CCAMLR SCIENTIFIC ABSTRACTS
1995/1996

Commission for the Conservation of
Antarctic Marine Living Resources

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Published in April 1999

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 1996 and lists papers submitted in 1995. It corresponds to the Fourteenth and Fifteenth 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 'submitted' or '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(iii) Scientific papers not intended for publication, which are listed as 'unpublished'; and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-EMM-96/8 (document number 8 submitted at the 1996 meeting of the Working Group on Ecosystem Monitoring and Management).

Unpublished papers must not be cited without written permission of the author(s).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-XV/BG/3
Trends in entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at South Georgia. J.P.Y. Arnould and J.P. Croxall. *Marine Pollution Bulletin*, Vol. 30 (11): 707-712, 1995 (English).

A study conducted at South Georgia in 1988/89 indicated that several thousand Antarctic fur seals were entangled mainly in man-made material originating from fishing vessels. Consequently, the authority responsible for the management of Southern Ocean marine resources (CCAMLR) actively campaigned for compliance with the MARPOL provisions relating to waste disposal at sea, and for cutting of any material unavoidably jettisoned which could form collars to entangle seals. Five subsequent years of recording entangled fur seals confirms that entanglement is a persistent problem, although its incidence has been halved in recent years. However, the South Georgia fur seal population has approximately doubled in the same period, so that the overall total of animals entangled may even have increased. Nevertheless, because most seals entangled are juvenile males, the current rate of entanglement will have negligible effects on the reproductive rate of the South Georgia population, especially in relation to its current rate of population increase. The reduction in observed entanglement incidence cannot be attributed mainly to improved waste disposal practices because it has coincided with substantial reductions in fishing activity around South Georgia. However, the particularreduction in entanglement due to packing bands and the fact that all such bands washed ashore over the last two years have been cut, does suggest a general improvement in standards of waste disposal on Southern Ocean fishing vessels.

SC-CAMLR-XV-BG/4
Oil, marine debris and fishing gear associated with seabirds at Bird Island, South Georgia 1995/96. R. Humpidge and J.P. Croxall (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 13 pp. (English, unpublished).

In the third year of standardised recording of oil, fishing gear and marine debris at Bird Island, South Georgia, one wandering albatross and two snow petrels contaminated with oil were reported. Ingested and regurgitated plastic debris were reported for wandering albatrosses (12 items) and grey-headed albatrosses (two items). One gentoo penguin chick was released from entanglement in a packaging band; another (uncut) band was found at a nest of a northern giant petrel. Parts of fishing gear were reported in association with grey-headed albatrosses (one squid jig decoy), black-browed albatrosses (one bird impaled with a longline hook, another hook found at a nest) and wandering albatrosses (two squid jigs; six hooks swallowed and impaled (four in adults, two in chicks), the remainder being hooks and lines regurgitated beside nests). Levels of plastic debris in fishing gear associated with seabirds at South Georgia have returned to the levels recorded in 1993/94, relatively few items having been reported in 1994/95. The reduction in 1994/95 probably related mainly to changes in the longline fishing season. The evidence of discarding of plastic waste and the loss of longline fishing gear, especially hooks, is a continuing cause for concern.

SC-CAMLR-XV/BG/5
Entanglement of Antarctic fur seals *Arctocephalus gazella* in man-made debris at Bird Island, South Georgia during the 1995 winter and 1995/96 pup-rearing season. T.R. Walker and R.I. Taylor (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 23 pp. (English, unpublished).

We report the results of the survey of entanglement of Antarctic fur seals at Bird Island, South Georgia for the sixth consecutive winter (1995) and eighth consecutive summer (1995/96). Only eight seals were observed entangled in winter, though this was nearly three times the number in 1994. Two were entangled in packaging bands, the first such record since 1993. As usual, the entangled animals were mainly juvenile males; the severity of injury was the lowest yet recorded. The number of entangled seals observed in summer was, at 70% higher than in 1995, the highest value since 1993. The proportions of entanglement in packaging bands and fishing nets were both higher than in recent years. Most animals involved were juvenile females; the severity of injury was the lowest yet recorded. Although the increase in entanglement - and especially that involving packaging bands (prohibited in the Convention Area since the start of the 1995 summer) is a cause for concern, it is likely that it reflects relatively high levels of fishing activity by vessels operating illegally in the area, rather than a failure of vessels operating under CCAMLR auspices to comply with waste disposal regulations.

SC-CAMLR-XV/BG/6
Report on a workshop entitled 'Harvesting krill: ecological impact, assessment, products, markets'. D.J. Agnew (CCAMLR Secretariat), 3 pp. (English, unpublished).

SC-CAMLR-XV/BG/7
Population changes in albatrosses at South Georgia. J.P. Croxall, P.A. Prince, P. Rothery and A.G. Wood. In: Robertson, G. (Ed.). *Albatross Ecology and Conservation*. Chipping Norton, Australia, Surrey Beatty and Sons, (in press) (English).

At Bird Island, South Georgia, populations of wandering (*Diomedea exulans chionoptera*) grey-headed (*D. chrysostoma*) and black-browed (*D. melanophrys melanophrys*) albatrosses have been studied continuously since 1975 and are all declining. The magnitude and nature of these population changes are reviewed, together with an assessment of their demographic causes. For wandering albatrosses, the decline was first recognised in 1979 and is still continuing. It reflects decreases of about 2 to 3% per annum in adult survival rate and 10% per annum in post-fledging juvenile survival rate, these contributing approximately equally to the 1% per annum reduction in population size. Breeding success is consistently high, and increased by 15% between 1975 and 1990, being stable currently. Average age of first breeding has decreased by about two years over the last 20 years, for both sexes. The decrease in grey-headed albatrosses is widespread amongst Bird Island colonies. However, unequivocal declines were not evident until the late 1980s because of the magnitude of interannual fluctuations in population size in this biennially-breeding species. Adult survival may be lower since the 1970s than previously but the main cause of decline is that recruitment to the breeding population nowadays is only 10% of values 15 years ago. Breeding success is variable but without obvious trends. In black-browed albatrosses, significant declines were only evident for a proportion of the colonies at Bird Island by 1990; nowadays all colonies are decreasing. At the main study colonies recruitment is only 20% of values 15 years ago and adult survival has decreased by about 4% per annum since 1987. Breeding success is highly variable and a recent succession of poor years (bad weather, low krill availability) has caused lower breeding (especially fledging) success this decade compared to last. Interactions with fisheries are known, or believed, to be important in almost all these population changes and are briefly reviewed. Comparisons with conspecific populations at other islands indicate broad similarities in timing of population declines but differences in the magnitude of these and in recovery rates. South Georgia albatross populations are unlikely to recover within the next 10 to 20 years and are potentially more seriously at risk than those of most other Southern Ocean islands.

SC-CAMLR-XV/BG/8
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SC-CAMLR-XV/BG/14
Trends of the *Dissostichus eleginoides* stock using the sequential population analysis (SPA) model in Subarea 48.3: 1992-1996. A. Zuleta, C.A. Moreno, P.S. Rubilar and Z. Young (Instituto de Ecología y Evolución, Universidad Austral de Chile, Casilla 567, Valdivia, Chile), *CCAMLR Science*, (submitted).

SC-CAMLR-XV/BG/15
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SC-CAMLR-XV/BG/16
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SC-CAMLR-XV/BG/17
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SC-CAMLR-XV/BG/18
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SC-CAMLR-XV/BG/19
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SC-CAMLR-XV/BG/20
Report on the workshop on the incidental mortality of albatrosses associated with longline fishing. (Australia), 67 pp. (English, unpublished).

SC-CAMLR-XV/BG/21
Albatross populations: status and threats. R. Gales (Tasmanian Parks and Wildlife Service, Department of Environment and Land Management, 134 Macquarie Street, Hobart 7000 Tasmania, Australia), 57 pp. (English, unpublished).

The status of the world's albatrosses are reviewed within the framework of the recently proposed taxonomic changes. The latest estimates of size of breeding populations (pairs) at all known localities of each of the 24 proposed species are presented; population trends are assessed where sufficient data are available. Despite increased efforts in population monitoring the status (i.e. population trends) of two-thirds of the world's ca. 150 albatross populations remain unknown. For those that are known, almost half are declining. The threats currently facing each species are briefly reviewed. The best available evidence indicates that longline fishing is the most serious threat facing albatrosses today. Twenty of the 24 species are known to be killed on longline hooks, including rare and endangered species. Widespread imple-mentation of appropriate mitigation measures is urgently required.

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SC-CAMLR-XV/BG/30
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Working Group on Ecosystem Monitoring and Management

WG-EMM-96/4
CEMP indices 1996: summary of anomalies and trends. Sections 1 to 3. CCAMLR Secretariat, 143 pp. (English, unpublished).

WG-EMM-96/5
Geographical aspects of utilising resources of krill (*Euphausia superba*). R.R. Makarov (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia), 22 pp. (English and Russian, unpublished).

This paper presents data on the distribution of *Euphausia superba* in the Atlantic sector and adjacent waters with an emphasis on areas located beyond the current fishing grounds of the Scotia Sea. In a number of areas on the periphery of the Weddell Gyre (both to the north and south), as well as in the coastal waters of the Antarctic continent, the formation of krill aggregations is a variable process, especially in terms of the location of individual aggregations. The main difficulty associated with initiating a fishery in these areas lies in assessing the variability of krill aggregations which should be done first. This must be undertaken in conjunction with a program directed at assessing the variability of krill transportation and aggregation in open oceanic waters.

WG-EMM-96/7
The relationship between foraging behaviour and energy expenditure in Antarctic fur seals. J.P.Y. Arnould, I.L. Boyd and J.R. Speakman. *J. Zool., Lond.*, 239: 769-782, 1996 (English).

By using time-depth recorders to measure diving activity and the double-labelled water method to determine energy expenditure, the relationship between foraging behaviour and energy expenditure was investigated in nine Antarctic fur seal females rearing pups. At-sea metabolic rate (MR) (mean of 6.34 ± 0.4 W.kg-1; 4.6 times predicted BMR) was positively correlated to foraging trip duration (mean of 4.21 ± 0.54 days; $r2 = 0.5$, $P < 0.04$). There were no relationships between MR and the total number of dives, the total time spent diving or the total vertical distance travelled during the foraging trip. There was, however, a close negative sigmoidal relationship ($r2 = 0.93$) between at-sea MR and the proportion of time at sea spent diving. This measure of diving behaviour may provide a useful, inexpensive means of estimating foraging energy expenditure in this species and possibly in other otariids.

The rate of diving (m.h-1) was also negatively related to at-sea MR ($r2 = 0.69$, $P < 0.005$). Body mass gain during a foraging trip had a positive relationship to the time spent at sea ($r2 = 0.58$, $P < 0.02$) and the total amount of energy expended while at sea ($r2 = 0.72$, $P < 0.004$) such that, while females undertaking long trips have higher metabolic rates, the energetic efficiency with which females gain mass is independent of the time spent at sea. Therefore, within the range of conditions observed, there is no apparent energetic advantage for females in undertaking foraging trips of any particular duration.

