 93/13. K. Hiramatsu (National Research Institute of Far Seas Fisheries 7-1, Orido 5 Chome, Shimizu-Shi, Shizuoka, 424, Japan), 3 pp. (English, unpublished).

WG-Krill-94/16

Demographic studies of Antarctic krill (*Euphausia superba* Dana) in the Sodruzhestva and Kosmonavtov Seas (Indian sector of the Southern Ocean). E.A. Pakhomov (Southern Ocean Group, Department of Zoology and Entomology, Rhodes University, PO Box 94, Grahamstown, 6140 South Africa), 31 pp. (English, unpublished).

The reproductive state and size composition of *Euphausia superba* specimens collected in the Indian sector of the Southern Ocean from 1985 to 1990 were analysed to estimate growth, life span and mortality rates of this species. The life cycle of *E. superba* exceeded five years in the Kosmonavtov Sea and six years in the Sodruzhestva Sea. Assuming that growth takes place for only 180 days per year, growth rates ranged from 0.120 to 0.133 mm.day^{-1} during the first year of life, to 0.019 to 0.022 mm.day^{-1} during the fifth year. Von Bertalanffy growth curves calculated for different areas are similar to those obtained by Australian researchers in the Prydz Bay region for the period 1981 to 1985. In mid-summer, *E. superba* of age 2+ to 4+ were predominant in all hauls made south of the Antarctic Divergence, while north of the Divergence the krill stock was clearly dominated by individuals of age 4+. The coefficients of natural mortality (M) of *E. superba* in the Indian sector of the Southern Ocean, calculated using the methods of Alverson and Carney, Richter and Efanov and Beverton and Holt, varied from 0.72 to 0.87, from 0.52 to 0.57 and from 0.76 to 2.92 respectively. The value of age-dependent natural mortality of *E. superba* derived using Zikov and Slepokurov's method ranged from 0.52 during the maturation period, to 1.1 to 2.41 during the first and last years of life. The relationship between age composition and spawning success of *E. superba* is examined based on longterm observations made in the coastal areas of the Sodruzhestva and Kosmonavtov Seas.

WG-Krill-94/17

Towards a new method for age determination in Antarctic krill, and evidence that krill shrink under natural conditions. S. Sun, W. de la Mare and S. Nicol (Institute of Oceanology, Academia Sinica, 7 Nanhai Rd, Qingdao, 266071, People's Republic of China), 12 pp. (English, unpublished).

Laboratory studies have shown that Antarctic krill (*Euphausia superba*) shrink if maintained in conditions of low food availability. Recent studies have also demonstrated that *E. superba* individuals may be shrinking in the field during winter. If krill shrink during winter, conclusions reached by length/frequency analysis may be unreliable. In this study, the correlation between the body length and the crystalline cone number of the compound eye was examined. Samples collected in late summer show an apparent linear relationship between crystalline cone number and body length. From a laboratory population, it appears that when krill shrink, the crystalline cone number remains relatively unchanged. If the crystalline cone number is little affected by shrinking, then this may be a more reliable

indicator of age than body length alone. The ratio of crystalline cone number to body length offers a method for detecting the effect of shrinking in natural populations of krill. On the basis of the crystalline cone number count, it appears that *E. superba* shrink during winter.

WG-Krill-94/18
Hydroacoustic survey of Antarctic krill populations in CCAMLR Division 58.4.1 during 1995/96 summer season. W. de la Mare (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia), 4 pp. (English, unpublished).

In the past, CCAMLR has used the results of hydroacoustic surveys to set precautionary limits on the krill fishery in all of the South Atlantic (Area 48) and in part of the South Indian Ocean (Division 58.4.2). Division 58.4.1 is the only area of the Southern Ocean that has been regularly fished for krill which has not been surveyed to obtain krill distribution and abundance estimates and thus there is no basis for setting a precautionary catch limit. In 1993 the CCAMLR Working Group on Krill, Scientific Committee and the Commission gave high priority to the conduct of a survey of Division 58.4.1, and the Australian Antarctic Division is planning to conduct such a survey with a joint oceanographic program in January/February 1996.

WG-Krill-94/19
Access to and use of data within CCAMLR. D.G.M. Miller, Convener WG-Krill (Sea Fisheries Research Institute, Private Bag X2, Roggebaai, South Africa), 2 pp. (English, unpublished).

WG-Krill-94/20
Suggested outline for the design and implementation of future near-synoptic krill surveys. D.G.M. Miller, Convener WG-Krill (Sea Fisheries Research Institute, Private Bag X2, Roggebaai, South Africa), 12 pp. (English, unpublished).

WG-Krill-94/21
Estimation of the biomass of krill in Prydz Bay during January/February 1991, February/March 1992 and January/February 1993 using echo integration. T. Pauly and I. Higginbottom (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia), 25 pp. (English, unpublished).

Hydroacoustic surveys of krill (*Euphausia superba*) abundance in the Prydz Bay region were undertaken in January/February 1991, February/March 1992 and January/February 1993. The surveys indicated some association of krill with the shelf break in the western part of the survey area and the centre of the Prydz Bay region, but also found that the shelf break was in general not a region of relatively high krill abundance. The mean surface density estimates of krill in 1991, 1992 and 1993 were 16.6, 10.3 and 7.7 g/m^2 respectively. These densities are large compared to estimates of 1.95, 3.45 and 1.78 g/m^2 for Statistical Subareas 48.1, 48.2 and 48.3 (SC-CAMLR 1991, p47), but small compared to the 20.2 g/m^2 estimated for January 1985 from the SIBEX-II data. The Australian SIBEX-II estimate falls in the middle of the range of densities estimated from seven surveys conducted between 1981 and 1985 (Higginbottom *et al.*, 1988). The distribution of the Sa values for the lower-biomass years 1992 and 1993 were similar and distinctly different from the higher-biomass year of 1991. The difference is characterised by the high percentage of lower *Sa* values (60%<10 m^2/n miles^2) for 1992 and 1993 compared with the relatively even distribution of medium *Sa* values (10 to 200 m^2/n miles^2) over the survey region in 1991. The extent of bias in these results due to the presence of substantial biomasses of species other than *Euphausia superba* in the survey areas (Williams *et al.*, 1983; Ikeda *et al.*, 1984, 1986; Hosie *et al.*, 1988) could not be determined.

WG-Krill-94/22
Recruitment variability of Antarctic krill (*Euphausia superba*). V. Siegel and V. Loeb (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, 22767 Hamburg, Germany), 5 pp. (English, unpublished).

Between-year variability of krill year-class success and recruitment during the period 1975 to 1994 is described, based

on data from German expeditions and US AMLR cruises to the Elephant Island area. Recruitment indices based on the relative abundance of the 1+ year class during each year indicate good recruitment for the 1980/81, 1985/86, 1987/88 and 1990/91 year classes; exceedingly poor recruitment occurred for the 1976/77, 1982/83, 1983/84, 1988/89, 1991/92 and 1992/93 year classes.

WG-Krill-94/23
Yet further krill yield computations. R.B. Thomson and D.S. Butterworth (Department of Applied Mathematics, University of Cape Town, Rondebosch 7700, South Africa), 28 pp. (English, unpublished).

Preliminary computations are carried out for the krill yield model of Butterworth *et al.* (1993), adjusted as requested by the fifth meeting of WG-Krill. This involves modifying the input distributions for the lengths at recruitment and maturity, natural mortality and the extent of recruitment variability. Sensitivity tests are carried out to assess the consequences of avoidance of gravid females by the fishery, and higher natural mortality for younger ages of krill. Results do not differ greatly from those of comparative calculations in Butterworth *et al*. (1993), except at higher harvesting intensities for which greater resource depletion is indicated. Comparatively greater depletion is also evident for males when gravid females are avoided, and if natural mortality is higher for younger ages.

WG-Krill-94/24
Further calculations of the effects of krill fishing on predators. D.S. Butterworth and R.B. Thomson (Department of Applied Mathematics, University of Cape Town, Rondebosch 7700, South Africa), 29 pp. (English, unpublished).

Earlier initial modelling attempts by the authors are extended to consider the situation where predator survival rates depend on factors other than krill biomass. This is achieved by making the survival rates depend instead on krill 'availability', where there is a random component in the relationship between krill biomass and availability. An examination of the consequences of this in the case of the black-browed albatross suggests that these other factors result in yet lesser resilience of the albatross population to the effects of a krill fishery. An approach for estimating the parameters of functional relationships between survival rates and krill biomass (or availability) is introduced. This is based on the method of moments, and is applied to a number of survival rate estimates provided by WG-CEMP members for the black-browed albatross and Antarctic fur seal. Attempts are made to estimate the levels of krill harvesting which would result in halving the sizes of various krill predator populations, and the precision and robustness to model-misspecification of the associated estimator are investigated. Results in those regards are not too encouraging. Estimates of the functional relationships for the black-browed albatross and Antarctic fur seal indicate a surprisingly low resilience of these populations to the effects of a krill fishery. Discussion is needed as to whether this reflects an inappropriate modelling approach or results from possible negative bias in estimates of survival rates from field data.

WG-Krill-94/25
Fishes incidentally caught by Japanese commercial Antarctic krill fishery in the vicinity of the South Shetland Islands during the austral summer months of 1994. T. Iwami (Laboratory of Biology, Tokyo Kasei Gakuin University, 2600 Aihara, Machida, Tokyo 194-02, Japan), 5 pp. (English, unpublished).

Observations of the abundance of by-catch fishes were made from 12 January to 18 February 1994 on board the FV *NiitakaMaru* to the north of the South Shetland Islands. A total of 77 specimens of fishes belonging to 13 species were found in 25 out of 99 krill trawl hauls. Among by-catch fishes, juvenile *Lepidonotothen larseni* was the most abundant (26 individuals) and most common (found in 11 hauls) species. Juvenile and postlarval *Chaenocephalus aceratus* (13 individuals from four hauls) and *Chaenodraco wilsoni* (10 individuals from six hauls) were also fairly abundant. To compare the abundance of each fish species, an index of its occurrence per 100 kg of krill was calculated. Fish

abundance could have been dependent on the density of krill concentrations. The large incidental catch of fishes occurred in hauls with low krill catch rates (haul Nos. 36 and 47), and fishes were not found or were scarce in hauls conducted on krill swarms of high density.

WG-Krill-94/26
Numerical model of ecosystem including *Euphausia superba* Dana as a key species in circumpolar region. M.J. Kishi and M. Naganobu (Ocean Research Institute, University of Tokyo, Minamidai 1-15-1, Nakano-ku, Tokyo 164, Japan), 4 pp. (English, unpublished).

A research plan for developing a model of the processes governing the biochemical cycle in the Southern Ocean comprises the following elements: (i) an Ocean General Circulation Model (OGCM); (ii) a one-dimensional ecosystem model that can be applied to primary production in the Southern Ocean; (iii) an ecosystem model able to describe krill ecology; (iv) a numerical model to combine the OGCM and ecosystem models; (v) the development of a numerical model which incorporates effects of marine mammal consumption and krill catch; and (vi) an integrated model of the above component models. This year an OGCM and a one-dimensional ecosystem model for the Southern Ocean have been developed. The OGCM was originally developed by the Center for Climate System Research (CCSR), University of Tokyo. The one-dimensional ecosystem model by Kawamiya *et al.* (1994) with seven component parts is combined with a one-dimensional mixed-layer model for calculating the diffusion coefficient.

WG-Krill-94/27
The plan for the 7th Antarctic research cruise by the RV *Kaiyo Maru* of the Japanese Fisheries Agency in 1994/95. M. Naganobu, T. Ichii, S. Kawaguchi, T. Ogishima and Y. Takao (National Research Institute of Far Seas Fisheries 7-1, Orido 5 Chome, Shimizu-Shi, Shizuoka, 424, Japan), 5 pp. (English, unpublished).

WG-Krill-94/28
CPUEs and body length of Antarctic krill in Japanese commercial fishery during 1992/93 season in the fishing grounds north of Livingston Island. S. Kawaguchi, T. Ichii and M. Naganobu (National Research Institute of Far Seas Fisheries, 5-7-1, Orido, Shimizu, Shizuoka 424, Japan), 15 pp. (English, unpublished).

This paper summarises Japanese commercial krill catch data pertaining to the 1992/93 austral summer season. As in previous years, the main fishing grounds were located to the north of Livingston Island. The highest values of CPUE occurred in the middle of summer (late February to late March). Krill with a modal length of 45 mm were dominant in catches, which is almost the same as in the previous season.

WG-Krill-94/29
Hydrographic flux in Statistical Area 88 of CCAMLR in the pacific sector of the Southern Ocean. M. Naganobu (National Research Institute of Far Seas Fisheries, 5-7-1, Orido, Shimizu, Shizuoka 424, Japan), 18 pp. (English, unpublished).

This document presents basic information on the hydrographic flux in Statistical Area 88 (Pacific Ocean sector), including data on the surface geostrophic current across the area and vertical distributions of geostrophic velocity and temperature along 90°W, 120°W, 170°W and 175°E.

WG-Krill-94/30
Change of sex ratio of krill (*Euphausia superba*) from austral early summer to midsummer in 1983/84 in the vicinity of Prydz Bay, Antarctica. M. Naganobu and S. Kawaguchi (National Research Institute of Far Seas Fisheries, 5-7-1, Orido, Shimizu, Shizuoka 424, Japan), 13 pp. (English, unpublished).