WG-EMM-96/8

A comparison of Antarctic krill (*Euphausia superba* Dana) caught by nets and taken by macaroni penguins (*Eudyptes chrysolophus* Brandt): evidence for selection? H.J. Hill, P.N. Trathan, J.P. Croxall and J.L. Watkins. *Mar. Ecol. Prog. Ser.*, 140: 1-11, 1996 (English).

Using stomach lavage samples from macaroni penguins (*Eudyptes chrysolophus* Brandt) breeding at Bird Island, South Georgia and concurrent net samples caught within the penguin foraging range, we examined the potential selection of different length and maturity stages of Antarctic krill (*Euphausia superba* Dana). Using Monte Carlo randomised simulation techniques we also determined the probability of obtaining length-frequency distributions of krill different from that obtained from the net samples. The krill taken by the macaroni penguins differed significantly from those caught in the nets. Small krill (28 to 38 mm) were absent from the stomach samples, whereas large krill (58 to 62 mm) were more abundant. Random sampling using Monte Carlo simulation techniques produced length-frequency distributions that were statistically different from the original distribution of krill caught in nets on 76 out of 100 trials. Nevertheless, these differences were smaller than those found between the penguin samples and net samples. Comparison of krill maturity stages showed that krill taken by macaroni penguins contained three times as many female as male krill, whereas krill caught in nets contained nearly equal proportions. The differences in size and maturity of krill taken by penguins are discussed in terms of aggregated random sampling, prey selection by predators, and evasion by krill of predators and nets. We conclude that the differences are unlikely to be accounted for simply in terms of sampling anomalies; the differences are more likely to relate to penguins selecting larger, nutritionally superior krill, but might also reflect differential escape responses of particular classes of krill when evading penguins or nets.

WG-EMM-96/9

Krill caught by predators and nets: differences between species and techniques. K. Reid, P.N. Trathan, J.P. Croxall and H.J. Hill. *Mar. Ecol. Prog. Ser.*, 140: 13-20, 1996 (English).

Samples of Antarctic krill collected from six seabird species and Antarctic fur seals during February 1986 at South Georgia were compared to krill from catches made by scientific nets in the area at the same time. The length-frequency distribution of krill was broadly similar between predators and nets although the krill taken by diving species formed a homogeneous group which showed significant differences from krill taken by other predators and by nets. There were significant differences in the maturity/sex stage composition between nets and predators; in particular, all predator species showed a consistent sex bias towards female krill. Similarities in the krill taken by macaroni (offshore feeding) and gentoo (inshore feeding) penguins and differences between krill taken by penguins and albatrosses suggest that foraging techniques were more important than foraging location in influencing the type of krill in predator diets. It was found that most krill taken by predators were adult; most female krill were sexually mature (particularly when allowance is made for biases caused by misclassification arising from predator digestion). Because female krill are larger, and probably less manoeuvrable than males, the biased sex ratio in predator diets at this time of year may reflect some combination of selectivity by predators and superior escape responses of male krill. Overall, adult, sexually mature female krill, forming 40% by number of the local krill population, may comprise 60 to 70% by number and 75 to

88% by mass of the krill taken by their main seabird and seal predators at South Georgia at the time of peak local demand in February.

WG-EMM-96/10
Dynamics of Antarctic penguin populations in relation to inter-annual variability in sea-ice distribution. P.N. Trathan, J.P. Croxall and E.J. Murphy. *Polar Biol*., 16: 321-330, 1996 (English).

To investigate the role of sea-ice cover on penguin populations we used principal component analysis to compare population variables of Adélie (*Pygoscelisadeliae*) and chinstrap (*P. antarctica*) penguins breeding on Signy Island (South Orkney Islands) with local and regional sea-ice variables (the former from direct observations; the latter from remote sensing data). Throughout the study period, the Adélie penguin population size remained stable, whereas that of chinstrap penguins decreased slightly. For neither species were there significant relationships between population size and breeding success, except for an apparent inverse density-dependent relationship between the number of Adélie breeding pairs and the number of eggs hatching. For both species, no general relationship was found between either population size or breeding success and the local sea-ice conditions. However, the regional sea-ice extent at a particular time prior to the start of the breeding season was related to the number of birds which arrived to breed. For both species, this period occurred before the sea-ice reached its maximum extent and was slightly earlier for Adélie than for chinstrap penguins. These results suggest that sea-ice conditions outside the breeding season may play an important role in penguin population processes.

WG-EMM-96/11
The fish diet of black-browed albatross *Diomedea melanophrys* and grey-headed albatross *D. chrysostoma* at South Georgia. K. Reid, J.P. Croxall and P.A. Prince. *Polar Biol*., 16: 469-477, 1996 (English).

The fish component of the diet of black-browed and grey-headed albatrosses at South Georgia was investigated by intercepting 155 meals from adults arriving to feed chicks during February 1986 and 1994. Fish represented 30% and 72% by mass of the diet of black-browed albatrosses and 14% and 60% by mass of the diet of grey-headed albatrosses in 1986 and 1994 respectively. We determined the identity and quantified the contribution (by numbers, size and mass) of fish species mainly by using otoliths (54 representing 9 taxa and 57 representing 17 taxa in black-browed and grey-headed albatross samples respectively). For black-browed albatrosses in 1986 the main fish prey was *Patagonotothenguntheri* (77% of otoliths, 51% of estimated fish biomass) and a single large specimen of *Icichthys australis* (40% estimated biomass), whereas in 1994 *Pseudochaenichthys georgianus* was the main fish prey (57% of estimated biomass) with *Magnisudis prionosa* (30%) and *Champsocephalus gunnari* (12%) also making substantial contributions. Grey-headed albatross samples from 1986 were dominated by southern lampreys (40% by number, 79% of estimated biomass), lanternfish (32% of number, 9% by mass) and *P. guntheri* (11% by mass); in 1994 *C. gunnari* (42% by numbers, 24% by mass), *M. prionosa* (13% by number, 36% by mass), *M. microps* (90% by number), *P. georgianus* (15% by mass) and lanternfish (18% by number but only 1% by mass) were the main prey. The importance of *P. guntheri* to both species in 1986 and its absence in 1994 probably reflect albatrosses, having obtained it from the commercial fishery, which was active in 1986 but closed in 1994. Otherwise the fish diet of black-browed albatrosses is dominated by krill-feeding fish, characteristic of the waters of the South Georgia shelf. In contrast, the grey-headed albatross diet comprises deeper-water mesopelagic species, especially lanternfish, which reflect its affinity for the Antarctic Polar Frontal Zone and associated oceanic upwellings.

WG-EMM-96/12
Cephalopods and mesoscale oceanography at the Antarctic polar front: satellite-tracked predators locate pelagic trophic interactions. P.G. Rodhouse, P.A. Prince, P.N. Trathan, E.M.C. Hatfield, J.L. Watkins, D.G. Bone, E.J. Murphy

and M.G. White. *Mar. Ecol. Prog. Ser.*, 136: 37-50, 1996 (English).

Predator data and exploratory fishing in the Scotia Sea have revealed the presence of cephalopod stocks in the Antarctic Polar Frontal Zone (PFZ). This is a vast, remote region where large epipelagic cephalopods aggregate into highly mobile schools making them difficult to locate and sample. We used satellite-tagged predators and shipboard acoustics for coarse- and fine-scale location of cephalopod concentrations, and sampled them with commercial and scientific nets to determine the relationship between cephalopod distribution and mesoscale oceanographic features at the PFZ. Satellite tags were attached to nine grey-headed albatrosses *Diomedea chrysostoma,* breeding at Bird Island, South Georgia, to monitor foraging at sea from January to March 1994. A foraging area at the PFZ, north of South Georgia, was located, an acoustic survey undertaken and a fixed station established where acoustic targets were found. A net survey was carried out with a commercial pelagic trawl, a rectangular midwater trawl 25 m^2 (RMT25), a horizontal multiple plankton sampler and a neuston net. Acoustic layers were targeted and the RMT25 sampled 200 m layers to 1 000 m in daylight and darkness. Cephalopods were simultaneously recovered from food samples fed to *D. chrysostoma* chicks at Bird Island. Two CTD transects, approximately normal to the major current flow, were undertaken across the PFZ and remote-sensed sea-surface temperature images from NOAA polar orbiting satellites were obtained aboard ship. The pelagic trawl sampled a cephalopod community that closely resembled that exploited by *D. chrysostoma*. The largest and most conspicuous species was the ommastrephid squid *Martialia hyadesi* which is the most important cephalopod prey species. Net-sampled *M. hyadesi* had been feeding on crustaceans and mesopelagic fish. The cephalopod community was sampled within a hydrological feature, interpreted as a warm core ring, in an area characterised by mesoscale features associated with the bathymetry of the northern end of the northeast Georgia Rise and near a gap in the Falkland Ridge. The association of these mesoscale features with the bathymetry suggests that they may be predictable foraging locations for the cephalopods and their predators.

WG-EMM-96/13
Developments in the CEMP indices 1996. CCAMLR Secretariat, 5 pp. (English, unpublished).

WG-EMM-96/14
Testing for normality in colony counts. CCAMLR Secretariat, 3 pp. (English, unpublished).

WG-EMM-96/15
A history of the acquisition and analysis of sea-ice data by CCAMLR. D.J. Agnew (CCAMLR Secretariat), 4 pp. (English, unpublished).

In the early years of development of the ecosystem monitoring program, sea-ice data, especially data derived from satellite images, was recognised as an important source of information for interpreting changes in monitored predator parameters. Standard methods for collection of environmental parameters were agreed in 1990, and following a pilot study carried out by the CCAMLR Secretariat, sea-ice data derived from US Joint Ice Centre charts were routinely acquired and analysed by the Secretariat from 1993. An alternative source of data, digital images produced by the US National Snow and Ice Data Centre, with a relatively low resolution of 25 km, have been archived and analysed routinely by the Secretariat since 1995 to produce a number of indices of 'subarea' scale sea-ice distribution. Archiving and analysing high resolution satellite images remains the responsibility of national monitoring programs.

WG-EMM-96/16
WG-EMM workshop on at-sea behaviour. I.L. Boyd (British Antarctic Survey, High Cross Madingley Road, Cambridge CB3 0ET, United Kingdom), 5 pp. (English, unpublished).

WG-EMM-96/17
Diet of the Cape petrel, *Daption capense*, during the chick-rearing period at Fildes Peninsula and Harmony Point, South Shetland Islands, Antarctica. G.E. Soave,

N. Coria, P. Silva, D. Montalti and M. Favero (Departamento Científico Zoología Vertebrados, Museo de Ciencias Naturales, Paseo del Bosque s/n, 1900 La Plata, Argentina), 15 pp. (English, unpublished).

The diet of the Cape petrel, *Daption capense*, was investigated in two localities in the South Shetland Islands, Antarctica, over the period January/February 1996. Stomach contents of adults and chicks and regurgitation of chicks were sampled during the chick-rearing period. The analysis showed that during the whole sampling period at Fildes Peninsula, euphausiids represented the predominant prey in terms of frequency of occurrence, mass and number, while at Harmony Point, euphausiids and fish were found in similar proportions in terms of mass and frequency. This is the first time myctophids are reported as prey of Cape petrels. The diet composition showed variations throughout the chick-rearing period. Diet composition in terms of frequency of occurrence, mass and number was compared between both sites and with results of previous studies. Different sampling techniques used to obtain food samples are discussed.