Changes in the distribution of Antarctic krill in the vicinity of Prydz Bay from December 1983 to January/February 1984 were analysed. The results showed notable

changes in sex ratio and the coefficient of fatness which took place from early to mid-summer. The high proportion of female krill having a high coefficient of fatness was considered to be an indicator that the study area was suitable for krill spawning. This area is characterised by (well-distinguished) shelf slope waters originating from cold winter waters.

WG-Krill-94/31
Modelling the spatial distribution of Antarctic krill (*Euphausia superba* Dana). A.W.A. Murray and D.G.M. Miller (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom) 53 pp. (English, unpublished).

Various simple probability models have been applied to describe the spatial distribution of krill (*Euphausia superba*) from acoustic data collected in the Southwest Atlantic and Indian Oceans. None of the 12 models applied provided a wholly satisfactory fit to the data. Results tend to support current thinking which interlinks krill aggregation with physical and biological processes on a number of scales. It is suggested that a two-component Weibull mixture model or a back-transformed Extreme Value approach appear to offer improvement on current efforts to simulate krill distribution. The efficacy of alternative stochastic modelling methods requires investigation.

WG-Krill-94/32
A biological acoustic survey in the marginal ice edge zone on the Bellingshausen Sea. A.W.A. Murray, J. L. Watkins and D. G. Bone. *Deep Sea Research* (in press): 29 pp. (English).

An acoustic survey at 38 and 120 kHz was carried out from RRS *Discovery* in the Bellingshausen Sea from 23 November to 7 December 1992 as part of the UK Joint Global Ocean Flux Study (JGOFS) Southern Ocean investigations (Turner and Owens, 1994). A total of 285 targets was identified and described from the chart record of the echosounder. Mean Volume Backscattering Strength data were collected using an echo integration system. These data are used to describe the spatial and temporal variability of krill (*Euphausia superba*) distribution and biomass in the marginal ice edge zone. Krill biomass density varied from a mean of 42 gm^{-2} during the first survey phase to 19.6 gm^{-2} on the second survey phase. The number of small swarms detected during the second phase was greater than during the first phase. On this first survey a large swarm (2.8 km in extent) had a potential biomass of 3.7×10^4 tonnes. Some calculations are presented to show the potential impact of krill on the flux of carbon in the area of the survey.

WG-Krill-94/33
Operation results of Ukrainian vessels at Antarctic krill fishery in Subareas 48.2 and 48.3 in March to June 1994: krill size composition. V.A. Bibik and V.N. Yakovlev (Southern Scientific Research Institute of Marine Fisheries and Oceanography (YugNIRO), 2 Sverdlov Street, Kerch 334500, Crimea Ukraine), 4 pp. (English, unpublished).

In 1994 Ukraine resumed krill fishing after a one-year hiatus in the 1992/93 season. Fishing was conducted by two vessels, BAT *Grigory Kovtun* and RKTS *General Petrov*. A scientific observer from YugNIRO was on board one of the vessels. The fishery and scientific information given in this paper is preliminary, and some clarification of data might be required after the observer returns from the cruise.

WG-Krill-94/34
A review of the Antarctic krill (*Euphausia superba* Dana) biomass in the Sodruzhestva Sea (=Prydz Bay region, Division 58.4.2). E.A. Pakhomov (Southern Ocean Group, Department of Zoology and Entomology, Rhodes University, PO Box 94, Grahamstown, 6140 South Africa), 8 pp. (English, unpublished).

In this paper the levels of Antarctic krill biomass estimated using different methods in the Indian sector of the Southern Ocean (Division 58.4.2), are reviewed. Annual estimates of krill biomass made by five countries (Australia, Japan, France, South Africa and Ukraine) from 1977 to 1992 are available in the current literature. The most comprehensive longterm estimates are available for the area south of 65°S between 60 and 80°E. Preliminary analysis of these data has shown that in this area six years variability in krill biomass may be detected,

when high levels of total krill biomass were observed during the austral summers of 1978, 1984 and 1990.

WG-Krill-94/35
Conditions for the precise measurement of fish target strength *in situ*. K. Sawada, M. Furusawa and N. J. Williamson. *Journal of Marine Acoustics, Society of Japan,* 20(2): 73-79, 1993 (English).

Conditions for the precise measurement of *in situ* fish target strength (TS) are empirically studied and two indices are proposed for this purpose. One is the number of fish in the effectivereverberation volume which contributes to the formation of an echo at a certain time, and the other is a percentage of the multiple echoes which is derived from a residual of the single echo extraction. As both indices decrease, target strength approaches a certain asymptotic value which previous studies have shown to be reliable. This shows the existence of some threshold values below which TS measurement will be reliable. The effectiveness of both indices is confirmed by a set of data obtained from one large school of fish in the eastern shelf of the Bering Sea during an inter-calibration exercise conducted by Japanese and US vessels on 15 and 16 August 1991.

Working Group for the CCAMLR Ecosystem Monitoring Program

WG-CEMP-94/4
TDR-derived foraging performance indices. J.P. Croxall (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 4 pp. (English, unpublished).

WG-CEMP-94/6
CCAMLR Ecosystem Monitoring Program Standard Methods: revision of methods for black-browed albatrosses. J.P. Croxall (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 5 pp. (English, unpublished).

WG-CEMP-94/7
CCAMLR Ecosystem Monitoring Program Standard Methods: revision of Method A4 for penguins. W.Z. Trivelpiece (Department of Biology, Montana State University, Bozeman, Mt. 59717, USA), 2 pp. (English, unpublished).

WG-CEMP-94/8
CCAMLR Ecosystem Monitoring Program Standard Methods: determination of sex of Adélie penguins. K. Kerry, J. Clarke and G. Else. *Wildl. Res.*, 20: 725-32, 1993 (English).

The suggestion that sex of Adélie penguins, *Pygoscelis adeliae*, might be assigned by observing which member of the pair (the male) takes the first long incubation shift (Anon., 1991) was examined for each of the 1990/91, 1991/92 and 1992/93 breeding seasons. There was an 8- or 9-day period when more than 90% of the incubating birds were male and a 6- or 7-day period when more than 90% of the birds were female. The dates of these peak periods of male or female presence overlapped by only two to five days between the three seasons but were constant to within two days relative to the commencement of egg laying. Peak presence of males occurred 15 to 21 days after the appearance of the first egg in the colony and peak presence of females after 33 to 36 days from this date. In all three seasons male birds could be identified with 91.8 to 98.6% accuracy within 15 to 21 days after the first sighting of an egg. The method provides, therefore, a means of identifying the sex of Adélie penguins with an accuracy greater than 90% and is applicable to whole colonies containing several hundred pairs without recourse to continuous observations or capturing the birds.

WG-CEMP-94/9 Rev. 1
Coordination of CEMP site protection within the Antarctic Treaty System. CCAMLR Secretariat, 9 pp. (English, unpublished).

WG-CEMP-94/10
Spatial structure of the Southern Ocean ecosystem: predator-prey

linkages in Southern Ocean food webs. E.J. Murphy. *Journal of Animal Ecology*, (in press): 43 pp. (English).

The food chain of the Southern Ocean has often been characterised as simple and homogeneous. However, the population processes of a key prey organism, krill (*Euphausia superba* Dana), operate over ocean basin scales and are strongly influenced by large-scale abiotic factors. A model was developed in which the local prey abundance is regulated by a continuous, hydrodynamically mediated, rate of prey intake into the area and the concentrating effects of abiotic-biotic interactions. This model was used with estimates of annual predator demands and prey concentration for the South Georgia area to investigate the relationship between flow rate and depletion in prey concentration as a function of distance from a predator colony. The model results indicate that concentrating factors need to be large to produce the build up of krill densities of the order estimated to occur in the South Georgia area, with the peak retention rates required to occur some distance offshore. It was found, however, that in order to maintain the estimated supply rates the region need not be an area of particularly high prey concentration to support the estimated predator impact. Differential predator foraging ranges produce a more complex response to the reduction in the abundance of particular predators by harvesting than in the situation where foraging ranges overlap completely. In such a system, predators which forage closer to shore encounter the greatest changes in prey abundance. Random fluctuations in the interannual prey availability were introduced into the simulation of the flow system. This can lead to apparent cycle changes in predator and prey abundance due to the interactive form of the system even though the prey population dynamics are not taken into account. The system enhances variability such that inshore foraging predators encounter greater variation in prey supply. The model results emphasise the importance of investigating the magnitude and timing of the horizontal fluxes of secondary production in this spatially distributed ecosystem.

WG-CEMP-94/11

Temporal patterns of milk production in Antarctic fur seals (*Arctocephalus gazella*). J.P.Y. Arnould and I.L. Boyd. *J. Zool., Lond*., (in press): 25 pp. (English).

The timing of milk production in Antarctic fur seals was studied at Bird Island, South Georgia. Like all lactating otariid seals (Pinnipedia: Otariidae), female Antarctic fur seals alternate between short nursing periods ashore and regular foraging trips to sea. Females do not necessarily return to the colony with full mammae, indicating that mammary volume capacity is unlikely to limit foraging trip duration. Upon arrival at the colony, milk fat (r^2 = 0.33, P <0.04) and protein (r^2 = 0.60, P <0.002) content were positively correlated to the time spent at sea. A similar trend was observed in the milk produced on land. The rate of milk energy production was much lower at sea (5.02 ± 0.5 MJ•day^{-1}) than on land (23.66 ± 4.41 MJ•day^{-1}). The rate of milk energy production during the foraging trip was negatively correlated to the time spent at sea (r^2 = 0.29, P < 0.05), whereas the rate of milk energy production on land was positively correlated (r^2 = 0.61, P < 0.001) to the duration of the preceding foraging trip. The total amount of milk energy delivered to the pup during each two-day nursing period was positively correlated (r^2 = 0.60, P < 0.002) to the duration of the previous foraging trip. The overall rate of milk energy delivery, however, was independent of foraging trip duration. This accords with Antarctic fur seal pup growth rates being unaffected by maternal foraging trip duration patterns.

WG-CEMP-94/12

Foraging behaviour of Antarctic fur seals during periods of contrasting prey abundance. I.L. Boyd, J.P.Y. Arnould, T. Barton and J.P. Croxall. *Journal of Animal Ecology*. 63: 703-713, 1994 (English).

Foraging behaviour of Antarctic fur seals rearing pups at Bird Island, South Georgia, was assessed using at-sea activity patterns measured by electronic time-depth recorders. Information was obtained for a

total of 75 individuals and 191 foraging trips to sea over five reproductive seasons from 1988/89 to 1992/93; this included one season (1990/91) of low prey abundance. A method was developed to divide the diving record up into logical units or bouts which differed from past methods used for defining bouts of behaviour. Foraging trips were significantly longer in 1990/91 than in the other years. There were significant differences between years in the proportion of time spent foraging when at sea and in the distribution of foraging through the day and night. These differences probably represent behavioural responses to changes in prey distribution and abundance and were reflected in the frequency of occurrence of different types of foraging behaviour. Four types of foraging bout were recognised using a cluster analysis. Type I (short) bouts were of short duration (17 minutes) and occurred mainly during daytime and at dusk. They probably represented exploratory behaviour. Type II (long) bouts occurred mainly at night and were of long duration (80 minutes). They increased in frequency in 1990/91 when food was scarce and 61 to 73% of time spent foraging was in these bouts. Type III (shallow) bouts occurred mainly at night, were of short duration (12 minutes) and represented feeding close to the surface, possibly in association with other, surface-feeding krill predators. Shallow bouts accounted for 8 to 14% of time spent foraging. Type IV (deep) bouts were of medium duration (19 minutes) and represented feeding at greater depth (40 to 50 m) than other bout types. They were most abundant around dawn. Mean dive duration during bouts exceeded the theoretical aerobic dive limit on >50% of occasions for short, long and deep bouts. There were positive correlations between mean dive duration and surface interval duration for most of these bout types in most years. This suggested that long dives incurred a cost in terms of the amount of time spent at the surface between dives. The study demonstrated that female fur seals invest a significantly greater effort in foraging during periods of low prey abundance by both increasing the time spent foraging and by increasing activity during foraging. This could represent a 30 to 50% increase in the costs of foraging during years of low food abundance.

WG-CEMP-94/13

The use of heart rate to estimate oxygen consumption of free-ranging black-browed albatrosses (*Diomedea melanophrys*). R.M. Bevan, A.J. Woakes, P.J. Butler and I.L. Boyd. *Phil. Trans. Roy. Soc. Lond., Ser. B.* (in press): 19 pp. (English).

Heart rates (fH) and rates of oxygen consumption (Vo_2) were measured in eight black-browed albatrosses (*Diomedea melanophrys*) when walking on a treadmill, with the aim of using fH to predict Vo_2 in free-ranging albatrosses. The resulting relationship between the variables was: Vo_2 (ml min^{-1}) = [0.0157 fH (beats min^{-1})]$^{1.60}$, r=0.80, P<0.001. In addition to the calibration procedure, six of the albatrosses were injected with doubly-labelled water (DLW), and fH and Vo_2 were monitored continuously over a three-day period while the birds were held in a respirometer. During the three-day period, the birds were walked for up to three to four hours day^{-1} in bouts lasting approximately 0.5 hours. The heart rate data were used to estimate the metabolic rates of these birds using the above regression. Estimates of metabolic rate derived from fH, DLW and respirometry did not differ (ANOVA; P=0.94), primarily because of the variance between individual birds. There was also no significant difference between the different estimates obtained from the different equations used to calculate energy expenditure from the DLW technique (ANOVA; P=0.95). Mean estimates of Vo_2 from fH under active and inactive conditions differed from measured values of Vo_2 by -5.9% and -1.7% respectively. In addition, the estimates of Vo_2 from fH at different walking speeds did not differ significantly from the measured values. It appears that, in the black-browed albatross, fH is as good a predictor of the mean metabolic rate of free-ranging birds as DLW or time-energy budgets combined with either respirometry or DLW. However, the method should be applied to as many individuals and as many instances of a

particular behaviour as possible. The heart rate technique offers potential for much more detailed analyses of the daily energy budgets of these birds, and over much longer periods, than has previously been possible.