WG-EMM-96/18

Krill biomass estimates for two survey boxes to the northeast and northwest of South Georgia in January 1996: the beginning of a five-year monitoring program.
A.S. Brierley, J.L. Watkins and A.W.A. Murray (British Antarctic Survey, High Cross Madingley Road, Cambridge CB3 0ET, United Kingdom), 25 pp. (English, unpublished).

Acoustic surveys were carried out in January 1996 within two 100 x 80 km boxes located over the shelf-break to the northeast and northwest of South Georgia. Surveys were conducted from RRS *James Clark Ross* using a Simrad EK500 echo-sounder operating at 38, 120 and 200 kHz. These surveys were the first in a new five-year British Antarctic Survey program initiated in part to monitor interannual variability in the abundance of the Antarctic krill, *Euphausia superba*, in the South Georgia region, and to provide krill biomass estimates for management purposes. Survey box 1 was located to the northeast of Cumberland Bay and encompassed Charlotte Bank, an area where, historically, whale catches were high and where numerous observations of elevated krill abundance have been made. Box 2 was located to the north of Bird Island, within a foraging area of prime importance for breeding krill predators. Together, therefore, the two boxes provide data of value to fishery scientists, ecologists and environmental modellers. The acoustic surveys were of randomised design and each nominally constituted 10 randomly-spaced parallel transects, 80 km in length, running perpendicular to the major direction of shelf-break in the area; poor weather however necessitated some modification of this plan during the 1996 surveys. All transects were carried out during the hours of daylight in order to avoid biases in krill biomass estimation caused by diel vertical migration. Echoes were integrated in 2 m depth intervals from 2 to 250 m below the transducers, over 100 second intervals (≈ 0.5 km at a survey speed of 10 knots). Two transects were run per day, and at night net hauls were carried out at a location toward the centre of the previous pair of transects to obtain krill for estimates of length frequency distributions. Weighted mean krill lengths of 29.5 mm for box 1 and 32.0 mm for box 2 were determined. Thresholded (MVBS 120 kHz minimum -1 dB) 120 and 38 kHz echo signal pairs were partitioned using a dB difference technique (δ MVBS = MVBS 120 kHz - MVBS 38 kHz) into those attributable to krill (δ MVBS between 2 and 12 dB), small zooplankton (δ MVBS > 12 dB) and nekton (fish/squid, δ MVBS < 2 dB), and a mean weighted biomass and variance estimate for each fraction was derived from the 120 kHz signal using a generic target strength (TS) to weight relationship (TS of 1 kg of krill in box 1 = -39.13 dB, in box 2 = -39.03 dB). Weighted mean krill density estimates (and their weighted variances) for the January 1996 surveys were 40.57 gm^{-2} (13.37) and 26.48 gm^{-2} (54.30) for boxes 1 and 2 respectively. Density estimates for the 1996 season were high compared to those obtained from similar regions during acoustic surveys conducted in January 1994. The previously published 1994 estimates were re-calculated here using the

same target identification and thresholding procedures as those applied to the 1996 data to facilitate direct comparison. The resulting 1994 box 1 and 2 density (and variance) estimates were 1.87 gm^{-2} (0.14) and 7.43 gm^{-2} (1.33) respectively. In 1994 the low krill abundance around Bird Island resulted in greatly reduced breeding success in most habitual krill predator species there. In the 1996 season, however, the breeding success of gentoo penguins, black-browed albatrosses and Antarctic fur seals, species particularly dependant upon krill, was normal. Instantaneous estimates of krill abundance using acoustic techniques are therefore supported by assessments made from predator data, the breeding performances of which provide a longer-term indication of prey abundance in the surrounding pelagic ecosystem within a particular season.

WG-EMM-96/19

A synoptic review of the energetic requirements of Southern Ocean krill predators. A.M. Stansfield (Section of Evolution and Ecology, University of California, Davis Ca. 95616, USA), *CCAMLR Science*, (submitted) (English).

The purpose of this paper is to synthesise information on the energetics and food requirements of krill predators that may be in the most direct competition with the krill fishery. These krill predators are the Adélie (*Pygoscelis adeliae*), chinstrap (*P.antarctica*), gentoo (*Pygoscelis papua*), and macaroni (*Eudyptes chrysolophus*) penguins and the crabeater (*Lobodon carcinophagus*) and Antarctic fur (*Arctocephalus gazella*) seals. Basal, active and reproductive energy requirements are compiled for each species. Estimates of the amount of krill needed to sustain individuals and/or breeding pairs and population requirements are provided.

WG-EMM-96/20

A model at the level of the foraging trip for the indirect effects of krill (*Euphausia superba*) fisheries on krill predators. P.V. Switzer and M. Mangel (Section of Evolution and Ecology, University of California, Davis Ca. 95616, USA). *Journal of Animal Ecology*, (submitted) (English).

Although the development of fisheries for krill in the southern oceans has prompted considerable work on the indirect effects of fisheries on krill predators, to date all work has focused on population level effects. Here, we present for the first time a model at the level of the foraging trip for the effects of a fishery on krill predators, using the Adélie penguin (*Pygoscelis adeliae*) as a model organism. The model has four main components: (i) the description of the spatial and temporal pattern of krill; (ii) the effects of the fishery on the krill; (iii) the description of penguin breeding; and, (iv) the indirect effects of the fishery on penguin reproduction and survival. As with all models, there is some degree of compromise between the level of tractability and the level of biological detail. The objective is to make relative comparisons of penguin reproductive success and adult survival in the absence or presence of a fishery. The biomass of krill appropriate for the predators (and the fishery) fluctuates from one year to the next according to an age-structured, stochastic recruitment model. We use the model to generate the long-term frequency distribution of krill biomass. Furthermore, we assume that there is some kind of spatial-temporal structure, determined by diffusion and advection, to krill availability in relation to the location of the penguin breeding colony. Fishing is assumed to change the spatial and temporal distribution of available krill. We assume that after fledging, the survival of offspring depends in part upon the amount of krill delivered to them during the feeding periods. We use empirical data to estimate the needs of parents and offspring and a standard life history model to set the upper limits for expected survival of parents and offspring. We assume that parental survival subsequent to breeding depends upon the krill deficiency (relative to needs) accumulated while feeding the young. A sensitivity analysis of the breeding model shows that the predictions are robust to parameters about which little is known, to the functional forms relating krill abundance to survival of parents and offspring, and to the rules that parents use to allocate krill to their offspring. We evaluate expected reproductive success (offspring survival) and expected parental survival as functions

of the amount of krill captured by the fishing fleet. Over the range of catch in our study, the reductions in reproductive success are essentially linear functions of krill catch, with slope 1.5. Reductions in adult survival are also linear functions of krill catch, but with slopes less than 1; that is, reductions in reproductive success and parental survival are linear functions of krill catch but not 1:1. The reductions in offspring and parent survival are mainly determined by how long the fishing season lasts and the potential for the fishery, rather than when fishing begins.

WG-EMM-96/21
Climate change and zooplankton dominance in the Antarctic marine ecosystem: implications for the food web. V. Loeb, V. Siegel, O. Holm-Hansen, R.P. Hewitt, W. Fraser, W.Z. Trivelpiece and S.G. Trivelpiece (Moss Landing Marine Laboratories, PO Box 450, Moss Landing, Ca. 95039-450, USA), 13 pp. (English, unpublished).

There is a growing body of evidence that the climate of the Antarctic Peninsula region has been warming over the past 40 years, with an associated decreased frequency of winters with extensive sea-ice development. These trends will potentially have a major impact on the structure and function of the Antarctic marine ecosystem. In the Antarctic Peninsula region, winter sea-ice coverage is a major factor regulating recruitment and population size of Antarctic krill (*Euphausia superba*) and population dynamics of salps (*Salpa thompsoni*). Strong krill recruitment success in this region follows years of extensive winter sea-ice development, and large summertime salp blooms follow winters with relatively little sea-ice. A decrease (by an order of magnitude) in krill population size, increased incidence of massive salp blooms, and decreased abundance of krill-dependent Adélie penguins (*Pygoscelis adeliae*) in the past 15 years suggests that the food web may be affected by climate change. The 1994/95 austral summer season followed the first prolonged winter sea-ice season in three years and provides a strong contrast to the previous years which had little or no winter sea-ice development. The hypothesised relationships between krill and salp population dynamics and winter sea-ice conditions are confirmed and the relative importance of krill and salps within the Antarctic food web are assessed here.

WG-EMM-96/22
Indices of prey availability near the Seal Island CEMP site: from 1990 to 1996. R.P. Hewitt, G. Watters and D.A. Demer (Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), *CCAMLR Science*, (submitted) (English).

Four indices of prey availability are calculated for prey surveys conducted in the vicinity of the Seal Island CEMP site during the austral summers of 1990 to 1996. The indices are measures of average prey density, depth, distance from Seal Island and persistence over time. Acoustic data from the two AMLR surveys carried out each year were sub-sampled to include the foraging range of predators breeding at Seal Island. The average depth of the prey field and its average distance from Seal Island were positively correlated; no other relationships between the indices were apparent. Indices of prey availability were compared with indices of predator performance at Seal Island. The depth of the prey field and its distance from Seal Island appear to have a positive effect on the duration of chinstrap foraging trips, but not on breeding success. The distance of the prey field from Seal Island appears to be negatively correlated with both the duration of fur seal foraging trips and pup growth rate.

WG-EMM-96/23
Distribution, biomass and abundance of Antarctic krill in the vicinity of Elephant Island during the 1996 austral summer. R.P. Hewitt, D.A. Demer and V. Loeb (Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), 10 pp. (English, unpublished).

Results from two acoustic and net surveys conducted in the vicinity of Elephant Island during the 1996 austral summer indicate very good krill recruitment from the 1994/95 spawning season. Areas of high krill density were mapped north of King George and Elephant Islands where

water depth was greater than 200 m. One-year-old juvenile krill numerically dominated catches during the first survey in January and were widely distributed throughout the southern portion of the survey area. Large, sexually mature adult krill were caught during both surveys north of the islands, but were numerically dominant only during the second survey in February/March. Intermediate-sized krill were caught in very low numbers reflecting poor recruitment from spawning in 1992/93 and 1993/94. Biomass and abundance estimates were the highest since 1992 when the effect of good recruitment from the 1991 spawning season was observed. The abundance of salps was similar to 1995 and two to three orders of magnitude less than observed in 1993 and 1994. Following three winters of relatively low sea-ice cover off the western side of the Antarctic Peninsula, the winter of 1994 marked the beginning of a period of relatively extensive ice coverage continuing through 1995. These observations support the hypothesised relationships between winter sea-ice conditions, the lack of a springtime salp bloom, the timing of spawning by adult krill, and the success of krill recruitment proposed by Loeb and Siegel (1994a) and Siegel and Loeb (1995).

WG-EMM-96/24
Areal and seasonal extent of sea-ice cover off the northwestern side of the Antarctic Peninsula: 1979 through 1995. R.P. Hewitt (Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), *CCAMLR Science,* (submitted) (English).