WG-CEMP-94/14
The food and feeding ecology of the white-chinned petrel (*Procellaria aequinoctialis*) at South Georgia. J.P. Croxall, A.J. Hall, H.J. Hill, A.W. North and P.G. Rodhouse. *J. Zool., Lond.*, (in press): 44 pp. (English).

The diet of the white-chinned petrel at Bird Island, South Georgia, was studied during the chick-rearing period in 1986 by quantitative analysis (by weight, frequency of occurrence and number of individuals) of regurgitated or lavaged adult stomach contents. Antarctic krill was the most important constituent of the diet, comprising over 90% of prey items and forming 47% of the diet by weight; fish and squid occurred in 67% and 35% of samples and formed 33% and 19%, respectively, of the diet by weight. Decapods, amphipods and salps occurred in a few samples. The fish were mainly lanternfish (Myctophidae) of eight species (chiefly of the genera *Electrona* and *Gymnoscopelus*), forming 80% by numbers and 52% by mass of fish prey, and the notothenioid *Patagonotothen guntheri* (14% by number and 35% by mass). Of the squid species taken, the ommastrephid *Martialiahyadesi* comprised 57% by number and 52% by mass, and the gonatid *Gonatus antarcticus* 14% by number and 42% by mass. These dietary data confirm white-chinned petrel as the most important avian consumer of fish and squid at South Georgia (and the third most important consumer of krill). In 1986 the notothenioid fish were probably obtained via commercial fishing operations, but the myctophids and squid were probably live-caught, most likely at night. Meal size increased rapidly until chicks were three weeks old and then remained constant until the chicks were within 10 days of fledging, when it decreased. Meal delivery rate was high (one per day) for young chicks (1 to 10 days old) and thereafter fluctuated between 0.56 and 0.88 meals per day until close to fledging, when it was halved. These provisioning rates, and the proportion of krill in the diet, are higher than those recorded previously at South Georgia and Indian Ocean sites, probably reflecting high local availability of krill at South Georgia in 1986. In many respects white-chinned petrels at South Georgia are intermediate ecologically between prions and albatrosses, although specialised in their extensive consumption of myctophids. Because krill and all their main fish prey are currently the targets of substantial commercial fishing and the main squid prey (*Martialia*) is a potential fisheries target, the role and status of white-chinned petrels is of additional importance.

WG-CEMP-94/15
Interannual variation in the breeding biology of the Antarctic prion (*Pachyptila desolata*) at Bird Island, South Georgia. G.M. Liddle. *J. Zool., Lond*., 234: 125-139, 1994 (English).

Interannual variation in aspects of the breeding biology of Antarctic prions was studied for three summers (1989 to 1992) at Bird Island, South Georgia. Egg size and mass and incubation period remained constant. Laying, hatching and fledging were significantly delayed and less synchronous in 1991/92 (the range of laying dates was 51 days compared to 10 to 15 days in the two other seasons). This was due to an unusually cold and protracted winter, with ice blocking burrows into the spring, restricting the availability of nest sites. Brooding lasted longer in 1991/92, but the overall fledging period was unchanged. Skeletal growth rates did not vary amongst years; growth in mass was slower in 1989/90 but fledging mass was similar in all three years. In 1989/90 and 1991/92 later-hatched chicks grew (in mass) faster. The survival of chicks from hatching to fledging did not vary amongst years or with hatching date. Feeding frequency was similar between years, once allowance had been made for starlit nights. Thus late and asynchronous breeding in 1991/92 did not result in reduced breeding success, either through predation or starvation. Crustaceans formed 98 to 99% of the mass of the identifiable portion of regurgitated food samples. Significant annual variation was found within these crustaceans, with the presence of krill (least

in 1990/91) being inversely related to that of amphipods and copepods. There was no relationship between diet composition and chick growth or survival. Other species, lacking the morphological specialisation for feeding on copepods and amphipods, had very low breeding success in 1990/91, when krill was scarce.

WG-CEMP-94/16 Rev. 1
CEMP indices and trends. CCAMLR Secretariat, 28 pp. (English, unpublished).

Indices of predator reproductive status are calculated for CEMP parameters such as adult weight on arrival at breeding colony, duration of foraging trips, breeding population size and success, chick weight and diet, and fur seal pup growth rates (Methods A1 to A9, B1 and B2 and C1 and C2) using data held at the CCAMLR Data Centre. Preliminary statistical and graphical analyses of the trends shown by indices are presented. Information on the ice-cover within CEMP study regions is also provided (Method F2).

WG-CEMP-94/17
Data on crabeater seal reproduction and demography: modelling functional relationships in the Antarctic marine ecosystem. J.L. Bengtson and P.L. Boveng (National Marine Mammal Laboratory, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, Wa. 98115, USA), 3 pp. (English, unpublished).

WG-CEMP-94/18
Compilation of information concerning the at-sea behaviour of marine mammals and birds and the prospects for a workshop on TDR-related data. P.L. Boveng (National Marine Mammal Laboratory, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, Wa. 98115, USA), 8 pp. (English, unpublished).

WG-CEMP-94/19
Variability in diving behaviour of Antarctic fur seals: implications for TDR studies. P.L. Boveng, B.G. Walker and J.L. Bengtson (National Marine Mammal Laboratory, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, Wa. 98115, USA), 4 pp. (English, unpublished).

WG-CEMP-94/21
Annual variation in fledging size and breeding success of cape petrels at Seal Island, Antarctica. M.K. Schwartz and J.L. Bengtson (National Marine Mammal Laboratory, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, Wa. 98115, USA), 5 pp. (English, unpublished).

Cape petrels (*Daption capensis*) are widely distributed, abundant Antarctic procellariids which utilise near-surface, marine prey. This species has been selected for inclusion in the CCAMLR Ecosystem Monitoring Program (CEMP), which seeks to detect and quantify various aspects of ecological change in selected components of the Antarctic marine ecosystem. Information about the relationship between the growth and reproductive performance of cape petrels and its prey availability would provide a useful complement to similar information on penguins, which utilise prey over a range of depths and, being solely reliant upon their swimming ability, must forage near breeding colonies. To evaluate the potential utility of incorporating cape petrel studies into the longterm CEMP monitoring and directed research being conducted at Seal Island, Antarctica (60°59'S 55°23'W), a low-intensity effort to collect relevant cape petrel data was initiated during the 1989/90 austral summer. The main objectives of this effort were to assess the feasibility of collecting data on parameters of growth and reproduction, and to determine the interannual variability of these parameters.

WG-CEMP-94/22
Effects of time-depth recorders on foraging behaviour of lactating Antarctic fur seals. B.G. Walker and P.L. Boveng (National Marine Mammal Laboratory, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, Wa. 98115, USA), 16 pp. (English, unpublished).

The use of microprocessor-controlled time-depth recorders (TDRs) or similar instruments has become widespread in studies of the diving behaviour and

foraging energetics of marine mammals (e.g., LeBoeuf *et al.*, 1989; Goebel *et al.*, 1990; Hindell *et al*., 1991; Boyd and Croxall 1992; Boness *et al.*, 1994), birds (e.g., Croxall *et al*., 1991; Kooyman *et al.*, 1992; Williams *et al*., 1992; Bengtson *et al.*, 1993), and turtles (e.g., Eckert *et al.*, 1989; Sakamoto *et al*., 1990; Sakamoto *et al.*, 1993). To ensure that data obtained by TDRs are accurate, it is important to assess changes in swimming and diving behaviour and foraging characteristics that may be caused by encumbering study animals with these instruments. A few studies have focused on the effects of attaching TDRs and other research devices to diving birds (Wilson *et al.*, 1986; Wanless *et al.*, 1988; Croll *et al*., 1991). A specialised conference addressing this issue was recently convened (Fraser and Trivelpiece, 1994). However, to our knowledge, no studies of reptiles and only one pertaining to mammals (Boyd *et al.*, 1991) have been reported regarding the effects of instrument attachment. A number of characteristics make Antarctic fur seals (*Arctocephalus gazella*) ideal subjects to use in examining the effects of instrument attachment. First, the general size of *A. gazella* females falls in between that of smaller seabirds (e.g., Adélie (*Pygoscelis adeliae*), chinstrap (*Pygoscelis antarctica*), gentoo (*Pygoscelis papua*), king (*Aptenodytes patagonica*) and emperor (*Aptenodytes forsteri*) penguins) and the larger pinniped species (e.g., grey (*Halichoerus grypus*), Weddell (*Leptonychotes weddellii*) and elephant (*Mirounga* sp.) seals), for which a large number of instrument studies have been conducted. Second, the repeated foraging-nursing strategy of otariid seals during the lactation period (Oftedal *et al.*, 1987; Costa, 1991) provides a short unit of comparison (i.e., one or a group of feeding trips as compared to, say, the long feeding trips that elephant seals or gray seals take between parturition and molt). Finally, the site fidelity of females during nursing provides a high probability of instrument return and retrieval. In this study, we evaluate differences in the duration of foraging trips at sea and nursing visits ashore between lactating Antarctic fur seals carrying either a TDR and radio transmitter (TDR + TX) or a radio transmitter only (TX-only).

WG-CEMP-94/23

Delayed laying and prolonged fasting in Adélie penguins (*Pygoscelis adeliae*). J. Ulbricht and D. Zippel. *Polar Biol.*, 14: 215-217, 1994 (English).

Observations of nesting Adélie penguins (*Pygoscelis adeliae*) were made at Ardley Island during spring 1990 when snow cover was unusually thick at some subcolony sites. Adélie penguins at these sites had to delay egg laying until the snow melted. Maximum length of fasting periods, comprising pre-breeding and incubation, was 50 days. Long fasting seemed to have no detrimental effect on breeding. Furthermore, there was no relationship between penguin arrival mass and duration of fast. Even birds with small mass had sufficient reserves to undergo long fasting periods. In spring 1990, when we started with a monitoring study for CEMP (CCAMLR, 1990) at Ardley Island, there were still high quantities of snow at the subcolony sites. Adélie penguins at Ardley Island inhabit both small rocky outcrops and flat, stony hillocks (storm bars). The latter had a distinctly thicker snow cover at this time so that the pebbles necessary for nest building were unattainable. Consequently, we observed the behaviour of the penguins in this situation and recorded the laying dates and lengths of fasting periods.

WG-CEMP-94/24

A generalised discriminant for sexing fulmarine petrels from external measurements. J.A. van Franeker and C.J.F. ter Braak. *The Auk.*, 110 (3): 492-502, 1993 (English).

Discriminant analysis can use morphometric differences between known male and female birds to predict the sex of unknown individuals in field studies. Geographic variation in birds morphometric measurements often limits the predictive value of a discriminant function to the population from which it was derived. Specific discriminant functions for populations of five species of fulmarine petrels (Northern fulmar, *Fulmarus glacialis*; Southern fulmar, *F. glacialoides*; Antarctic petrel, *Thalassoica antarctica*; Cape petrel, *Daption capense*; and snow petrel, *Pagodroma nivea*) assigned 81 to

98% of birds in the samples to the correct sex, but the validity of each discriminant applied to alternative populations remained questionable. Our approach to overcome this limitation is to combine data from the different species into a single discriminant. Adequate performance of this generalised discriminant in samples of different species shows its validity for use in other populations of any of these species. The generalised function calculates the discriminant scores for individual fulmarine petrels as: Y = HL + 2.38 BD + 0.41 TL - 0.21 CL, where HL is head length, BD is bill depth, TL is tarsus length and CL is bill length (measurements in millimetres). The cut point to split sexes is different in each sample and may be calculated directly from discriminant scores, without reference to sexed birds, by using a maximum-likelihood method. Depending on species, the generalised method results in 84 to 97% correct classifications and can be applied to other populations of fulmarine petrels without requiring samples of birds of known sex.

WG-CEMP-94/25

Sexing chinstrap penguins (*Pygoscelis antarctica*) by morphological measurements. J. Amat, J. Viñuela and M. Ferrer. *Colonial Waterbirds*, 16 (2): 213-215, 1993 (English).

We applied discriminant analysis to morphometric data from chinstrap penguins (*Pygoscelis antarctica*) to obtain a function that can be used to predict sex. The function correctly classified 95% of 55 individuals. Bill depth was the most important discriminating variable, with males having deeper bills.

WG-CEMP-94/26

The diet of shags (*Phalacrocorax aristotelis*) during the chick-rearing period assessed by three methods. M. Harris and S. Wanless. *Bird Study*, 40: 135-139, 1993 (English).

This paper describes a study of the diet of shags using regurgitations by chicks, stomach contents and pellets collected concurrently. Sand eels predominated in all collections. Non- and failed breeders took a wider food spectrum than did chicks. Although adults fed their chicks almost entirely on sand eels, they themselves ate some fish from other fish families and probably digested these before they returned to the colony. Pellets are easy to collect and are useful to detect gross changes in the diet of full-grown, but possibly non-breeding, shags between years or colonies. Otoliths recovered from pellets cannot be used for age determination or back-calculations of size of sand eels eaten by shags. Regurgitations can be used to describe the diet of chicks. There is no easy way to determine the diet of adults feeding chicks.

WG-CEMP-94/27

Monitoring Antarctic environmental variables using penguins. R. Wilson, B. Culik, R. Bannasch and J. Lage. *Mar. Ecol. Prog. Ser.*, 106: 199-202, 1994 (English).

Water temperature and krill abundance in Maxwell Bay, Antarctica, were examined using Pygoscelid penguins carrying appropriate sensors linked to position-determining devices. Fifty-three foraging trips by 49 penguins indicated that during December 1991 and January 1992 the temperature in the top 100 m of the water column was highest in the western section of the bay, which concurred with higher krill abundance as determined by a catch-per-unit-effort index. This work demonstrates that abiotic and biotic features of the environment can be studied using animals to transport probes to the study site, provided information is given on the position of the animals when measurements are made.

WG-CEMP-94/28

Synthesis of CEMP activities carried out at Cape Shirreff. D. Torres (Jefe Departamento Planes, Instituto Antártico Chileno, Luis Thayer Ojeda 814, Correo 9, Santiago, Chile), 4 pp. (English, unpublished).

During the 1993/94 Antarctic season a census of Antarctic fur seals was carried out over the whole area of SSSI No. 32 and the Cape Shirreff CEMP site: 15 139 animals were recorded, i.e. an increase of 14.3% on 1992/93 numbers. Only two sets of data on pup growth, using Standard Method C2, were obtained, for both (n = 48) male and females, on 15 December 1993 and

22 January 1994. Average weights for males were 7.2 kg and 10.62 kg, and for females 6.70 and 9.73 on those respective dates. Foraging trips made by females were observed, and environmental data recorded. Additional censuses of post-breeding elephant seals (1 375) and Weddell seals (75) were carried out. Nearly all marine debris (280 kg) along the shoreline of Cape Shirreff (13 986.5 m) was removed. Three fur seals (peripheral males) were sighted with neck collars. A draft bathymetric chart (SHOA No. 14.301, scale 1:15 000) of the waters around the CEMP site was produced to provide background information for this research.

WG-CEMP-94/29
Preliminary results of a feeding trial on the blue-eyed shag (*Phalacrocorax atriceps*). R. Casaux, M. Favero, E. Barrera-Oro and P. Silva (Dirección Nacional del Antártico, Cerrito 1248, 1010 Buenos Aires, Argentina), 14 pp. (English, unpublished).

Local fish species were fed to a captive blue-eyed shag *Phalacrocorax atriceps bransfieldensis* during 45 days of the austral summer at Jubany Station, King George Island, South Shetland Islands. The otoliths of fish identified in pellets were affected by the digestive process and, consequently for this reason the fish species were differentially under-represented in number and size (length/mass). Except for *Gobionotothen gibberifrons*, *Nototheniops nudifrons*, and, to some extent, for *G. gibberifrons* the numbers of all species were underestimated. *N. rossii*, *Pagothenia bernachii*, *N. nudifrons*, *Trematomus newnesi* and *Notothenia coriiceps* were largely underestimated. Preliminary correction factors were obtained to improve the accuracy of weight estimations of fish ingested, calculated by means of equations based on otolith lengths. The shag produced a total of 16 pellets, with a frequency of one every 2.5 days. It willingly ingested a mean ration equivalent to 31% of its mass, which is a higher energy requirement than that observed in experiments on other non-Antarctic shag species. Algae and polychaetes were found in casts and fish stomachs. Therefore, their importance in the diet of the blue-eyed shag may have been overestimated in previous studies.

WG-CEMP-94/30
Progress report on AMLR project 'A modelling study of the population biology of krill, seabirds and marine mammals in the Southern Ocean'. M. Mangel, A. Stansfield and S. Rumsey (Section of Evolution and Ecology, University of California, Davis Ca. 95616), 9 pp. (English, unpublished).

WG-CEMP-94/31
Analysis of the stomach content in the blue-eyed shag (*Phalacrocorax atriceps bransfieldensis*) at Nelson Island, South Shetland Islands. N. Coria, R. Casaux, M. Favero and P. Silva (Dirección Nacional del Antártico, Cerrito 1248, 1010 Buenos Aires, Argentina), 16 pp. (English, unpublished).

The stomach contents of 40 blue-eyed shags (*Phalacrocorax atriceps bransfieldensis*) were sampled at Nelson Island, South Shetland Islands, in January 1994. The analysis of the diet showed that fish were by far the main component, followed by octopods, polychaetes and gammarids. *Notothenia coriiceps* predominated by frequency (58%) and weight (65%), whereas *Nototheniops nudifrons* was the most important by number (47%). A comparison with published data on pellet analysis of shags from the same colony gave similar results. However, although the methodology used in the present study requires more time in the field, it reduces errors caused by factors confounding the examination of regurgitated casts, such as erosion by digestion or otolith loss through the gastrointestinal tract. The analysis of stomach contents is complemented with information obtained from film footages of shags' foraging trips.

WG-CEMP-94/32
Fish as diet of the blue-eyed shag (*Phalacrocorax atriceps bransfieldensis*) at Half-moon Island, South Shetland Islands. E. Barrera-Oro and R. Casaux (Dirección Nacional del Antártico, Cerrito 1248, 1010 Buenos Aires, Argentina), 15 pp. (English, unpublished).

Thirty eight regurgitated casts collected in a colony at Half-moon Island, South Shetland Islands, during January and February 1993, were analysed to determine the importance of fish in the diet of the blue-eyed shag, *Phalacrocorax atriceps bransfieldensis*. Fish species were identified by means of otoliths found in the casts. The size and weight of the fish were estimated from the otolith lengths, using equations derived from data on local populations. Fish remains were present in all casts and comprised 91% of prey items. In the 937 otoliths found, 562 individual fish were present and 524 of these were assigned to five demersal benthic species: *Nototheniops nudifrons*, *Harpagifer antarcticus*, *Trematomus newnesi*, *Notothenia coriiceps* and *Gobionotothen gibberifrons*. *N. nudifrons* was the most frequent (68.4%) and important by number (37.9%), whereas *N. coriiceps* prevailed according to mass (35.8%). With the exception of *G. gibberifrons*, the fish species (and their size and age ranges) were identical to those found in a similar study at Duthoit Point, Nelson Island. However, the relative importance of the various fish species in the diet differed among shags from the two areas.

WG-CEMP-94/33
Adélie penguins as consumers of fish and zooplankton communities. K. Kerry, J. Clarke, S. Brown, R. Lawless and K. Young (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia), 10 pp. (English, unpublished).

WG-CEMP-94/34
Infectious diseases and parasites of Antarctic and sub-Antarctic penguins and the implications for CEMP. J. Clarke and K. Kerry (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 14 pp. (English, unpublished).

This paper draws attention to the possible implications for the CCAMLR Ecosystem Monitoring Program (CEMP) of infectious and parasitic disease among penguins being monitored. A summary of all such diseases of penguin species found in the Antarctic and sub-Antarctic is presented. Haematological and biochemical values for healthy penguins, which may be of use in diagnosis, are presented also. Just as environmental factors are being examined for their possible effect on the variables being monitored, we suggest that the health of monitored species should also be considered in CEMP.

WG-CEMP-94/35
Diseases and parasites of penguins. J. Clarke and K. Kerry. *Korean Journal of Polar Research*, 4 (2): 79-96, 1993 (English).

The study of diseases in wild penguins is important for the identification of endemic diseases and the detection of exotic diseases should these occur. It is also important in the understanding of the degree to which disease may be expected to influence the results of biological studies. Results may be confounded and interpretation made difficult by both the transient and longterm presence of disease, particularly if it is at the sub-clinical level. We present here a compilation of diseases and parasites recorded for all species of penguins both in the wild and in captivity. Normal values for blood biochemistry and haematology are given as an aid to the identification of illness in penguins.

WG-CEMP-94/36
Diving behaviour of chinstrap penguins at King George Island. H.-C. Shin and S. Kim (Polar Research Center, Korea Ocean Research and Development Institute, Ansan PO Box 29, Seoul, Republic of Korea), 12 pp. (English, unpublished).

The diving behaviour of three chick-rearing adult chinstrap penguins (*Pygoscelis antarctica*) was studied at King George Island, Antarctica in January 1994. Foraging dives by chinstrap penguins were made most frequently at depths of 5 to 10 m and were usually less than 40 m deep. Dive duration distribution was between 20 and 120 seconds and only a small number of foraging dives were longer than 120 seconds. Diving effort was concentrated around midnight, with a slight peak observed around noon and infrequent dives occurring in the morning. Average dive depth was approximately 20 to 30 m around midnight and 40 to 50 m around noon. Diurnal changes in the diving pattern

of chinstrap penguins may be related to the diurnal migration of their prey, Antarctic krill.

WG-CEMP-94/37
AMLR 1993/94 field season report: Objectives, accomplishments and tentative conclusions. *Administrative Report LJ-94-13,* Southwest Fisheries Science Center, Ja Jolla, Ca., USA, 1994, 117 pp. (English).

WG-CEMP-94/38
TDR-derived foraging performance indices. W.Z. Trivelpiece and S.G. Trivelpiece (Department of Biology, Montana State University, Bozeman, Mt. 59717, USA), 1 pp. (English, unpublished).

WG-CEMP-94/39
Seabird research at Svarthamaren, Dronning Maud Land. N. Røv (Norwegian Institute for Nature Research, Tungasletta 2, N-7005 Trondheim, Norway), 6 pp. (English, unpublished).

WG-CEMP-94/40
Recommendations from the workshop on researcher-seabird interactions for consideration for inclusion in the WG-CEMP Standard Methods. W.Z. Trivelpiece (Department of Biology, Montana State University, Bozeman, Mt. 59717, USA), 4 pp. (English, unpublished).

WG-CEMP-94/41
Sex determination of Antarctic petrels (*Thalassoica antarctica*) by discriminant analysis of morphometric characters. S.-H. Lorentsen and N. Røv. *Polar Biol.*, 14: 143-145, 1994 (English).

We present data on sexual dimorphism in some morphological measurements (wing length, head length, bill depth and bill length) in the Antarctic petrel, *Thalassoicaantarctica*. Males were on average larger than females for all measurements. Sexual dimorphism was on average largest for bill depths, whereas wing lengths discriminated least between the sexes. A discriminant function including bill depth, head length and wing length correctly sexed 92% of the sample. Due to between-measurer variation, it is recommended that morphometric measurements obtained by others on sexed birds are compared with ours before proceeding with the use of the discriminant function on unsexed individuals.

Joint Meeting of WG-Krill and WG-CEMP

WG-Joint-94/4
Further development of a krill fishery simulation model. D.J. Agnew (CCAMLR Data Manager, 25 Old Wharf, Hobart, Tasmania 7000, Australia), 4 pp. (English, unpublished).

The krill fishery model presented in 1993 (WG-Krill-93/14) is refined and applied to both Japanese and Chilean krill-fishing fleets in Subarea 48.1. A stochastic element is introduced to account for variability in catch rates. The most successful management regime is found to be one which limits fishing within 75 km of breeding penguins during January and February. For this regime, the model predicts a 90% reduction in overlap with foraging predators and a 15 to 20% reduction in catch. Closure of Livingston Island for the breeding period resulted in a 60% reduction in overlap with predators and a 0 to 15% reduction in catches.

WG-Joint-94/5
Modelling functional relationships between predators and prey. J.P. Croxall, I.L. Boyd and P.A. Prince (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 9 pp. (English, unpublished).

Preliminary analyses of this topic identified some problems with the data originally submitted. To clarify these problems and to provide additional data to make the overall model more accurate and relevant, this paper provides quantitative information on potential biases associated with the estimation of survival rate, observed rates of population increase (both maxima and by study colonies from which the data derived) and diet for black-browed albatross, gentoo penguin and Antarctic fur

seal at Bird Island, South Georgia. In addition, the paper presents year-specific data for (i) black-browed albatross breeding population size and success and adult survival (1976 to 1992); (ii) gentoo penguin breeding population size and success (1977 to 1993); and (iii) Antarctic fur seal adult female survival (1984 to 1993, including allowance for tag loss), pregnancy rate, pup production, pup growth rates and mortality rates and foraging trip duration (1984 to 1993).

WG-Joint-94/6
Modelling functional relationships between predators and prey. W.Z. Trivelpiece and S.G. Trivelpiece (Department of Biology, Montana State University, Bozeman, Mt. 59717, USA), 6 pp. (English, unpublished).

WG-Joint-94/7
Diagnostic model of functioning of Antarctic krill population in the Sodruzhestva Sea. V. Belyaev, M. Khudoshina, V.N. Yakovlev, V.A. Bibik and E.A. Pakhomov (Scientific Centre of Problems in Ecological Modelling, Ukrainian Academy of Science, Crimea, Ukraine), 2 pp. (English, unpublished).

This paper describes several approaches to the mathematical modelling of Antarctic krill populations in the Sodruzhestva Sea. The area was chosen because YugNIRO has been conducting longterm observations there on krill biology and biomass and other components of the local pelagic ecosystem, and also because of the availability of catch data from 1978 to 1984 and 1988. The objective of the study was to reveal by means of mathematical modelling the causes of sharp fluctuations in krill abundance in the Sodruzhestva Sea. The main task was to assess variations in parameters of the ecosystem and its stability against the impact of such variations. The potential for developing a prognostic model describing the functioning of Antarctic krill population is discussed.