Analysis of seasonal sea-ice cover of a 1 250 000 km^2 area off the northwestern side of the Antarctic Peninsula indicates that four 'ice events' have occurred during the last 17 years. The most recent event was first apparent in 1994 and continues through the latest data available. Variability between ice events in seasonal timing, areal extent, seasonal duration and persistence over multiple years is apparent. Annual curves of sea-ice cover were integrated over time to produce an annual index of sea-ice cover in units of 10^6 km^2 month.

WG-EMM-96/25
Reporting of fine-scale krill data in the 1994/95 season. CCAMLR Secretariat, 22 pp. (English, unpublished).

WG-EMM-96/26
Observations of fishing vessel activity, RKTS *General Petrov*, March to July 1995. Ukraine, 16 pp. (English, unpublished).

WG-EMM-96/27
A way forward in the multivariate analysis of Antarctic predator, prey and environment indices: predator-environment interactions at Seal Island. D.J. Agnew, G. Watters and R.P. Hewitt (Renewable Resources Assessment Group, ICCET, Imperial College, 8 Prince's Gardens, London SW7 1NA, United Kingdom), 8 pp. (English, unpublished).

The CCAMLR Ecosystem Monitoring Program has two aims: to detect changes in critical components of the Antarctic ecosystem, and to distinguish between changes due to the harvesting of commercial species and changes due to environmental variability. Data from Seal Island are used to construct a multivariate model which relates chinstrap penguin breeding success, krill abundance and sea-ice conditions, in order to effectively predict chinstrap success given sea-ice data with an R^2 of 0.914. This model is then used to propose a method of distinguishing between effects of environmental variation and harvesting on chinstrap breeding success. Other Antarctic Peninsula predator parameters are also briefly analysed. The results demonstrate that this methodology could be applied to other CEMP sites, even with the relatively short time series now available, and provides a way forward in the analysis and interpretation of the CEMP indices.

WG-EMM-96/28
Results of a hydroacoustic survey of Antarctic krill populations in Division 58.4.1 carried out in the period January to April 1996. T. Pauly, I. Higginbottom, S. Nicol and W. de la Mare (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 16 pp. (English, unpublished).

From January to March 1996 a

hydroacoustic survey for Antarctic krill was conducted in Division 58.4.1 for the purposes of estimating overall biomass (B_0). The krill biomass in the area surveyed (873 000 km^2) was estimated to be 6.67 million tonnes with a CV of 27%. Krill were more abundant in the west of the survey area, from 80° to 120°E, than in the 120° to 150°E region. The majority of the krill detected were found in the top 80 m of the water column.

WG-EMM-96/29
An overview and some preliminary results of a biological/oceanographic survey off the coast of east Antarctica (80 to 150°E) carried out in the months January to March 1996. S. Nicol, N. Bindoff, W. de la Mare, D. Gillespie, T. Pauly, D. Thiele, E. Woehler and S. Wright (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 30 pp. (English, unpublished).

A major biological/physical survey of the waters off east Antarctica was carried out between January and April 1996. The focus was on the distribution and abundance of Antarctic krill in Division 58.4.1 but in addition, measurements were made of a whole suite of oceanographic and biological variables over the entire survey area. This paper summarises the range of variables measured and provides an overview of some preliminary results.

WG-EMM-96/31
Fish in the diet of the blue-eyed shag *Phalacrocorax atriceps* in the South Shetland Islands: six years of monitoring studies. R. Casaux and E. Barrera-Oro (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 5 pp. (English, unpublished).

The results of six years' monitoring of changes in the diet of the blue-eyed shag, *Phalacrocoraxatriceps*, and based on the analysis of regurgitated pellets collected at two localities of the South Shetland Islands are described. The comments focus principally on *Gobionotothen gibberifrons* and *Notothenia rossii*, species of particular interest for CCAMLR. Although *N. rossii* appeared in the diet of this bird in recent years and no trends were found in the occurrence of *G. gibberifrons* overall, the contribution of these two species to the diet of the blue-eyed shag remains low.

WG-EMM-96/32
The importance of fish in the diet of the South Polar skua, *Catharacta maccormicki*, at the South Shetland Islands, Antarctica. D. Montalti, R. Casaux, N. Coria and G.E. Soave (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 7 pp. (English, unpublished).

Twenty-eight stomach contents of the South Polar skua, *Catharactamaccormicki*, were collected throughout the breeding season at Half-moon Island, South Shetland Islands, Antarctica. The analysis of samples indicated that fish was the most frequent (100%) and dominant (98% by weight) food item and that its importance remained constant throughout the study period. Eight fish species were identified (*Electrona antarctica, Pleuragramma antarcticum, Krefftichthys anderssoni, Chaenocephalus aceratus, Gymnoscopelus braueri, Electrona carlsbergi, Protomyctophum normani* and *P. tenisoni*) with *E.antarctica* being the most important prey. The importance of fish in the diet of the South Polar skua and its implication for CCAMLR studies are discussed.

WG-EMM-96/33
Monitoring of seal populations on King George Island, 1995/96. VNIRO (17a V. Krasnoselskaya, Moscow 107140, Russia), 22 pp. (English and Russian, unpublished).

WG-EMM-96/34
On selectivity of commercial and research trawls during krill fishing. S.M. Kasatkina (AtlantNIRO, 5 Dimitry Donskoy Street, Kaliningrad 236000, Russia), *CCAMLR Science*, (submitted) (English).

This paper describes the results of fishing a single krill aggregation with a commercial trawl RT 72/308 and an Isaacs-Kidd research trawl (IKMT). The commercial trawl catches contained more large krill (35-58 mm) than catches of the research trawl (30-54 mm). The maximum difference in mean length in catches made by both trawls was $\Delta L = 6.2$ mm.

Statistically significant variability in krill length composition was observed between catches made by the research trawl, while in commercial trawl catches krill length composition hardly varied at all. The selectivity properties of the trawl used in acoustic surveys to determine the length-weight composition of krill aggregations are sources of bias in estimating krill target strength (TS), density (in individuals/m^2) and abundance. Using the same value of MSBS (mean surface backscattering strength), krill density calculated from commercial trawl data was lower than density calculated from research trawl data. According to the parameters of the regression between krill length and krill target strength (TS=f(L)) recommended by CCAMLR, the mean difference in krill length (ΔL = 6.2 mm) between catches made by two types of trawl produces a difference in TS (ΔTS) = 2.1 dB. The corresponding variation in krill density (in individuals/m^2) was 1.65 times. Selectivity studies carried out for the commercial trawl RT 72/308 showed that, in general, krill selectivity of midwater trawls depends on its design and trawl rigging used, trawling speed and the rate at which the trawl bag fills up with krill.

WG-EMM-96/35

Hydrometeorological condition features in South Orkneys subarea in February/March 1996. M.I. Polischuk and V.N. Shnar (AtlantNIRO, 5 Dimitry Donskoy Street, Kaliningrad 236000, Russia), 13 pp. (English, unpublished).

Some results of the atmospheric circulation in the Antarctic sector of the Atlantic, thermochaline conditions and surface geostrophic transfers are described in the paper. Daily indices of atmospheric circulation were calculated for the period February/March 1996, and contained ten-day periods and monthly. Thermochaline conditions were evaluated for the study area near South Orkneys. The distribution of maximum temperatures in the study area has allowed description of the main water masses, the position of a secondary frontal zone and geostrophical currents. Some anomalies in the atmospheric circulation were observed during the period of investigation (February/March 1996) over the average for many years. The predominance of the meridional transfer over the zonal transfer was noted. Negative anomalies of the thermochaline characteristics in Subarea 48.2 were also noted. The presence of an anticyclonic current near the South Orkneys was recorded.

WG-EMM-96/36

Results of acoustic assessment of krill biomass in Subarea 48.2 during summer 1996. S.M. Kasatkina, V.A. Sushin, V.Yu. Sunkovich, M.I. Polischuk and V.N. Shnar (AtlantNIRO, 5 Dimitry Donskoy Street, Kaliningrad 236000, Russia), *CCAMLR Science*, (submitted) (English, Russian original).

From 24 February to 7 March 1996, an acoustic survey of krill biomass and distribution was carried out on board RV *Atlantida* in the area between 59°10'S to 60°30'S and 42°00'W to 50°00'W (Subarea 48.2). The study area, comprising 19 200 square miles, was located in the section in which two circulation systems, Antarctic Circumpolar Current and Weddell Sea Gyre, occur. The survey area included a broad spectrum of hydrobiological and oceanographic observations and studies. Echointegration equipment on board consisted of EK-500 and BI-500 echo-sounders. Calibration of the EK-500 echosounder was performed by specialists from SIMRAD (Norway). The echosurvey was carried out using a uniform square grid of tacks located 20 miles apart. The echosurvey was carried out on a 24-hour basis. Krill target strength was estimated using the TS/length relationship recommended by WG-Krill (SC-CAMLR, 1991). The recorded range of MSBS values variations was (-77 ÷ -43) dB. Krill biomass in the study area was estimated to be 1.12 million tonnes at a confidence limit of 95% (CL = 93.1 thousand tonnes). The coefficients of variation of krill density and biomass within strata specified did not exceed 8%. Biomass estimates were below those expected in accordance with data obtained by AtlantNIRO in previous years. In part, these results are explained by a 24-hour regime of hydroacoustic observations used during the survey. According to Demer and Hewitt (1995), if

krill vertical diurnal migrations are not taken into account in hydroacoustic evaluations, krill biomass would be underestimated by 1.9 dB at s.d. = 0.6 dB. Furthermore, the study area did not include the southern part (southwards of 60°30'S) of Subarea 48.2 where considerable krill fishing grounds are located to the south of Coronation Island. According to data held by AtlantNIRO, the biomass of krill southwards of 60°30'S amounts to about 883 ± 264.9 thousand tonnes. Therefore, the total krill biomass in Subarea 48.2 may be assessed at 2.6 million tonnes at a confidence limit of 95% (CL = 298.2 thousand tonnes).

WG-EMM-96/37

Evaluation of krill transport factor results in Subarea 48.2 in summer period of 1996. S.M. Kasatkina, V.N. Shnar, M.I. Polischuk, A.M. Abramov and V.A. Sushin (AtlantNIRO, 5 Dimitry Donskoy Street, Kaliningrad 236000, Russia), *CCAMLR Science,* (submitted) (English, Russian original).

This paper describes the results of an experiment conducted to assess krill flux factors in Subarea 48.2 from 19 February to 7 March 1996. The study area (80 x 240 miles) was located in the zone of interaction between waters of the Antarctic Circumpolar Current (ACC) and Weddell Sea in the Secondary Frontal Zone. The study area covered sites where high krill concentrations were usually observed in the past. The intensity of krill biomass transport across boundaries of the study area was calculated as a product of two variables integrated over a depth range 0-200 m: krill density (tonnes/n.mile^3) and water mass transport (n.miles^3/hour) per nautical mile of the study area boundary. Also given are the results of krill density assessment, calculations of geostrophic velocities and water transport along the study area perimeter. Mean krill transport intensity was 7.2 tonnes/hour/n mile with a standard deviation of 15.5 tonnes/hour/ n mile. Significant variability of krill transport across the study area boundary was observed, in terms of both the amount of biomass transported and the direction of flux. It was found that because of the location of the study area it was only possible to assess krill flux caused by waters of the southern periphery of ACC. Based on estimations of krill density and geostrophic velocities obtained during the experiment, an annual outflow of krill from the study area into adjacent areas would amount to approximately 9.2 million tonnes.