WG-Joint-94/8
Development of a fine-scale model of land-based predator foraging demands in the Antarctic. D.J. Agnew and G. Phegan (CCAMLR Secretariat, 25 Old Wharf, Hobart, Tasmania 7000, Australia). *CCAMLR Science*, (in press): 8 pp. (English).

CCAMLR has been using the total catch of krill taken within 100 km of penguin colonies during their breeding season (December to March) as an indicator of the overlap between the foraging areas of penguins and the distribution of the krill fishery in Subarea 48.1 (South Shetland Islands). As this indicator of the overlap of predators and the fishery is unsuitable for a number of reasons, an alternative method of calculating an indicator of fishery-predator interaction has been developed. The new indicator reflects the functional interaction between these two utilisers of the krill resource and is based on a detailed model of the foraging patterns of the penguins combined with catch positions. This analysis shows that the overlap between the fishery and chinstraps is much greater than for other penguins, and that this overlap has been decreasing since 1988.

WG-Joint-94/9
Distribution and abundance of Antarctic krill in the vicinity of Elephant Island during the 1994 austral summer. R.P. Hewitt and D.A. Demer (Southwest Fisheries Science Center, La Jolla, Ca. 92038, USA), 15 pp. (English, unpublished).

The distribution and abundance of Antarctic krill (*Euphausia superba*) were estimated from four acoustic surveys conducted in the vicinity of Elephant Island, Antarctica, from mid-January to mid-March 1994. The first and fourth surveys covered approximately 15 000 n miles^2 around Elephant Island and the eastern end of King George Island; the second and third surveys covered approximately 2 100 n miles^2 immediately north of Elephant Island. During the first survey, the highest densities of krill were mapped north of King George Island and over a broad band northwest of Elephant Island. For a portion of the survey area around Elephant Island (approximately 12 000 n miles^2), biomass was estimated to be 401 x 10^6 tonnes. Five weeks later highest densities of krill were mapped north of Elephant Island and biomass in the same survey portion was estimated to be 359 x 10^6 tonnes. During the second and third surveys, high densities

of krill were mapped in the shoal waters to the north of Elephant Island; biomasses were estimated to be 87 x 10^6 tonnes and 97 x 10^6 tonnes respectively. Average krill densities were the lowest observed during the last five years of AMLR surveys in the Elephant Island study area and one-fifth of the average density for the period 1990 to 1992. In spite of the low krill densities, the reproductive success of land-breeding predators did not appear to be adversely affected.

WG-Joint-94/10
Antarctic neritic krill *Euphausia chrystallorophias*: spatio-temporal distribution, growth and grazing rates. E.A. Pakhomov and R. Perissinotto (Southern Scientific Research Institute of Marine Fisheries and Oceanography (YugNIRO), 2 Sverdlov Street, Kerch 334500, Crimea Ukraine), 11 pp. (English, unpublished).

Dynamics of distribution, growth, life-span and feeding were studied in the endemic Antarctic euphausiid *Euphausia chrystallorophias* in the central part of the Indian sector of the Southern Ocean during the austral summer (1977 to 1990), and in the Lazarev Sea during the summer of 1990/91. Both larvae and adult *E. chrystallorophias* were found in abundance in shelf waters 100 to 500 m deep. Maximum abundances of larvae (up to 7 688 ind/m^{-2}) and adults (up to 1 267 ind/m^{-2}) were found in the Prydz Bay region. Size frequency analysis indicated that the generation time was ≈ three years in the Indian sector of the Southern Ocean. Total life span of *E. chrystallorophias* may exceed five years in the Prydz Bay region and four years in the Kosmonavtov Sea. Analysis of size distribution by sex showed that male *E. chrystallorophias* had a shorter life-span than females, although their growth rates were similar. Assuming growth for only 180 days per year, mean growth rates ranged from 0.070 to 0.075 to 0.019 to 0.022 mm per day during the first and the fourth year respectively. Von Bertalanffy growth curves calculated for different areas were similar to those obtained by Siegel (1987) for the Antarctic Peninsula region. In Prydz Bay and the Kosmonavtov Sea, spawning of *E. chrystallorophias* appears to peak from the end of November to early December and may extend to the beginning of January. Most larvae were in the stage of metanauplius/calyptopis I at the beginning of January, and calyptopis III/furcilia I during February. The year-1 cohort was identified in January-February with a mean length in the range of 10.8 to 16.8 mm. *In situ* feeding rates were estimated in the Lazarev Sea using the gut fluorescence method. Ingestion rates during austral summer 1990/91 ranged from 52 to 471 ng (pigm) ind/$^{-1}h^{-1}$ in adults and from 2.5 to 25.2 ng (pigm) ind/$^{-1}h^{-1}$ in calyptopis III larvae. Total population impact on the phytoplankton biomass varied between 160 to 2 860 and 215 to 652 µ g (C) $m^{-2}d^{-1}$ for adults and larvae respectively. This is equivalent to 0.06 to 1.12% and 0.02 to 0.07% of total daily primary production. In areas with dense *E. chrystallorophias* swarms, however, daily consumption rates may attain levels as high as 13.6 to 96.5% of daily primary production. The longterm monitoring of different populations of *E. chrystallorophias* allowed the identification of covariance patterns between abundance and spawning success of this species and the formation of coastal polynyas, especially in the Prydz Bay region.

WG-Joint-94/11
Gentoo penguin (*Pygoscelis papua*) diet as an indicator of planktonic availability in the Kerguelen Islands. C.A. Bost, P. Koubbi, F. Genevois, L. Ruchon and V. Ridoux *Polar Biol.*, 14: 147-153, 1994 (English).

Since penguins rely on the main planktonic resources of the Southern Ocean, knowledge of penguin diet may be used for monitoring these resources. During the winter and spring of 1987 and 1989, we investigated the composition of the diet of gentoo penguins, *Pygoscelis papua*, in relation to changes in the availability of two prey species, *Euphausia vallentini* and *Themisto gaudichaudii*, sampled during plankton surveys in the Kerguelen Islands. The results of plankton surveys and diet analysis were compared for samples taken 2 to 4 km from the studied colonies. Data on the abundance of zooplankton derived from penguins' diet

matched closely those obtained from net hauls during a year of high plankton availability (1987). On the other hand, a weaker correspondence was found during a year of restricted availability (1989). The mean sizes of amphipods taken by penguins and caught in net hauls were very similar, but the size distribution showed comparatively fewer small and large individuals in net-hauls than in penguin stomachs. Detailed studies on the feeding range and foraging effort of penguins are therefore needed in the near future to validate the potential of penguin diet as a measure of plankton abundance.

WG-Joint-94/12
Acoustic visualisation of the three-dimensional prey field of foraging chinstrap penguins. J.E. Zamon, C.H. Greene, E. Meir, D.A. Demer, R.P. Hewitt and S. Sexton (Department of Ecology and Evolutionary Biology, University of California - Irvine, Irvine Ca. 92717, USA), 25 pp. (English, unpublished).

Predator-prey interactions play an important role in determining the dynamics of pelagic ecosystems. Human intervention in such interactions may have effects that cascade throughout these ecosystems. Recently, concerns have arisen due to the commercial harvesting of *Euphausia superba*, the Antarctic krill, a keystone prey species in the Southern Ocean food web. It has been difficult to evaluate these concerns because of problems associated with determining the availability of krill to its natural predators. In this paper we report a novel method for assessing prey availability to an important krill predator, *Pygoscelis antarctica*, the chinstrap penguin. Acoustic techniques were used to analyse the three-dimensional distribution of krill within a 1 852 x 1 852 x 100 m volume of ocean. Our study revealed the presence of at least six distinct krill aggregations and substantial vertical and horizontal patchiness at scales of tens to hundreds of metres. Monte Carlo simulations revealed significant spatial concordance between the surface distribution of penguins and krill distributed in the 30 to 40 m depth layer; no spatial concordance was detected in shallower layers. We conclude that fine-scale, depth-dependent patterns of krill patchiness must be incorporated into analyses of krill availability to predator populations if we are to predict predator responses to a changing food environment.

WG-Joint-94/13
Birds as indicators of change in marine prey stocks. W.A. Montevecchi. *Birds as Monitors of Environmental Change*. Chapman and Hall, London: 217-266, 1993 (English).

WG-Joint-94/14
Draft report of the study ground on seabird/fish interactions. Copenhagen, 6-10 September 1993, 22 pp. (English).

WG-Joint-94/15
Estimated food consumption by penguins at the Prince Edward Islands. N.J. Adams, C. Moloney and R. Navarro. *Antarctic Science*, 5 (3): 245-252, 1993 (English).

The consumption of food by the four species of penguins breeding at the Prince Edward Islands is assessed on annual and seasonal bases. Total annual food consumption was estimated at 880 000 tonnes, of which king penguins accounted for 74%, macaroni penguins 21%, rockhopper penguins 5% and gentoo penguins <1%. Pelagic fish, almost entirely myctophids, were the most important prey (70% of total prey biomass), followed by pelagic crustaceans (18%) and cephalopods (11%). Demersal fish and benthic crustaceans accounted for <1% of total consumption, being consumed only by gentoo penguins. Peak demands of between 2 and 3.3 x 10^6 kg day^{-1} occurred from October to December when three of the four species, including the two demi-populations of king penguins, were breeding. Food demand decreased to 1.2 x 10^6 kg day^{-1} during winter, when only king and gentoo penguins were present. Much of the prey are presumably captured within 300 km of the islands. Assuming an even distribution of foraging effort within their respective foraging ranges, rates of food transferred to penguins in November from 4.1 x 10^{-3} $gm^{-2}day^{-1}$ for macaroni penguins to 1.24 x 10^{-2} $gm^{-2}day^{-1}$ for king penguins. In mid-July, transfer rates to king and gentoo

penguins were 3.9 x 10^{-3} gm^{-2} day^{-1} and 6.7 x 10^{-3} gm^{-2} day^{-1} respectively. The importance of pelagic myctophid fish to penguin populations at the Prince Edward Islands is clear.

WG-Joint-94/16
An environmental information and modelling system (EIMS) for sustainable development: from the arid subtropical to Antarctica. V. Marín (Depto. Cs. Ecológicas, Facultad de Ciencias, Universidad de Chile, Casilla 653, Santiago, Chile), 2 pp. (English, unpublished).

WG-Joint-94/17
A revised assessment of the impact of the krill fishery on penguins in the South Shetlands. T. Ichii, M. Naganobu and T. Ogishima (National Research Institute of Far Seas Fisheries 5-7-1, Orido, Shimizu 424, Japan), 20 pp. (English, unpublished).

This paper presents a revision of the assessment of the competition between the Japanese krill (*Euphausia superba*) fishery and penguins (WG-Krill-93/7). The main fishing areas were confined to the slope and shelf to the north of either Livingston or Elephant Islands. In contrast, the main foraging areas of penguins are considered to be found in areas to the north of King George, Nelson and Robert Islands, and around Low, Clarence and Deception Islands. This small overlap between the main fishing and foraging areas occurs because large colonies of the dominant penguin species (chinstrap penguins, *Pygoscelis antarctica*) are closely associated with areas where sea-ice disappears earlier in spring, and not necessarily with areas of high krill abundance. The overlap between trawling depth and foraging dive depth of penguins was also insignificant. Furthermore, less similarity was observed between krill caught by trawlers and those captured by penguins. The abovementioned results imply a low level of competition between the fishery and penguins. Krill biomass was estimated to be as large as 200 to 1 500 x 10^3 tonnes within the preferred fishing areas during the breeding season. Compared with the level of biomass (≥200 x 10^3 tonnes) and its variability (the order of 100 x 10^3 tonnes/half-month period), the present catch rate (≤13 x 10^3 tonnes/half-month period) is smaller by one or more orders of magnitude within the localised areas. Thus, the present fishery is very unlikely to be having an adverse impact on the local krill biomass and hence on penguins, when catch levels are also taken into account.

Working Group on Fish Stock Assessment

WG-FSA-94/4
Dynamics of *Notothenia rossii rossii* size-age structure on the Kerguelen Islands shelf. P.B. Tankevich (Southern Scientific Research Institute of Marine Fisheries and Oceanography (YugNIRO), Laboratory of Southern Ocean Fish Resources, 2 Sverdlov Street, Kerch 334500 Crimea, Ukraine), 12 pp. (English, unpublished).

Size-age structure dynamics of the marbled rockcod (*Notothenia rossii rossii*) population are shown (based on results of research expeditions and fishing cruises to the Kerguelen Island shelf in the period 1970 to 1991). Age data from 1970 to 1989 (Tankevich, 1990) and data collected during the joint Soviet-French expedition of the RTMA *Orlinoye* in May and June 1991 were used to characterise age composition. It was determined that in the initial years of exploitation of the stock, most catches (more than 80%) were comprised of repeat spawners. As the fishery developed, the proportion of fish spawning for the first time increased considerably in catches, and in some years (1981 to 1985) fisheries were based practically on recruitment. After the closure of the fishery in 1985, and after the marbled rockcod by-catch in other fisheries was limited to 500 tonnes, a stable trend towards an increase in catches of the mean age and length was noted. In May and June 1991, the mean length was 59.2 cm and mean age was 7.4 years; some 70% of the catch consisted of repeat spawners. The author considers the demographic population structure in 1991 to be close to that observed in the initial years of exploitation and that further closure of the marbled rockcod fishery may lead to an

increase in natural mortality of the population as the whole. Removal of older age groups is recommended to start in the near future. This will make it possible to control size-age structure changes in the spawning part of the population.

WG-FSA-94/5
Analyses performed at the 1993 Meeting of the Working Group on Fish Stock Assessment. CCAMLR Secretariat (25 Old Wharf, Hobart, Tasmania 7000, Australia), 25 pp. (English, unpublished).

WG-FSA-94/6
Preliminary results of mackerel icefish (*Champsocephalus gunnari*) age determination by weight method. I.B. Russelo (Southern Scientific Research Institute of Marine Fisheries and Oceanography (YugNIRO), 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine), 1 pp. (English, unpublished).

WG-FSA-94/7
Course of fisheries in the Lena Bank area (Division 58.4.4) in the season of 1990/91. A.K. Zaitsev (Southern Scientific Research Institute of Marine Fisheries and Oceanography (YugNIRO), 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine), 8 pp. (English, unpublished).

In the season of 1990/91, fishing operations in Division 58.4.4 (Lena Bank) were carried out by only one vessel, RTMA *Zvezda Kryma*, from April to June 1991. The total catch in that period comprised 971 tonnes of grey rockcod (*Notothenia squamifrons*) and 29 tonnes of Patagonian toothfish (*Dissostichus eleginoides*). The real catch exceeds the data in the *Statistical Bulletin* by nearly two-fold. Therefore it is necessary to update the relevant documents. The size-age composition of catches did not undergo significant changes. The mean age of fish was 7.0 years. Interannual fluctuations in size-age composition of populations are more a result of the quality and period of sampling than a reflection of objective changes in population structure of the species.

WG-FSA-94/8
Preliminary results of age determination by otolith mass in mackerel icefish (*Champsocephalus gunnari* Lönnberg 1905) in the Heard Island area (Australia). I.B. Russelo (Southern Scientific Research Institute of Marine Fisheries and Oceanography (YugNIRO), 2 Sverdlov Street, Kerch 334500 Crimea, Ukraine), 10 pp. (Russian, unpublished).

Otolith mass was used to determine the age of mackerel icefish *Champsocephalus gunnari*. The material was collected in July and August 1987 during the joint Soviet-Australian expedition of the RV *Professor Mesyatsev* to the Heard Island shelf area. The otoliths were weighed with an electric balance to within 0.0001 g. The data thus obtained underwent statistical processing using the cluster analysis method. Five age groups were defined. The Bertalanffy linear growth equation was calculated:

$$L_t = 41.73\ (1\text{-e}^{\ -0.5149(1+0.05225)})$$

On this basis the age/length key for this season has been estimated.

WG-FSA-94/9 Rev. 1
New data on spawning, hatching and growth of the Kerguelen Islands *Champsocephalus gunnari* shelf stock. G. Duhamel (Museum national d'histoire naturelle, Laboratoire d'ichtyologie générale et appliquée, 43 rue Cuvier, 75231 Paris Cedex 05, France). *CCAMLR Science*, (in press): 8 pp. (English).

Combined studies of the inner and outer shelves of the Kerguelen Islands (1989/90 to 1992/93) have provided new information about the *Champsocephalus gunnari* stock. An inner-shelf quarterly program allows the yearly identification, both from the results of ichthyoplanktonic surveys and bottom hauls, of an annual cohort. Large differences in the abundance of larvae are observed yearly. One cohort seemed dominant in the samples taken during the study. This would explain the previously observed three-years cycle. Spawners have been observed in large numbers only once during the studied period, and are fishes of the 1988 cohort that first spawned during the winter of 1991/92.

WG-FSA-94/10
Fish distribution and biomass in the Heard Island zone (Division 58.5.2).
WG-FSA-94/30
Addendum to document WG-FSA-94/10. R. Williams and W. de la Mare (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia). *CCAMLR Science*, (in press): 32 pp. (English).

Division 58.5.2 encompasses the southern part of the Kerguelen Plateau, and contains Heard Island and the McDonald Islands, an Australian territory around which a 200-mile EEZ has been declared. In order to assess the potential of this area for commercial fishing, and to obtain some preliminary data for its management, three biomass surveys were conducted on the Kerguelen Plateau in this division to investigate the distribution, abundance and biology of the most important species, covering a number of years and seasons. Results of these surveys are discussed.

WG-FSA-94/11
Age-length key for *Champsocephalus gunnari* from Subarea 48.3, RV *Dr Eduardo Holmberg* survey, February/March 1994. E. Barrera-Oro, E. Marschoff and R. Casaux (Dirección Nacional del Antártico, Cerrito 1248, 1010 Buenos Aires, Argentina), 10 pp. (English, unpublished).

An age/length key was prepared for *Champsocephalus gunnari* in Subarea 48.3, based on the readings of otoliths randomly collected during the RV *Dr Eduardo Holmberg* survey in February/March 1994. Small and medium-sized fish (total length - 12 to 33 cm) constituted the bulk of the samples (93%), while larger specimens (>33 cm) were scarce. At South Georgia, fish of age groups 1 to 4 were truly represented; at Shag Rocks, a large concentration of fish belonging to age groups 2 (90%) and 3 (10%) was found. The length-weighted distribution of all the fish sampled in Subarea 48.3 showed good correspondence between modes and the mean lengths of age groups 1 and 2. Such correspondence was also obtained for age group 3 when the data from South Georgia were analysed separately. Mean length-at-age data presented here fall in the range of available results from previous surveys in the South Georgia region.

WG-FSA-94/12
Validation of age determination in *Notothenia coriiceps* by means of a tag-recapture experiment at Potter Cove, South Shetland Islands. E. Barrera-Oro and R. Casaux (Dirección Nacional del Antártico, Cerrito 1248, 1010 Buenos Aires, Argentina), 21 pp. (English, unpublished).

Of 409 *Notothenia coriiceps* specimens tagged and released at Potter Cover, South Shetland Islands, in successive years from 1989 to 1992, nine were recaptured at the same site after periods of 11 to 21 months. A comparison was carried out between the annuli found in scales removed at the moment of tagging and after recapture. In scales of those specimens recovered after 11 to 13 months, one extra annulus was laid down. The same analysis in one individual recovered after 21 months resulted in two extra closely spaced sclerite zones, which corresponds with two winter seasons having elapsed. The comparative analysis between scales taken at recapture and otolith cross sections of the same individual allowed the simultaneous counting of annuli, which showed good agreement. These results validate the principle of annual deposition of the annulus in scales and otoliths of *N. coriiceps*. A preliminary analysis of scales regenerated after release indicates that these observations are of value in validation studies.

WG-FSA-94/13
Areas of seabed within the 500 m isobath around Elephant Island (CCAMLR Statistical Subarea 48.1). K.-H. Kock and U. Harm (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9 D-22767 Hamburg, Germany). *CCAMLR Science*, (in press): 8 pp. (English).

Areas of seabed within 50 m depth contours down to 100 m and within 100 m depth contours from 100 to 500 m have been estimated from soundings obtained during plankton and bottom trawl surveys around Elephant Island (the northernmost

island of the South Shetland Islands) from 1977/78 to 1992/93. The results are presented on a fine-scale grid of 15' latitude x 30' longitude.

WG-FSA-94/14

The early life history of the Patagonian toothfish (*Dissostichus eleginoides* Smitt, 1898). S.A. Evseenko, K.-H. Kock and M.M. Nevinsky (Laboratory of Oceanic Ichthyofauna, P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Krasikova 23, Moscow 117218, Russia), 17 pp. (English, unpublished).

Patagonian toothfish, *Dissostichus eleginoides*, spawn over the continental slope from July to September. Eggs have been observed primarily in the upper part of the water column over 2 200 to 4 400 m bottom depth. Embryos in stages III and IV of their embryonic development are described. Hatching is likely to occur in October/November. Scales do not start to form before the fish are 64 to 74 mm long.

WG-FSA-94/15

The diet composition and feeding intensity of mackerel icefish (*Champsocephalus gunnari*) at South Georgia in January/February 1994. K.-H. Kock, I. Everson, L. Allcock, G. Parkes, U. Harm, C. Goss, H. Daly, Z. Cielniaszek and J. Szlakowski (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9 D-22767 Hamburg, Germany), 24 pp. (English, unpublished).

The diet composition and feeding intensity of mackerel icefish (*Champsocephalus gunnari*) around Shag Rocks and the mainland of South Georgia were analysed from 3 691 stomachs collected in January/February 1994. Main prey items were the amphipod hyperiid *Themisto gaudichaudii*, mysids (primarily *Antarctomysis maxima*), and krill (*Euphausia superba*) in the vicinity of South Georgia, and *T. gaudichaudii* and *Thysanoessa* sp. around Shag Rocks.

WG-FSA-94/16

Evidence of two stocks of *Champsocephalus gunnari* in the South Georgia region, CCAMLR fishing Subarea 48.3. A.W. North (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 11 pp. (English, unpublished).

In 1991 the 0 age-class of *C. gunnari* was sampled at Shag Rocks on 18 January, off Possession Bay, South Georgia during 19 and 20 January and off much of the north-east coast of South Georgia between 19 January and 19 February. The size frequency of fish at Shag Rocks contained two modes of 31 to 46 mm and 55 to 87 mm SL. However, off Possession Bay only one mode of 25 to 57 mm SL was apparent. Fish in combined samples off the coast of South Georgia were 24 to 63 mm SL. The mean and median sizes of fish at these locations were all significantly ($p < 0.001$) different. The size difference between the large size mode at Shag Rocks and those at South Georgia must be the result of different spawning seasons and/or egg development periods and/or growth rates. This suggests that there are two separate stocks of *C. gunnari* in a single CCAMLR statistical subarea. There is an apparent growth of around 0.76% SL d^{-1} (0.27 mm SL d^{-1}) for larvae on the South Georgia shelf, which is comparable with previous reports of early growth in *C. gunnari*.

WG-FSA-94/17

Large variations in mackerel icefish (*Champsocephalus gunnari*) standing stock at South Georgia: are Antarctic fur seals (*Arctocephalus gazella*) the cause? I. Everson, G. Parkes, I.L. Boyd and K.-H. Kock (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 9 pp. (English, unpublished).

The mackerel icefish (*Champsocephalus gunnari*) stock at South Georgia has been subject to heavy fishing in the past 20 years which has caused significant impact on stock size. There has been no reported commercial catch since March 1990. Variations in standing stock in recent years however, have been far greater than can be explained by the effects of fishing alone. A major component in the diet of icefish is krill (*Euphausia superba*). Seasons in which icefish show the greatest reduction in its stock size coincide with periods of krill

scarcity. Food shortage appears to have some effect on fish condition, but this is not sufficient to explain recent large-scale stock declines. Emigration and dispersal into the water column in years of scarcity can lead to a negative bias in stock size estimates. Both of these factors are considered unlikely to have such a dramatic effect, but neither are considered likely to have produced the dramatic changes in observed stock size. Fur seals feed preferentially on krill, but when krill are scarce they switch to feeding on fish. Even if icefish represented a very small proportion of the diet of fur seals, this could explain the great reduction in icefish standing stock. This conclusion has significant implications for managing icefish and for fisheries marine mammal interactions in general.

WG-FSA-94/18
Fish stock assessment survey in Subarea 48.3. I. Everson, G. Parkes, K.-H. Kock, C. Goss, Z. Cielniaszek, J. Szlakowski, H. Daly, L. Allcock and G. Pilling (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 34 pp. (English, unpublished).

WG-FSA-94/19
Software for WG-FSA-94. CCAMLR Secretariat (25 Old Wharf, Hobart, Tasmania 7000, Australia), 4 pp. (English, unpublished).

WG-FSA-94/20
Summary of the *Dissostichus eleginoides* fishery in Subarea 48.3 in the 1993/94 season. D.J. Agnew (CCAMLR Secretariat, 25 Old Wharf, Hobart, Tasmania 7000, Australia), 7 pp. (English, unpublished).

The progress of the fishery for *Dissostichus eleginoides* in Subarea 48.3 in the 1993/94 season is described. Fishing took place around Shag Rocks and South Georgia, being concentrated in four of the five experimental areas. CPUE for 1994 appears similar to that from previous years, except for Chilean vessels.

WG-FSA-94/21
Revised estimates of yield for *Electrona carlsbergi* based on a generalised version of the CCAMLR krill yield model. A.J. Constable and W. de la Mare (School of Aquatic Science and Natural Resources Management, Deakin University, PO Box 426, Warrnambool, Victoria 3280, Australia), 12 pp. (English, unpublished).

Traditional methods for estimating yield-per-recruit as a function of fishing mortality can result in inappropriate high estimates of yield that may lead to depletion of stocks because of widely varying recruitment patterns, overestimation of the abundance of the stock and age of the most recent survey. These problems are addressed in this paper by using stock projections to assess the probabilities of the stock of *Electrona carlsbergi* becoming depleted over a 20-year period. These projections have been undertaken using a generalised version of the CCAMLR Krill Yield Model. This is appropriate because this species shares a number of attributes with krill, including population dynamics, behaviour and its importance as prey in the Antarctic ecosystem. The decision rules for determining yield adopted by the Working Group on Krill were used for this analysis (where yield = γ, median pre-exploitation biomass): (i) choose γ_1, so that the probability of the spawning biomass dropping below 20% of its pre-exploitation median level over a 20-year harvesting period is 10%; (ii) choose γ_2, so that the median escapement over a 20-year period is 75%; (iii) select the lower of γ_1 and γ_2 as the level of γ for calculation of yield. The estimate of γ for a fishery targeting juvenile fish was 0.091.