WG-EMM-96/38

Trends in size and success of breeding colonies of macaroni and rockhopper penguins at Marion Island, 1979/80 to 1995/96. J. Cooper, A. Wolfaardt and R.J.M. Crawford (African Seabird Group, PO Box 34113, Rhodes Gift 7707, South Africa), *CCAMLR Science,* (submitted) (English).

At Marion Island, breeding success of macaroni penguins, *Eudyptes chrysolophus*, was measured at three colonies between 1979/80 and 1995/96. Breeding success of rockhopper penguins, *E. chrysocome*, was measured at three colonies between 1985/86 and 1995/96. For macaroni penguins, averages of 0.48 and 0.35 chicks were hatched and fledged respectively for each clutch laid. Average numbers of chicks hatched per clutch at colonies varied between 0.00 and 0.83, and average numbers of chicks fledged between 0.00 and 0.80. For rockhopper penguins, averages of 0.68 and 0.48 chicks were hatched and fledged respectively for each clutch laid. Average numbers of chicks hatched per clutch at colonies varied between 0.41 and 0.96, and average numbers of chicks fledged between 0.17 and 0.72. The largest of the three macaroni penguin colonies decreased over the study period; the other two remained stable. The only significant relationship between inter-season trends in the number of pairs breeding at the three colonies was a negative relationship between two adjacent colonies, which suggests pairs may have moved between these two colonies. The larger two of the three rockhopper penguin colonies both decreased over the study period; the other remained stable. Trends in the number of pairs breeding at the three colonies were all strongly significantly related. This suggests that the proportion of rockhopper penguins attempting breeding may vary as a result of some environmental signal, whereas there is little

inter-season variation in numbers of macaroni penguins that attempt breeding. For macaroni penguins over the entire period, inter-season trends in breeding success were significantly correlated at the 5% level in all three of the inter-colony comparisons possible. Both hatching success and chick survival were significantly related at the 2% level in one inter-colony comparison. One other comparison of chick survival was significantly related at the 5% level. At all three macaroni penguin colonies, chick survival was poor in 1989/90. For rockhopper penguins, inter-season trends in both breeding success and chick survival were correlated at the 5% level in only one of the three inter-colony comparisons possible. No trends in hatching success were correlated at this level. Coherence in the performance of colonies was greater for macaroni penguins than for rockhopper penguins, suggesting that breeding success of macaroni penguins may be influenced by a wider-scale phenomenon than is applicable to rockhopper penguins. For both species, coherence was primarily the result of similar trends in chick survival. Trends in breeding success, hatching success and chick survival of macaroni penguins and rockhopper penguins were not related to each other, even for nearby colonies. This suggests that factors influencing the reproductive performance of the two species are not the same.

WG-EMM-96/39

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

WG-EMM-96/40

Uncertainty in echosounder calibrations. D.A. Demer and M.A. Soule (Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), 17 pp. (English, unpublished).

Calibration of echosounders for fish stock assessment are commonly performed using the standard sphere method (Johannesson and Mitson, 1983; Simmonds et al., 1984). To determine the accuracy of the method, direct measurements of target strength (TS) were made of three standard spheres (Copper (Cu) - 23.0 mm and tungsten carbide (WC) - 33.0 mm and 38.1 mm). At the best-case range of 5 m, the TS measurements of the spheres differed from the theoretical values (derived by integrated intensities) by -0.1, 0.3 and 0.1 dB, with standard deviations of 0.1, 0.3 and 0.2 dB respectively. The operative measure (derived by peak intensities), differed from the theoretical values by -0.2, 0.4 and 0.2 dB with standard deviations of 0.1, 0.3 and 0.2 dB respectively. To characterise the precision of the method for a fixed pulse length (0.3 ms) and water temperature (18.9°C), a Simrad EK500 echosounder was used to measure sphere TS versus time. Over two 15-hour periods, the measured TS ranged 1.2 dB for a 23.0 mm Cu sphere and 1.4 dB for a 38.1 mm WC sphere. Vector admittance measurements were made of an ES120 transducer versus water temperature (0.06 to 16.8°C). Although the measurements were not free-field, and were in consequence noisy, the trends versus increasing water temperature indicated decreasing admittance at the operating frequency (119.047 kHz), decreasing resonance frequency, and increasing motional resistance. Judging from these experiments, system calibration at 120 kHz, at a fixed water temperature, using an optimal standard sphere and a 0.3 ms pulse length is estimated to be accurate to ± 0.3 dB, and precise to ± 0.2 dB for TS measurements, and accurate to ± 0.2 dB and precise to ± 0.2 dB for echo integration. Additionally, more pronounced imprecision may be contributed by instabilities in the echosounder electronics. Furthermore, when operating under conditions of varying water temperature, associated changes in transducer performance may cause significant increases in calibration uncertainty. The temperature effects on system gain are consistent with predictions (Blue, 1984), and prior experimental results (Demer and Hewitt, 1993).

WG-EMM-96/41

Measurements of fish school velocities with an acoustic Doppler current profiler. D.A. Demer (Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA),

16 pp. (English, unpublished).

Horizontal and vertical velocities of fish schools were measured using an acoustic Doppler current profiler (ADCP). To determine three orthogonal velocity vectors (east, north and vertical), it was required that the four ADCP beams simultaneously insonified a fish school, in the same depth bin. Velocity vectors which satisfied these conditions were extracted from individual ping velocity estimates and ensemble averaged to determine the average speeds and directions of fish aggregations. The results suggests that the ADCP can be a useful tool for observing fish behaviour in certain situations. Some applications may include the quantification of horizontal and vertical migration patterns of large scattering layers and possibly vessel avoidance reaction. The method can be enhanced by utilising the radial velocity components from each beam and correcting for platform motion.

WG-EMM-96/42

An acoustic survey of Antarctic krill on the South Georgia shelf, Subarea 48.3, in January 1992. C. Goss and I. Everson (British Antarctic Survey, High Cross Madingley Road, Cambridge CB3 0ET, United Kingdom), 22 pp. (English, unpublished).

Acoustic surveys designed to assess krill abundance are costly in terms of time and money, so the opportunity was taken in 1992 to produce a krill biomass estimate as a by-product of a fish stock assessment survey in Subarea 48.3. Acoustic transects were run between trawl stations using a sounder operating at 38 kHz and 120 kHz. The results have been analysed for all straight sections of track when the ship's speed exceeded 7 knots and when the ship was over the shelf around the main island of South Georgia. The appearances of echoes on echocharts were used to decide which echoes to include in krill estimates. The results were partitioned by depth to remove deep echoes that were thought to be mostly due to other scatterers. A threshold at one frequency was used to remove noise and any echoes too weak to be separated from the background. The remaining fraction was further subdivided using the ratio of backscattering strength at the two frequencies into (i) echoes from krill-sized scatterers and smaller and (ii) echoes from larger scatterers. The data in the krill-size subset has been converted to density estimates; these are presented for day and for night sections of the survey and at locations mapped around the island. An overall mean for daytime transects was 95 g m^{-2}.

WG-EMM-96/43

Interannual variation in condition index of the mackerel icefish *Champsocephalus gunnari*. I. Everson, K.-H. Kock and G. Parkes (British Antarctic Survey, High Cross Madingley Road, Cambridge CB3 0ET, United Kingdom), 17 pp. (English, unpublished).

Mackerel icefish (*Champsocephalus gunnari*) are widespread on the South Georgia (54°S 36°W) shelf. Analysis of results on condition index indicated a strong interannual variation. High condition indices, indicative of good feeding conditions, were present when krill was abundant in the region. Years when krill was scarce, and condition index was consequently low, were consistent with years when indices from land-based krill predators also indicated krill was scarce.

WG-EMM-96/44

Diet of the Cape petrel, *Daption capense*, during the post-hatching period at Laurie Island, South Orkney Islands, Antarctica. N. Coria, G.E. Soave and D. Montalti (Departamento Bilogía, Grupo Aves, Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 13 pp. (English, unpublished).

The diet of the Cape petrel, *Daption capense*, was investigated at Laurie Island, South Orkney Islands (60°46'S, 44°42'W), Antarctica, over the period January/ February 1996. Stomach contents of adults and regurgitates of chicks were sampled during the post-hatching period. The analysis showed that during the whole sampling period, Antarctic krill and fish were predominant prey items in terms of frequency of occurrence. Fish made up almost 64% by mass, and krill comprised 35.8% of prey items throughout the sampling period. *Electrona antarctica* was the species most frequently observed in

stomachs. Amphipods were present in lower numbers and cephalopods comprised only a very small proportion of the diet of Cape petrels on the Mossman Peninsula. Results of this study were compared with results of previous studies.

WG-EMM-96/45

Long-term monitoring of krill recruitment and abundance indices in the Elephant Island area (Antarctic Peninsula). V. Siegel, W. de la Mare and V. Loeb (Bundesforschungsanstalt für Fischerei, Institut für Seefischerei, Palmaille 9, 22767 Hamburg, Germany), *CCAMLR Science*, (submitted) (English).

Krill distribution and density are reviewed for the Elephant Island area with regard to the representativeness of the study area (60°-62°30'S and 53°-57°30'W) for the recruitment and density indices. Recruitment indices were re-calculated applying the delta distribution approach introduced by de la Mare (1994a). The high interannual variability of krill recruitment is confirmed by the present analysis. Results are compared for one- (R_1) and two-year-old (R_2) age classes. Statistically significant fluctuations in krill density over the period 1977 to 1994 are also confirmed by this study using randomisation tests on an analysis of variance.

WG-EMM-96/46

Effect of missing modes on calibration sphere target strengths. K.G. Foote (Institute of Marine Resources, PO Box 1870, Nordnes N-5024 Bergen, Norway), 10 pp. (Submitted to ICES as document number ICES CM 1996/B 37, Fish Capture Committee) (English).

It has been suggested that modes of vibration of solid elastic spheres, such as those used in the calibration of echosounder systems, can be affected by the manner of suspension. This hypothesis is investigated in the context of reported experimental calibration trials with the SIMRAD EK500 / 120 kHz echosounder. In these trials, as many as four different spheres were used: 23- and 30.05 mm diameter spheres composed of electrical grade copper and 33.2- and 38.1 mm diameter spheres composed of tungsten carbide with 6% cobalt binder. Theoretical target strengths are computed for each sphere under the reported measurement conditions for a series of cases in which single vibration modes remain unexcited. The computed target strengths are compared with the corresponding experimental values. The working hypothesis is not supported by the data.

WG-EMM-96/47

CPUE and body length of Antarctic krill during the 1994/95 season in the fishing grounds around the South Shetland Islands. S. Kawaguchi, T. Ichii and M. Naganobu (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, Shizuoka 424, Japan), 18 pp. (English, unpublished).

This paper summarises Japanese krill catch data for the 1994/95 austral summer. The main fishing grounds were consistently located to the north of Livingston Island throughout the season (except in April), and around Elephant Island during April and May. While CPUEs on fishing grounds to the north of Livingston Island were relatively stable throughout the season, they were highly variable around Elephant Island. Krill with a modal length of 48 to 50 mm, i.e. significantly larger than the previous season, were dominant in catches.

WG-EMM-96/48

Report of the 1995/96 Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) in Area IV and the eastern part of Area III. S. Nishiwaki, H. Ishikawa, D. Tohyama, M. Kawasaki, K. Shimamoto, S. Yuzu, T. Tamura, T. Mogoe, T. Hishii, T. Yoshida, H. Hidaka, H. Nibe, K. Yamashiro, K. One and F. Taguchi (Institute of Cetacean Research, 4-18 Toyomi-cho, Chuo-ku, Tokyo 104, Japan), 48 pp. (English, unpublished).

The ninth survey of the Japanese Whale Research Program Under Special Permit in the Antarctic (JARPA) was carried out in Antarctic Area IV (south of 60° between 70°E and 130°E) and in the eastern part of Area III (south of 60°S between 35°E and 70°E). The survey was conducted for 118 days, from 26 November 1995 to

22 March 1996. The research fleet consisted of a research base vessel, carrying out a biological survey of minke whales, three sighting/sampling vessels (SSVs) conducting sighting and sampling studies and one sighting vessel (SV) dedicated exclusively to sighting activities. The survey in the eastern part of Area III was conducted before and after the survey of the whole of Area IV. The Area IV survey was conducted during the period in which the peak migration of minke whales was expected. The survey in the eastern part of Area III was conducted as a feasibility study on stock identification, and samples were taken both early and late in the feeding season in order to study intra-seasonal changes. During sampling, one animal was taken randomly from schools sighted as primary sighting. This was made in order to conduct a more representative study of the population. Dwarf form minke whales were not sampled. The sighting vessel was exclusively engaged in a whale sighting survey in all of the research areas, along an independent sighting track line. Sighting and sampling activities were independently conducted by the three SSVs, along track lines which were parallel to each other. The search distance for these four vessels was 21 455.5 n miles. During the research period, 893 schools (2 021 animals) of the normal form minke whale were sighted as primary sightings and 244 schools (564 animals) as secondary sightings. From the 693 schools (1 439 animals) primarily sighted by the SSVs, 440 ordinary form minke whales (273 males and 167 females) were randomly sampled. The distribution pattern of minke whales in Area IV was not significantly different from that observed during the 1993/94 JARPA. In previous research, a high density was observed in Prydz Bay. However, such a high density was not found in the present research. The distribution of cetacean species during the research period suggests the segregation of minke and humpback whales, and sperm and beaked whales including the southern bottlenose whale. This segregation was related to the pattern of the ice edge in the research area. It is presumed that concentrations of pregnant females in Prydz Bay may cause differences, as no significant difference is observed when the Prydz Bay data is excluded from data from the western part of Area IV. The eastern part of Area III is close to Prydz Bay and many large mature females were sampled in the southeast of Area III during the second survey. It seems that most female minke whales in Prydz Bay tend to migrate through the eastern part of Area III. During the survey, three schools (four animals) of blue whales, 25 schools (48 to 50 animals) of humpback whales and four schools (four animals) of right whales were photographed for natural markings. Ten skin biopsy samples were taken from humpback whales and one sample each was taken from blue and right whales.

WG-EMM-96/49

Comparisons in prey distribution between inshore and offshore foraging areas of chinstrap penguins and Antarctic fur seals at Seal Island. T. Ichii, J.L. Bengtson, T. Takao, P. Boveng, J.K. Jansen, M.F. Cameron, L.M. Hiruki, W.R. Meyer, M. Naganobu and S. Kawaguchi (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, Shizuoka 424, Japan), 18 pp. (English, unpublished).

At Seal Island, breeding predators such as Antarctic fur seals (*Arctocephalus gazella*) and chinstrap penguins (*Pygoscelis antarctica*) which incorporate overnight periods into their foraging trips foraged beyond the inshore region, in the slope/offshore region, even though krill was less abundant there and the region was more remote from their breeding sites. Only chinstrap penguins with diurnal patterns of foraging trips foraged in the inshore region. Feeding at night is considered to have the following advantages for predators which use their vision to locate prey: (1) krill is distributed more evenly in the slope/offshore region in contrast to patchy distribution in the inshore region and therefore krill may be found more easily; (ii) krill tend to be larger and at later stages of maturity in the slope/offshore region than in the inshore region - larger gravid female krill, which may be easily located and captured by predators, were present in numbers in the slope/offshore region; and (iii) myctophid fish occurred

more towards the surface at night in the slope/offshore region (their ventral light organs may be an easy target for predators at night). These advantages may make the slope/offshore region a more favourable foraging area in spite of lower krill density.

WG-EMM-96/50

CPUE and recruitment indices calculated from logbook data of Japanese krill fisheries. S. Kawaguchi, T. Ichii and M. Naganobu (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, Shizuoka 424, Japan), *CCAMLR Science*, (submitted) (English).

CPUE and recruitment indices for the years 1980 to 1995 were calculated, using on the logbook data from commercial krill trawlers. Monthly CPUE was seen to vary in the long term, but this trend might be the result of changes in the operational strategy of vessels aiming to obtain high quality krill. In general, recruitment indices presented in the paper agreed with those published by Siegel and Loeb (1995), however, some discrepancies were also found and discussed.

WG-EMM-96/51

CPUE, net towing depth and body length of krill during the winter operation of Japanese krill fishery around South Georgia. S. Kawaguchi, T. Ichii and M. Naganobu (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, Shizuoka 424, Japan), 8 pp. (English, unpublished).

Monthly CPUEs of Japanese krill trawlers fishing in winter around South Georgia were calculated. The range of CPUE values in the 1991 season (a year of poor krill abundance) was comparable to the range of CPUEs from summer fishing operations around Elephant Island and Livingston Island. Vertical distribution of krill was evaluated from net towing depths. Net tow depth data implied that, in general, krill in winter may be distributed to a greater depth than in summer seasons. Interannual variability in vertical distribution was also discussed. Length frequency distribution implied the evidence of a strong influx of krill from the Antarctic Peninsula and Weddell Sea regions.

WG-EMM-96/52

Preliminary results on by-catch of fish caught by the FV *Chiyo Maru No. 3* to the north of the South Shetland Islands (February to March 1996). S. Kawaguchi, T. Ichii and M. Naganobu (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, Shizuoka 424, Japan), 4 pp. (English, unpublished).

The by-catch of fish was examined from samples taken during krill fishing by FV *Chiyo Maru No. 3* from 3 February to 6 March 1996 to the north of the South Shetland Islands. From the 147 hauls examined, a total of 99 specimens of fish was caught in 41 hauls containing 14 species belonging to five families. Notothenioid juveniles were found in 30 hauls taken in waters with a depth of 87 to 853 m (average 186 m). On the contrary, bathypelagic fish (myctophids and paralepidids) were found in 11 hauls taken at some distance from the shelf, in offshore waters between 275 to 1 780 m in depth (average 1 006 m). Notothenioid juveniles were never caught together with bathypelagic fish species in any of the hauls examined. Among by-catch fish, juvenile *Lepidonotothen larseni* was the most abundant. This species was found in 15 hauls. An estimated by-catch of this species (arithmetic mean) was 4 ± 19 spp./tonne (0 to 140 spp./tonne of fish caught) or 51 ± 217 spp./hour (0 to 3 927 spp./hours) of trawling respectively. The next most abundant fish was the Bathypelagic species, *Electrona carlsbergi*, which was found in samples from six hauls. Its by-catch (arithmetic mean) was 3 ± 21 spp./tonne (0 to 220 spp./tonnes) of catch and 32 ± 178 spp./hour (0 to 1 509 spp./hour) of trawling. Although the CPUE of krill in hauls in which there was no by-catch of fish ranged widely, large incidental catches of fish tended to occur in hauls in which the CPUE of krill was lower.

WG-EMM-96/55

Comparisons in diet between diurnal and overnight foraging chinstrap penguins at Seal Island. T. Ichii, T. Hayashi, J.L. Bengtson, P. Boveng,

J.K. Jansen, M.F. Cameron and A. Miura (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, Shizuoka 424, Japan), 17 pp. (English, unpublished).

Diets of diurnal and overnight foraging chinstrap penguins (*Pygoscelis antarctica*) breeding at Seal Island during the 1988/89, 1989/90, 1993/94 and 1994/95 chick-brooding seasons were analysed. Diet estimated from digested and intact stomach contents mass indicates that krill were predominant in their diets. Fish constituted from 0 to 1% and 14 to 45% of the diet of diurnal and overnight foragers respectively. The highest consumption of fish was observed in 1993/94 when krill abundance was very low. Calorific values of the estimated dietary mass were 4 085 kJ for diurnal foragers and 4 809 kJ for overnight foragers, which were comparable with daily average energy requirements calculated for a diurnal forager (4 853 kJ) and an overnight forager (5 732 kJ) based on available input parameters. A comparison of krill in the diet and those in the foraging areas indicates that diurnal foragers took krill in the inshore region, where krill tended to be smaller and less mature. Overnight foragers, on the other hand, took krill in both the offshore region, where krill tended to be larger and mature, as well as in the inshore region. Penguins which foraged overnight tended to select larger female krill, but diurnal foragers tended to select subadult male krill; both types of foragers took very few adult male krill and juvenile krill. It is, therefore, considered that both types of foragers tend to take the larger krill of those least capable of avoiding capture in their respective foraging areas.

WG-EMM-96/56
Calculating precautionary catch limits based on mass of krill consumed by predators. I. Everson and W. de la Mare (British Antarctic Survey, High Cross Madingley Road, Cambridge CB3 0ET, United Kingdom), 4 pp. (English, unpublished).

WG-EMM-96/57
Cooperative project Belgium - Argentina into EMM: 'Gerlache - Sobral'. D. Vergani, L. Holsbeek, Z. Stanganelli and C. Joiris (VRIJE University Brussel, Lab for Ecotoxicology and Polar Biology, Pleinlaan 2, 1050 Brussels, Belgium), 1 pp. (English, unpublished).

WG-EMM-96/58
The breeding biology and distribution of Adélie penguins: adaptations to environmental variability. W.Z. Trivelpiece and W. Fraser. In: Ross, R., E. Hofmann and L. Quetin (Eds). *Foundations for Ecological Research West of the Antarctic Peninsula.* American Geophysical Union, Washington D.C., 1996 (English).