WG-FSA-94/22
Determination of local density of *Dissostichus eleginoides* in Subarea 48.3: CCAMLR protocol local depletion experiment *Ihn Sung 66* - January 1994. C. Jones and G. Parkes (Marine Resources Assessment Group, 8 Prince's Gardens, South Kensington, London SW7 1NA, United Kingdom), 46 pp. (English, unpublished).

A longlining stock depletion trial was undertaken by the Korean longliner *Ihn Sung 66* in January 1994 in accordance with CCAMLR Conservation Measure 69/XII and the Experimental Protocol circulated by the Secretariat in COMM CIRC 93/50. The results of this experiment are presented.

Leslie and DeLury methods are tested using simulations to determine which of these is the most appropriate method. The Leslie method is applied using a specialised Catch and Effort Data Analysis computer package (CEDA) to calculate local abundance. Alternative error models are investigated to estimate confidence intervals for the local stock estimate. The initial population size was estimated to be 2 914 fish. Assuming a fishable area of 50 n miles^2, this represented a density of 0.5kg/n miles^2. Suggestions are made for the design of future depletion experiments.

WG-FSA-94/23

Performance and geometry of the FP-120 trawl used during the UK 1993/94 fish stock assessment survey around South Georgia, Subarea 48.3. G. Pilling and G. Parkes (Marine Resources Assessment Group, 8 Prince's Gardens, South Kensington, London SW7 1NA, United Kingdom). *CCAMLR Science*, (in press): 18 pp. (English).

Methods for the calculation of the horizontal opening (swept area) of a bottom trawl are discussed. Details are provided of the Scanmar trawl monitoring equipment used for making *in situ* measurements of horizontal opening and heading height of the FP-120 trawl during the 1993/94 UK fish stock assessment survey around South Georgia on the MV *Cordella* are provided. Empirical equations are derived for the calculation of horizontal opening from other, more easily obtained, measurements, such as tow speed and trawl depth. A new multiple regression equation is compared to that used previously for the estimation of biomass parameters of the major fish species around South Georgia. The resulting difference in biomass estimates is of the order of a 1% to 5% increase, depending upon species.

WG-FSA-94/24

Comments on the use of stock depletion models for the assessment of local abundance of toothfish in Subarea 48.3 and adjacent waters. G. Parkes and G. Pilling (Marine Resources Assessment Group, 8 Prince's Gardens, South Kensington, London SW7 1NA, United Kingdom), 12 pp. (English, unpublished).

WG-FSA-94/25

Preliminary results on by-catch of fish during krill fishery in March to May 1993 on the Polish trawler MT *Lepus*. Z. Cielniaszek and R. Pactwa (Department of Biology and Conservation of Fish Resources, Sea Fisheries Institute, Kollataja 1, 81-332 Gdynia, Poland), 15 pp. (English, unpublished).

From the end of March to the beginning of May 1993 investigations were carried out to determine biological/fisheries characteristics of exploited fish stocks during krill fishing operations conducted by the MT *Lepus* on the fishing grounds off South Orkney Islands and South Georgia. One goal was to determine the proportion of juvenile fish forms present in krill concentrations. This study gives the results of these observations. It appears from the investigations that the by-catch of juvenile fish in the krill fishery was small, while off the South Orkney Islands there was no such by-catch at all in the samples collected. In both areas a small by-catch of species from the family Myctophidae was observed.

WG-FSA-94/26

Preliminary aspects of a simulation model to be used for evaluating the experimental crab fishery. G. Watters (Southwest Fisheries Science Center, PO Box 271 San Diego, Ca. 92038, USA), 23 pp. (English, unpublished).

At the 1993 meeting of the Working Group on Fish Stock Assessment, members requested that work be undertaken to evaluate certain aspects of the experimental management strategy for the Antarctic crab fishery. A simulation model is proposed for conducting this work. Length-frequency and catch-rate data from the 1991/92 crab fishery are used to motivate the construction of an ontogenetic migration model for describing crab distribution, movement and recruitment during the simulation. The fishery simulation is spatially explicit, and the dynamics of crab abundance are described on a daily basis. The simulation includes advective and diffusive movement rates, a

lagged Beverton-Holt stock recruitment relationship, and a model for catch that contains a random normal deviate. Finally, an algorithm is developed for describing the spatial and temporal distribution of fishing effort during the simulation. This algorithm is based on the idea that each fishing vessel constructs a map of expected catch rates across the fishing grounds. Each vessel updates this expectation map on a daily basis and uses it to determine the distribution of targeted fishing effort and searching effort.

WG-FSA-94/27
Diet composition of *Champsocephalus gunnari* in Subarea 48.3, RV *Dr Eduardo Holmberg* survey, February/March 1994. E. Barrera-Oro, R. Casaux and A. Roux (Dirección Nacional del Antártico, Cerrito 1248, 1010 Buenos Aires, Argentina), 17 pp. (English, unpublished).

The diet composition of the icefish *Champsocephalus gunnari* caught in Subarea 48.3 in February/March 1994 was analysed using the frequency of occurrence (%) method. Krill (*Euphausia superba*), followed by the amphipod hyperiid *Themisto gaudichaudii*, were the main prey items at South Georgia and Shag Rocks; fish were found in the stomachs more frequently than in past seasons around South Georgia, which contrasts with the virtual absence of mysids and *Thysanoessa* spp. Krill abundance was at levels similar to those of previous years (e.g., 1985, 1992). However, high proportions of empty stomachs were found in fish at South Georgia and Shag Rocks, close to the values reported for the 1991 year of krill 'shortage'. Moreover a tentative analysis of part of the samples using the coefficient Q (%) showed *T. gaudichaudii* to be more important than krill. It is possible that the inconsistencies found between the results obtained by both methods are due to a particular spatial distribution of krill in the area during the period of study, however no previous data are available for comparison. No krill aggregations were found in the region by acoustic methods in the 1994 summer season; this may be related to a significant change in surface temperature observed during the cruise.

WG-FSA-94/28
Preliminary study on reproduction in *Champsocephalus gunnari* from Subarea 48.3, RV *Dr Eduardo Holmberg* survey, February/March 1994. G. Macchi and E. Barrera-Oro (Instituto Nacional de Investigación y Desarrollo Pesquero, Mar del Plata, Argentina), 6 pp. (English, unpublished).

A preliminary histological analysis of the ovarian development in *Champsocephalus gunnari* was carried out. Six stages of oocytary development were identified and are similar to those described for other species. A gonad maturation scale was elaborated and adapted to the macroscopic scale commonly used. Oocytary resorption processes were observed during ovarian maturation. In some cases the ovaries presented few atretic oocytes; in others a generalised regression was found. In the southwest portion of the South Georgia shelf, 50% of the ovaries exhibited a pre-reproductive regression stage similar to that reported for the same species in the 1991 summer season.

WG-FSA-94/29
Preliminary results of the RV *Dr Eduardo Holmberg* 1994 cruise to Subareas 48.2 and 48.3. E. Marschoff, B. Prenski, B. Gonzalez, C. Remaggi and C. Balestrini (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 28 pp. (English, unpublished).

A total of 63 hauls and 10 oceanographical transects were carried out. Of these, 44 hauls made in Subarea 48.3 according to a random stratified design are used to estimate the size of standing stocks of the main commercial fish species using different methods, as well as to estimate their length frequency distributions. A change in surface water temperature of about -0.5° to -1.0° over a period of approximately 20 days was detected around the South Georgia islands. In the Scotia Sea the boundary of the Weddell-Scotia confluence was within historical limits, while surface water (down to 50/70 m) was warmer than expected. It was also found that the spatial structure of fish populations significantly affects the results of biomass estimates.

WG-FSA-94/31
Depletion experiment of *Dissostichus eleginoides* stock in the south of South Georgia Island (Antarctica). P.S. Rubilar, C. Moreno and J.R. Ashford (Instituto de Ecología y Evolución, Universidad Austral de Chile, Casilla 567, Valdivia, Chile), 13 pp. (Spanish, unpublished).

A depletion experiment was carried out from 11 to 21 April 1994 to assess an initial biomass of *Dissostichus eleginoides*, south of South Georgia. Ten longlines were set with at least part of each longline falling within a circle of diameter 10 n miles centred at 55°03'S 36°53'W. The Leslie method was applied to the data. Initial biomass was projected to 3 244.8 n miles^2, giving an estimated biomass of 937.8 tonnes. Due to the statistical limitations of these data, another data-based analysis (kg/n miles^2) of the fished area was also performed. The positions of the vessel were verified by information obtained from an ARGOS automatic position system.

WG-FSA-94/32
Bottom trawling survey on the Ob and Lena Banks. Ukraine, 5 pp. (English, unpublished).

Ad Hoc Working Group on Incidental Mortality Arising from Longline Fishing

WG-IMALF-94/4
Seabird mortality on longline fishing for tuna in southern Brazil. T. Vaske Junior. *Ciencia e Cultura,* 43(5): 388-390, 1991 (English).

The mortality of seabirds (Procellariiformes) accidentally hooked during longline fishing for tuna in southern Brazil is estimated. Results obtained through onboard observation during fishing cruises showed that this fishing technique is a significant cause of bird mortality associated with tuna fishing.

WG-IMALF-94/5
Seabird mortality in longline fisheries around South Georgia. J. Dalziell and M. de Poorter. *Polar Record,* 29 (169): 143-145, (English).

WG-IMALF-94/6
Albatross mortality and associated bait loss in the Japanese longline fishery in the Southern Ocean. N. Brothers. *Biol. Conservation,* 55: 255-268, 1991 (English).

A conservative calculation of the number of albatrosses killed annually on Japanese longlines in southern oceans is 44 000. The actual figure could be double this, and is sufficiently high to substantiate claims that serious declines in albatross populations are due to this fishing activity. Albatrosses have an economic impact on longline fisheries, with annual losses to the southern bluefin tuna fishery alone exceeding A$7 million. If all fish species and the total longlining effort were considered, this figure would be many millions of dollars greater. Apart from a concern for albatrosses, Japan's longline fishermen would also benefit by using the solutions offered. It is suggested that a 70% reduction in the problem is possible and that an overall reduction in excess of 90% could be achieved. Further monitoring is essential.

WG-IMALF-94/7
Population dynamics of the wandering albatross (*Diomedea exulans*) on Macquarie Island and the effects of mortality from longline fishing. W. de la Mare and K. Kerry (Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia) 50 pp. (English, unpublished).

The estimated breeding population of wandering albatrosses on Macquarie Island increased from 17 in 1956 to a maximum of 97 in 1966, and then declined at an average rate of 8.1% per year. Mark-recapture analysis shows that the population is not closed (i.e., it is subject to immigration and emigration). The decline is correlated with the onset of large-scale fishing for tuna in the Southern Hemisphere using longlines. The effect of longline mortality on the population dynamics of the wandering albatross is estimated. An annual number of longline hooks in the Southern Hemisphere tuna fishery of 41.6 million is calculated as the ceiling below which the population would begin to recover.

WG-IMALF-94/8
Use of a population model to assess the impact of longline fishing on wandering albatross (*Diomedea exulans*) populations. C. Moloney, J. Cooper, P. G. Ryan and W. Roy Siegfried. *Biological Conservation*, 70: 195-203, 1994 (English).

An age-structured model of a wandering albatross *Diomedea exulans* population is developed to simulate population trends over time, using demographic parameters from the population at Possession Island, Crozet Island, during the period 1968 to 1986. The simulation results portray a population decreasing at a rate of 2.29% per year, which concurs with global population trends. Sensitivity analyses of model parameters indicate that both adult and juvenile mortality are contributing to the decrease. Wandering albatross mortality is presumed to have increased as a result of deaths caused by longline fishing vessels; such deaths are likely to be relatively more frequent among young, naive birds. The model is used to investigate the potential impacts of new longline fisheries such as that for Patagonian toothfish *Dissostichus eleginoides* in Antarctica. Assuming that longline fishing operations affect juveniles more than adults, there is a time lag of 5 to 10 years before further decreases in population numbers are reflected in the breeding population. Also, because wandering albatrosses are long-lived, population growth rates take approximately 30 to 50 years to stabilise after a perturbation. Consequently, caution must be exercised when interpreting population trends; short-term (<20 year) estimates may not provide good indications of longterm trends.

WG-IMALF-94/9
Reduced bait loss and by-catch of seabirds in longlining by using a seabird scarer. S. Løkkeborg and Å. Bjordal (Fish Capture Division, Institute of Marine Research, PO Box 1870, N-5024 Bergen, Norway), 5 pp. (English, unpublished).

Although longlining is regarded as a highly conservation-oriented method of fishing, the by-catch of seabirds on longlines is a problem in certain seasons and areas. Birds feeding on bait during the setting of gear might cause considerable bait loss and occasional hooking of birds might eventually give high mortalities considering the large numbers of hooks used. Both from a fishery and bird conservation point of view there is a strong incentive to solve this problem. This paper describes trials using a seabird scarer in the Norwegian longline fishery. The scarer, a line with streamers trailing behind the vessel during setting of the gear, proved to be an effective device for scaring the birds away, and gave significantly reduced bait loss and no bird mortality.