Adélie penguins are long-lived, highly philopatric seabirds which dominate the bird biomass of the western Antarctic Peninsula region, and serve as focal animals for our Long Term Ecological Research (LTER) study of the effects of environmental variability on animal populations in the Antarctic marine ecosystem. The major physical factors affecting the breeding success, distribution and demography of Adélie penguins in the Southern Ocean are variability in sea-ice cover, ocean circulation patterns and terrestrial topography. We analysed Adélie distributions in the Antarctic Peninsula region and concluded that Adélie penguins have discrete sub-populations in the northeastern and southwestern regions of the area. These sub-populations are separated by a 400 km gap in their respective distributions, but each is within several hundred kilometres of predictable pack-ice areas in the Weddell and Bellingshausen Seas, respectively. We propose that these pack-ice areas are the wintering grounds for each of the sub-populations, and that access to these pack-ice areas, early in the season following courtship fasting, is the key to successful breeding in Adélies. We further analysed the colony distributions within each sub-population and found highly clumped distributions of Adélie penguins that were strongly correlated to physical factors such as bathymetry, currents and wind direction. We propose that these variables reduce the occurrence of pack-ice in the vicinity of breeding colonies of Adélie penguin populations, thereby assuring access to open water early in the

season. Finally, we examined the influence of the interaction of local topography and weather on the size, location and persistence of breeding groups within Adélie penguin colonies. Snow accumulation, melt water runoff and solar radiation all have an impact on the microclimate of breeding colonies and influence the selection of nesting sites among Adélie penguins. The abandonment of breeding areas by Adélie penguins, following two to three years of failure at 'poor' sites, suggests that changes in the population distribution of Adélie penguins may be very rapid in response to changing environmental conditions, such as increased snow deposition. Adaptations to environmental variability are seen in every aspect of the natural history of the Adélie penguin, from the distribution of sub-populations around Antarctica, to the sizes and distributions of colonies within regions and the choice of breeding sites within colonies.

WG-EMM-96/59
Use of at-sea distribution data to derive potential foraging ranges of macaroni penguins during the breeding season. P.N. Trathan, E.J. Murphy, J.P. Croxall and I. Everson (British Antarctic Survey, High Cross Madingley Road, Cambridge CB3 0ET, United Kingdom), 22 pp. (English, unpublished).

WG-EMM-96/60
A conceptual framework for modelling Antarctic krill. E.E. Hofmann (Center for Coastal Physical Oceanography, Crittenton Hall, Old Dominion University, Norfolk Va. 23529, USA), 6 pp. (English, unpublished).

WG-EMM-96/61
Oceanographic circulation models for the western Antarctic continental shelf and Drake Passage. J.M. Klinck, E.E. Hofmann and E.J. Murphy (Center for Coastal Physical Oceanography, Crittenton Hall, Old Dominion University, Norfolk Va. 23529, USA), 10 pp. (English, unpublished).

WG-EMM-96/62 Rev. 1
Executive summary of SCAR/ COMNAP workshops on 'Monitoring of Environmental Impacts from Science and Operations in Antarctica'. (Oslo, Norway 17 to 20 October 1995 and College Station, Texas, USA, 25 to 29 March 1996).

WG-EMM-96/63
Estimation of the biomass of krill (*Euphausia superba*), and birds and mammals censuses during the Xth Italian expedition to the Ross Sea, November/December 1994. M. Azzali, J. Kalinowski and N. Saino (C.N.R - I.R.Pe.M., Largo Fiera della Pesca, 60100 Ancona, Italy), 31 pp. (English, unpublished).

During the Xth Italian Antarctic Expedition to the Ross Sea Pacific sector of the Antarctic in November and December 1994, a krill biomass acoustic survey was conducted. During the survey sightings of birds and mammals sightings were also recorded. At the time of the survey a considerable part of the ocean was covered by ice, which affected survey results. The sea-ice cover was assessed on a scale of 0 to 10. The results of all observations are summarised in tables.

WG-EMM-96/64
Detailed distribution of krill fishing around South Georgia. E.J. Murphy, P.N. Trathan, I. Everson and G. Parkes (British Antarctic Survey, High Cross Madingley Road, Cambridge CB3 0ET, United Kingdom), *CCAMLR Science*, (submitted) (English).

The distribution of krill harvesting effort and associated catch rates has previously only been available to the scientific community in the form of subarea or fine-scale (0.5° latitude by 1° longitude) statistics recorded by subarea or fine-scale rectangle. Earlier analyses of these data have shown the krill fishery was a shelf-break fishery over much of the Scotia Sea. Although these statistics give a general idea of where the fishery has operated they do not reveal the localised nature of the fishing operation. In particular they give little ecological insight

into how the fishable aggregations relate to the local environmental conditions. Over the last three winter fishing seasons (1993 to 1995), haul-by-haul statistics have been recorded in the South Georgia area. Analyses of these data show marked interannual variability and indications of a seasonal pattern. In 1994 the fishery was almost totally based over a large shallow bank area on the northeast shelf edge. During 1995 the fishery was still predominantly in this area but also operated further west on a range of banks associated with submarine canyons. The data for 1993 were only available from August but the fishery was restricted in that period to an area on the western edge of the shelf break where negligible fishing occurred in the following two seasons. The results are discussed in relation to the ecology of krill and the interaction of the fishery with the local predator colonies.

WG-EMM-96/65
Hatching season and growth of *Pleuragramma antarcticum* larvae near the Antarctic Peninsula in the 1993/94 austral summer. T. won Lee, S. Kim and S. Sik Cha (Department of Oceanography, Chungnam National University, Taejon 305-764, Republic of Korea), 13 pp. (English, unpublished).

The hatching season and larval growth of *Pleuragramma antarcticum* in the water off the Antarctic Peninsula were determined by the examination of growth increments in otoliths. The samples were collected by BONGO and MOCNESS plankton nets from December 1993 to January 1994. *P. antarcticum* was predominant (54 out of 77 fish larvae collected) in ichthyoplankton samples, and occurred mainly in cold waters in the Weddell Sea. Body length of *P. antarcticum* ranged from 12 to 67.3 mm. Otolith radii (R) ranged from 150 to 260 μm, and bore a linear relationship to body size (L); R = -43.6 + 5.99 L (r^2 = 0.79). The mean size of otolith cores was about 50 μm in diameter. The width of the growth increments was narrow near the core, but became broader at around 50 to 100 increments (ca. 1.3 μm). However, it decreased thereafter toward the edge, maintaining a size of ca. 0.5 μm. Assuming that growth increments were deposited daily after hatching and the mean number of increments was 178.3 ± 12.8, *P. antarcticum* seems to be hatched during June/July. Based on the samples examined, two hatching periods for *P. antarcticum* were suggested, the larger larvae (40 to 50 mm) hatched in winter (June/July), with the smaller ones hatching in early summer (December).

WG-EMM-96/66
Preliminary estimates of krill consumption by Antarctic fur seals and macaroni penguins at South Georgia. I.L. Boyd and J.P. Croxall (British Antarctic Survey, High Cross Madingley Road, Cambridge CB3 0ET, United Kingdom), 28 pp. (English, unpublished).

WG-EMM-96/67
Extension to the krill-predator modelling exercise. R.B. Thomson and D.S. Butterworth (Department of Applied Mathematics, University of Cape Town, Rondebosch 7700, South Africa), 20 pp. (English, unpublished).

The krill-predator modelling calculations of Thomson and Butterworth (1995) are extended to take account of a number of the suggestions made at the 1995 meeting of the CCAMLR Working Group on Ecosystem Monitoring and Management (WG-EMM). The resilience of the Antarctic fur seal population to krill harvesting is found to be strongly dependent on the estimate of the maximum annual growth rate (R) which the population can achieve. For R = 10%, it is estimated that a krill harvesting intensity rate γ of slightly more than 0.1 would be required to reduce the seal population to half its pre-exploitation level. Similar calculations are initiated for the black-browed albatross, but require the separation of fishery-related mortality effects from overall survival rate data before they can be taken further.

WG-EMM-96/68
Modelling the growth dynamics of Antarctic krill. C.M. Lascara and E.E. Hofmann (Center for Coastal Physical Oceanography, Crittenton Hall, Old Dominion University, Norfolk Va. 23529, USA), 11 pp. (English, unpublished).

A time-dependent, size-structured,

bioenergetically-based model was developed to examine the growth dynamics of Antarctic krill, *Euphausia superba*. A system of coupled, ordinary differential equations was developed to describe the growth of krill between 2 and 60 mm. The metabolic processes included in the model were ingestion, assimilation efficiency, a baseline respiration, respiratory losses due to feeding and digestion, and an activity-based respiration factor. Positive net production resulted in the transfer of individuals to the next highest size class (growth), whereas negative net production resulted in transfer to the next smallest size class (shrinkage). Size-dependent parameterisations of model coefficients were constructed from an analysis of field and laboratory measurements provided in the current literature. The model was run based on an environmental time series of food availability (pelagic phytoplankton concentration) that was derived from data sets collected west of the Antarctic Peninsula. Three time series were created to represent high, low and intermediate food conditions with the high and low conditions representative of phytoplankton concentrations observed on the inner and outer shelf, respectively. Simulated growth rates during the spring and summer for all size classes were consistent with published growth rates; however, winter shrinkage rates were too large. Although the use of a seasonally-varying respiration activity factor (reduced winter respiration rates) resulted in winter shrinkage rates of adults that were consistent with observations of experimentally-starved individuals, the annual change in length of specific size classes was still inconsistent with observations. Subsequent simulations were designed to examine the effect of the ingestion of sea-ice algae in the late winter and early spring. The annual growth cycle best matched observations with reduced winter respiration rates and ingestion of sea-ice algae, particularly for larval and subadult krill (< 35 mm).

WG-EMM-96/69

The foraging range of Adélie penguins - implications for CEMP and interactions with the krill fishery. K.R. Kerry, J. Clarke, S. Corsolini, S. Eberhard, H. Gardner, R. Lawless, D. Rodary, R.B. Thomson, R. Tremont and B. Wieneke (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 14 pp. *CCAMLR Science*, (submitted) (English).

This paper presents a summary of the foraging locations of the Adélie penguin at seven widely-spaced locations along the coast of eastern Antarctica between 55°E near Enderby Land and 175°E in the Ross Sea region. Birds feeding chicks regularly travel 100 to 120 km offshore to the continental shelf and return with krill. The pattern of foraging is similar between sites. The potential for overlap with the krill fishery occurs where ice conditions permit the fishing fleet to cross onto the continental shelf. Observations at Casey and Dumont D'Urville over one season suggest that such an overlap may not occur at these sites in years of normal ice cover. It is suggested that an understanding of the potential for overlap between the foraging areas of the birds and fishing grounds be established by tracking before a decision is taken to establish new CEMP sites.

WG-EMM-96/70

State of fishing resources of Antarctic krill in Subarea 48.3 in June to August 1995. V.A. Bibik (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea Ukraine), 8 pp. (English and Russian, unpublished).

Based on a scientific program conducted on Ukrainian vessels fishing for krill near South Georgia from 16 June to 15 August 1995, details of krill distribution are examined, and krill biomass estimates are given.

WG-EMM-96/71

ICES working group on fisheries acoustics science and technology (FAST); summary of topics discussed at the 1996 meeting. I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 16 pp. (English, unpublished).

WG-EMM-96/73

AMLR 1995/96 field season report: Objectives, accomplishments and tentative conclusions. Southwest

Fisheries Science Center, La Jolla, Ca., USA, 1996, 14 pp. (English).

Working Group on Fish Stock Assessment

WG-FSA-96/4
Brief information on fishing operations conducted by SRTM *Primorets* inside the economic zone of the Kerguelen Islands during the 1994/95 season. A. Vertunov, V. Frimer and V.N. Chikov ('YUGRYBPOISK' Fishing and Scientific Research Enterprise, 6 Kozlov Street, Kerch 334500, Crimea, Ukraine), 3 pp. (English, unpublished).