WG-IMALF-94/10
Report on a tuna longlining fishing voyage aboard *Southern Venture* to observe seabird by-catch problems. M.J. Imber (New Zealand), Department of Conservation, 1994 (*Science and Research Series*, 0113-3713, No. 65).

Incidental captures of seabirds, and the behaviour of seabirds around the fishing gear as it was deployed, were observed during eight days' fishing by a New Zealand-owned tuna longliner. From 11 200 hooks set, six seabirds were hooked and recovered: five wandering albatross (*Diomedea exulans*) of which three were released alive, and one black-browed mollymawk (*D. melanophrys impavida*). Relatively more birds survived hooking in this study because of the lighter gear and quicker recovery of the longline (about six hours between beginning the set and beginning hauling in). Petrels, particularly cape pigeons *Daption capense*, were mainly responsible for bringing the sinking baits back to the surface where albatrosses/mollymawks subsequently ate most of them. About 1.2% of baits were taken by seabirds, but only 4.5% of bait-takes resulted in a bird being hooked. The mollymawk was hooked at night near full moon, but under thick cloud. Most bait-takes occurred in daylight, particularly before dusk. The vessel's bird-scaring line seemed to reduce, but not eliminate bait-taking. The mortality rate of seabirds (0.27/1 000 hooks set) is similar to that in the only other two reported studies. Seabirds scavenged intensively on the waste baits (41% of those cast) thrown overboard during hauling in. More birds

followed in the wake during hauling than during setting.

WG-IMALF-94/11
Changes in population size of large procellariiformes breeding in the French sub-Antarctic islands: potential influence of southern fisheries and particularly longlining. H. Weimerskirch and P. Jouventin (Centre d'Etudes Biologiques de Chizé, Centre National de la Recherche Scientifique, Villiers-en-Bois, 79360 Beauvoir-sur-Niort, France), 21 pp. (English, unpublished).

Studies carried out over the past three decades in the French austral territories indicate that most albatross and giant petrel populations have markedly declined. Demographic studies indicate that these declines are mainly the result of increased adult mortality. This high rate of mortality has been suspected to be the result of mortality incurred in longline fisheries. Satellite tracking studies of breeding birds and band recoveries of non-breeding birds indicate that during and outside the breeding season these populations are in contact with longline fisheries, mainly the pelagic Japanese tuna fishery but also, to a lesser, extent the neritic toothfish, *Dissostichus eleginoides*, fishery operating in the Kerguelen EEZ. The decrease in the fishing effort of the Japanese fishery during recent years has probably resulted in the slow recovery of the wandering albatross population. Longline fisheries are likely to represent a major threat to long-lived seabirds in the Southern Ocean. Indian Ocean populations are particularly at risk from the tuna fishery. Potential threats from the Kerguelen toothfish fishery exist, but can be kept to a minimum if measures to reduce mortality continue to be enforced in the EEZ.

WG-IMALF-94/12
Interactions between longline vessels and seabirds in Kerguelen waters and a method to reduce seabird mortality. Y. Cherel, H. Weimerskirch and G. Duhamel (Centre d'Etudes Biologiques de Chizé, Centre National de la Recherche Scientifique, Villiers-en-Bois, 79360 Beauvoir-sur-Niort, France), 30 pp. (English, unpublished).

In recent years, a new longline fishery for the fish *Dissostichus eleginoides* has developed in the vicinity of South Georgia and Kerguelen Islands, two internationally important breeding areas for procellariiform birds. The attractiveness of this fishery for seabirds, together with the incidental capture of birds and a method to reduce mortality were investigated during 13 days of fishing activity in Kerguelen waters during February 1994. Between 100 and 600 seabirds were observed to be following the vessel at all times. The main species observed to be following the ship were the white-chinned petrel (67% of the counts), the giant petrel (8%) and three species of albatrosses, the wandering (11%), black-browed (6%) and grey-headed (2%) albatrosses. All these species are attracted by baited hooks which sink during line setting(s). More attempts to feed on baits are made by skilled divers such as the white-chinned petrel (87% of the total number of tries), the black-browed (7%) and the grey-headed (6%) albatrosses, than by species never observed submerged such as the wandering albatross (<1%). Consequently, the seabird by-catch included only species which are capable of diving, i.e., the white-chinned petrel (n = 36) and the grey-headed albatross (n = 2). Marked differences in the mortality rate were observed between day and night (1.00 versus 0.38 birds per 1 000 hooks), and, at night, when the deck lights were on or off (0.59 versus 0.15 birds per 1 000 hooks). Importantly, dumping of homogenised offal during line setting greatly reduced incidental capture of seabirds (only one white-chinned petrel killed on 41 longlines), mainly because birds were more attracted by offal than by hooked baits. On average, the mass of offal (crushed head, gut and tail of *D. eleginoides*) thrown overboard during line setting was 10-times greater than that of bait. Moreover, offal sank slower than hooked baits, being thus available to the seabirds in larger amounts and over a longer time. We therefore propose that regulation governing the longline fishery for *D. eleginoides* include the use of offal dumping during line setting in order to minimise seabird mortality.

WG-IMALF-94/13
Entanglements and incidental mortality of birds and seals - summary of reports to CCAMLR 1985 to 1993. CCAMLR Secretariat (25 Old Wharf, Hobart, Tasmania 7000, Australia), 21 pp. (English, unpublished).

This paper summarises the incidence of entanglements and incidental mortality of birds and seals reported by CCAMLR Members for the CCAMLR Convention Area and adjacent waters from 1985 onwards. A bibliography on entanglement, incidental mortality and effects of marine debris on seabirds and marine mammals is attached. The bibliography includes papers cited in documents submitted to CCAMLR.

WG-IMALF-94/14
Report on incidental bird mortality and effectiveness of mitigation measures during demersal longlining by *Ihn Sung 66* in Subarea 48.3: December 1993 to February 1994. C. Jones and G. Parkes (Marine Resources Assessment Group, 8, Princes Gardens, South Kensington, London SW7 1NA, United Kingdom), 17 pp. (English, unpublished).

A method of surveying incidental mortality of seabirds during longlining operations and the effectiveness of mitigation measures is described. An alternative streamer line design for use with the 'Spanish' method of longlining (separate hauling and fishing lines) is described. The results of observations of incidental mortality of seabirds made during the fishing operations of the Korean longliner *Ihn Sung 66* are presented. Preliminary findings suggest that the phase of daylight during which the longline is set is more important than the use of a streamer line in the mitigation of incidental mortality. The use of a streamer line during setting of longlines during the day reduced the observed rate of bird deaths from snagging and drowning by 79%. More data are required to develop the investigation further.

WG-IMALF-94/15
Seabird interactions with longlining operations for *Dissostichus eleginoides* around South Georgia, April and May 1994. J.R. Ashford, J.P. Croxall, P.S. Rubilar and C. Moreno (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom). *CCAMLR Science*, (in press): 22 pp. (English).

Longlining operations for *Dissostichus eleginoides* off South Georgia were assessed for incidental mortality and interactions with seabirds. Twenty-seven lines were observed and 98 mortalities recorded over 20 sets of the line; no mortalities occurred during hauls. The 16 sets made at night contributed 15% of the overall mortality, all of white-chinned petrels; the four day-time sets contributed 85% of overall mortality, with giant petrels, grey-headed albatrosses and black-browed albatrosses predominating. Our data suggest that grey-headed albatrosses, whose populations at South Georgia are in serious decline, were disproportionately affected in relation to their numbers in the vicinity of the fishing vessel; giant petrels also may be disproportionately affected, at least in relation to the size of their breeding population at South Georgia when compared to the albatrosses. Average mortality rate for the 20 sets was 0.48birds/1 000 hooks and maximum mortality 3.12 birds/1 000 hooks. Mortality and interactions of birds with operations varied with site and time of day, and due to behavioural interactions between birds. Setting only at night would dramatically reduce albatross deaths, but would substantially increase white-chinned petrel mortalities. A streamer line made to CCAMLR specifications may also reduce mortalities but may be less effective during calm weather, intense feeding activity by seabirds, or when incorrectly constructed.

WG-IMALF-94/16
Interactions between cetaceans and longlining operations for Patagonian toothfish *Dissostichus eleginoides* around South Georgia. J.R. Ashford and P. S. Rubilar (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom), 18 pp. (English, unpublished).

Longlining operations for *Dissostichus eleginoides* around South Georgia were assessed for interactions with sea

mammals. Twenty seven lines were observed and interactions recorded during 25 of these. During setting of lines neither mortalities nor interactions were recorded. All interactions occurred during hauling operations, both during the day and at night. Killer whales (*Orcinus orca*) were present during one haul, from which only 11 intact fish were taken aboard, compared to a mean of 510 fish/haul for all 27 lines. Sperm whales (*Physeter macrocephalus*) were also associated with hauling operations and may have been removing fish captured on the lines. Numbers of sperm whales varied with location; some whales with identifying marks were observed over successive lines to the southwest of South Georgia, but were not seen on subsequent operations to the northwest of the island. On two occasions, sperm whales were snagged on the line but were freed. Interviews with fishermen indicated that interactions of killer whales and sperm whales with longlining operations may be common in the South Atlantic and off southern Chile. Fishermen recognised that these interactions were costly in terms of fish and fishing time lost; the development of measures to reduce interactions may help prevent fishermen taking action potentially harmful to cetaceans.

WG-IMALF-94/17
Mortality of albatrosses and other seabirds produced by tuna longline fisheries in Uruguay. L. Barea, I. Loinaz, Y. Marin, C. Ríos, A. Saralegui, A. Stagi, R. Vaz-Ferreira and N. Wilson (Instituto Nacional de Pesca (INAPE), Consitiuyente 1497, Montevideo C.P. 11200, Uruguay), 12 pp. (English, unpublished).

WG-IMALF-94/18
Seabird mortality from longline fisheries: evidence from Marion and Gough Islands. J. Cooper (Percy Fitzpatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7700, South Africa), 8 pp. (English, unpublished).

Two tuna longline-fishing hooks have been recovered from beside wandering albatross (*Diomedea exulans*) nests at Marion Island in the 1990s. No hooks have been found at Gough Island and no birds have been found dead ashore on either island as a result of fishing gear. Recoveries of banded birds at sea suggest that wandering albatrosses are more at risk of being hooked than giant petrels *Macronectes* sp.

WG-IMALF-94/19
Principles of birdline construction and use to reduce bait loss and bird deaths during longline setting. N. Brothers (Department of Parks, Wildlife and Heritage, GPO Box 44A, Hobart, Tasmania 7001, Australia), 5 pp. (English, unpublished).

WG-IMALF-94/20
Catching fish not birds: a guide to improving your longline fishing efficiency (English version). N. Brothers (Department of Parks, Wildlife and Heritage, GPO Box 44A, Hobart, Tasmania 7001, Australia), 40 pp. (English, unpublished).

Part 1 of this guide provides general information on species composition and numbers of birds caught, and Part 2 explains why and how the birds take baits and how many they take. Part 3 discusses the factors which affect the rate of bait loss, while Part 4 gives details of methods which can be used to reduce bait loss and bird deaths. Finally, Part 5 briefly describes what makes seabirds so vulnerable to being caught on longlines.

WG-IMALF-94/21
Population trends and vulnerability to tuna longlining by-catch of albatrosses, mollymawks and *Procellaria* petrels of New Zealand seas. M.J. Imber (Science and Research Division, Department of Conservation, PO Box 10-420, Wellington, New Zealand), 6 pp. (English, unpublished).

This paper presents up-to-date data on counts and estimates of those groups of seabirds most often caught on longlines for tuna. The by-catch problem has prompted increased effort towards counts of several species poorly surveyed before. The sources of data on censuses were as follows: southern wandering albatross, southern royal albatross, black-browed mollymawk, yellow-nosed mollymawk

(Gales, 1993); Gibson's wandering albatross (Robertson, 1975; Walker *et al.*, 1991; Walker, 1993); antipodes wandering albatross (Warham and Bell, 1979; C.J.R. Robertson, pers. comm.; Clark *et al.*, in press); northern royal albatross, northern Buller's mollymawk (Robertson, 1991); New Zealand black-browed and grey-headed albatrosses (Moore and Moffat, 1990; Gales, 1993); New Zealand white-capped mollymawk (Robertson, 1975; B. Rebergen, pers. comm.); Salvin's mollymawk (Robertson and van Tets, 1982); Chatham mollymawk (Robertson, 1991); southern Buller's mollymawk (Sagar *et al.*, 1994); grey petrel, Westland petrel (Marchant and Higgins, 1990); black petrel (pers. obs.); white-chinned petrel (Walker, 1993; Marchant and Higgins, 1990).

WG-IMALF-94/22
Aspects of seabird by-catch and its mitigation in the New Zealand longline fishery for tuna. M.J. Imber (Science and Research Division, Department of Conservation PO Box 10420, Wellington, New Zealand), 5 pp. (English, unpublished).

WG-IMALF-94/23
Cooperative analysis of New Zealand seabird by-catch data - interim report. New Zealand Fishing Industry Board (Fishing Industry House, 74 Cambridge Terrace, Private Bag 24-901, Wellington, New Zealand), 4 pp. (English, unpublished).

WG-IMALF-94/24
Influence of bait quality on seabird mortality and economic losses in longline fishing: an experimental approach. N. Brothers, A. Foster and G. Robertson (Department of Parks, Wildlife and Heritage, GPO Box 44A, Hobart, Tasmania 7001, Australia), 7 pp. (English, unpublished).