Data on toothfish-harvesting operations carried out by SRTM *Primorets* on its twenty-eighth expedition targetting Patagonian toothfish (*Dissostichus eleginoides*) in the Kerguelen Island Economic Zone during 1994/1995.

WG-FSA-96/5
Summary of data on activities of RTMS *Vozrozhdenye* inside the economic zone of the Kerguelen Islands during the 1994/95 season. E. Goubanov and Yu. Domashenko ('YUGRYBPOISK' Fishing and Scientific Research Enterprise, 6 Kozlov Street, Kerch 334500, Crimea, Ukraine), 3 pp. (English, unpublished).

Data from studies of icefish-harvesting operations conducted by RTMS *Vozrozhdenye* during its twenty-first fishing expedition targetting icefish (*Champsocephalus gunnari*) in the Kerguelen Island Economic Zone during the 1994/1995 season.

WG-FSA-96/6
Seabird by-catch and bait loss in longlining operations using different setting methods. S. Løkkeborg (Institute of Marine Research, PO Box 1870, N-5024 Bergen, Norway), 10 pp. (English, unpublished).

From time to time seabirds taking baits during longline setting become caught and are killed, while the associated bait loss may have a serious impact on longlining efficiency and profitability. Two different setting methods were tested as a solution to this problem; lines were set either through a setting funnel to guide the baited line beneath the sea surface, or in association with a seabird scaring device. Bait loss and the catches of target species and seabirds were compared with those observed when lines were set without using such devices. Both methods led to a reduction in accidental catches of birds, the seabird scarer being the most effective. Losses of mackerel bait were also significantly reduced by using the scarer, but not by using the setting funnel. No increase in the catches of target species was demonstrated when either of the setting methods was used. However, bait loss caused by seabirds was regarded as a minor problem in this fishing experiment. Suggestions on how the efficiency of the two methods tested might be improved are discussed.

WG-FSA-96/7
Ukrainian data update. CCAMLR Secretariat, 8 pp. (English, unpublished).

WG-FSA-96/8
The pelagic distribution of South Georgia albatrosses and their relationships with fisheries. P.A. Prince, J.P. Croxall, P.N. Trathan and A.G. Wood. In: Robertson, G. (Ed.). *Albatross Ecology and Conservation*. Surrey Beatty and Sons, Chipping Norton, Australia, (in press) (English).

At South Georgia, populations of wandering (*Diomedea exulans chionoptera*), black-browed (*D. melanophrys*) and grey-headed (*D. chrysostoma*) albatrosses are all declining. Interactions with fisheries are known, or believed, to be important in all these population changes. Such interactions are reviewed, using recoveries of banded birds and recent data from satellite-tracking studies. Wandering albatrosses range particularly widely: while breeding, birds from South Georgia range over vast areas of the South Atlantic, from 67°S off the Antarctic Peninsula to 26°S off southern Brazil and from 17°W to 85°W off the Pacific coast of southern Chile. During the breeding season, birds are frequently caught in subtropical areas on the Patagonian shelf by vessels using longlines

to fish for tuna; recoveries from other longline fisheries further south are increasing. In the non-breeding season birds from South Georgia move rapidly across the Atlantic Ocean, spending time off South Africa before crossing the Indian Ocean to winter around Australia. They are vulnerable to longline fishing at all stages of this migration. In the breeding season, grey-headed albatrosses are particularly associated with the Antarctic Polar Frontal Zone (APFZ) over a wide arc to the west and north of South Georgia. During this time few interactions with fishing vessels are reported. Information on their distribution in the non-breeding season is scarce; mortality derives from interactions with longline fishing in the Indian and Pacific Oceans, particularly in the vicinity of Australia. Black-browed albatrosses breeding at South Georgia also frequent the APFZ but are most commonly associated with the shelf slope areas around South Georgia and the South Orkney Islands. After the breeding season, birds from South Georgia migrate across the Atlantic Ocean to winter in South African waters, where they commonly associate with fishing vessels in the Benguela Current; some birds reach Australian waters. The rapid development of longline fisheries in many regions of the Southern Ocean, particularly at the edge of the continental shelves of South America and South Africa and in deeper waters of the Indo-Pacific, poses substantial actual and potential threats to South Georgia albatross species. Whereas black-browed and grey-headed albatrosses are at present at risk outside the breeding season around South Africa and Australasia respectively, wandering albatrosses are vulnerable year-round throughout most of the shelf and oceanic waters of the Atlantic and Indian Oceans as far east as New Zealand. They and grey-headed albatrosses may also be at risk in the Pacific Ocean.

WG-FSA-96/9

Population dynamics of wandering albatross (*Diomedea exulans*) and Amsterdam albatross (*D. amsterdamensis*) in the Indian Ocean and their relationships with longline fisheries: conservation implications. H. Weimerskirch, N. Brothers and P. Jouventin. *Biol. Conservation*, in press. (English).

Studies carried out over the past three decades at Crozet and Kerguelen Islands in the Indian Ocean indicate that wandering albatross (*Diomedea exulans*) populations declined markedly at first, but have been recovering slowly since 1986. Similarly the population of the endangered Amsterdam albatross (*D. amsterdamensis*) appears to have recovered since 1985, but remains close to extinction. A demographic study of the Crozet population indicates that the earlier decline was mainly the result of increased adult mortality, but also, to some extent, of low recruitment. Satellite tracking studies of breeding birds and band recoveries of non-breeding birds indicate that both during and outside the breeding season these populations are in contact with longline fisheries, mainly the pelagic Japanese southern bluefin tuna fishery and, to a lesser extent, the Patagonian toothfish fishery operating on the Kerguelen shelf. Decreased fishing effort and the concentration, in recent years, of the Japanese fishery on areas outside the central Indian Ocean has probably resulted in the slow recovery of these albatross populations as a result of improved adult survival and recruitment. Longline fisheries still represent a major threat to wandering albatross populations, most of which are still declining in the Southern Ocean. Possible conservation measures to reduce mortality in the fishery and to reduce contact between fishing units and foraging albatrosses are examined.

WG-FSA-96/10

Incidental mortality of seabirds around the Kerguelen Islands (Division 58.5.1) and effectiveness of mitigation measures: cruises from 1993/94 to 1995/96. D. Capdeville (Centre d'Etudes Biologiques de Chizé, 79360 Villiers-en-Bois, France), 11 pp. (French, unpublished).

Incidental captures of seabirds were observed during 1993/94 to 1995/96 longlining fishing cruises around the Kerguelen Islands (Division 58.5.1). The mean by-catch rate is 0.81 birds/1 000 hooks. The main species affected, because of its diving ability, is the white-chinned petrel, *Procellaria aequinoctialis*, (86% of

catches). Various ways proposed by CCAMLR of minimising seabird by-catch are tested and their effectiveness discussed.

WG-FSA-96/11
By-catch in the longline fishery on the Kerguelen shelf slope (Division 58.5.1) during the 1994/95 and 1995/96 cruises. D. Capdeville and G. Duhamel (Centre d'Etudes Biologiques de Chizé, 79360 Villiers-en-Bois, France), 6 pp. *CCAMLR Science*, (submitted) (English, original French).

This report presents the by-catch observed during two successive cruises made by longliners targetting Patagonian toothfish (*Dissostichus eleginoides*) at depths of approximately 500 m over the western part of the Kerguelen shelf. An analysis of catch levels indicates that by-catches consisted mainly of Rajidae *Bathyraja* spp. (85%). The proportion of by-catch species taken was low (less than 0.75%) and should not cause problems for these species so long as fishing effort remains limited. The results indicate that longlining is a highly target-specificmethod of fishing for Patagonian toothfish.

WG-FSA-96/12
Impact of marine mammals on the longline fishery around the Kerguelen Islands (Division 58.5.1) during the 1995/96 cruise. D. Capdeville (Centre d'Etudes Biologiques de Chizé, 79360 Villiers-en-Bois, France), 5 pp. *CCAMLR Science*, (submitted) (English, original French).

Interactions observed between longliners targetting Patagonian toothfish (*Dissostichus eleginoides*) to the west of the Kerguelen Islands during the 1995/96 cruise and marine mammals involved only Antarctic fur seals (*Arctocephalusgazella*). The latter caught 0.75% of toothfish on the longlines for which interactions were noted, as opposed to 2.2% of fish lost from hooks during hauling.

WG-FSA-96/13
Composition and vertical distribution of the benthopelagic ichthyofauna off the southern part of the Kerguelen ridge. A.S. Piotrovsky (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine), 12 pp. (English and Russian, unpublished).

As many as 18 species of benthopelagic fishes belonging to 12 families were caught in trawls during surveys conducted in December 1977 and January 1978 on Elan Bank. Of these fishes, some species were found to inhabit sub-Antarctic and Antarctic waters exclusively (endemics), while others had a wider geographical range. The 900 to 1 000 m depth range was characterised by the greatest diversity of fish species, although the numbers of each species present were lowest at those depths. Sub-Antarctic and Antarctic fish species were the dominant group. The proportion of deep-dwelling fishes increased with depth, and these fishes were quite abundant. Most abundant on Elan Bank were *Macrourus whitsoni*, *Antimora rostrata* and *Alepocephalus sp. cf. antipodiana*. This paper contains an annotated list of species and a brief description of their vertical distribution by area and depth, together with information on their biology.

WG-FSA-96/14
***Squalis acanthias* - a new species in the Antarctic ichthyofauna (Division 58.5.1).** L.K. Pshenichnov (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine), 5 pp. (English and Russian, unpublished).

To date, four species of shark are known to occur in sub-Antarctic waters: *Lamna nasus*, *Somniosus microcephalus*, *Etmopterus lucifer* and *E. granulosus*. A specimen of *Squalis acanthias* was captured in February 1995 on the shelf of the Kerguelen Islands from a depth of about 195 m and duly described. *S. acanthias* is believed to be one of the most widespread shark species in the world's oceans. The capture of this specimen in the Kerguelen waters provides new information about its geographical range and adds this species to the list of Antarctic ichthyofauna.

WG-FSA-96/15
Potentially commercial invertebrates on Ob Bank: *Moroteuthis ingens* (Oegopsida) and *Paralomis aculeata* (Anomura) (Division 58.4.4) L.K. Pshenichnov (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine), 9 pp. (English and Russian, unpublished).

The biomass of cephalopods in the Antarctic is thought to be high. However, they have not been fished, nor have any fishable aggregations of these species been detected to date in the CCAMLR Convention Area. The squid *Moroteuthis ingens* is regularly found in bottom trawl catches on Ob Bank during fishing for *Lepidonotothen squamifrons.* At most, the proportion of squid caught made up more than half of the total catch, reaching 1 310 kg per hour of trawling. All the squid caught were observed to be in the pre-spawning state. It has been concluded that searching and fishing for *M. ingens* with a midwater trawl over the sub-Antarctic seamounts may result in good commercial yields.

Antarctic crabs (craboids) are now the subject of intense scientific and fishery interest for CCAMLR Members, especially in view of the development of experimental fishing by a US vessel on the South Georgia shelf. The biology and environmental aspects of the life history of craboids in the Antarctic are poorly known. On Ob Bank, anomuran crabs are represented by a single species, *Paralomis aculeata.* Craboids have been regularly found in bottom trawl catches during target fishing for *L. squamifrons*, the frequency of their occurrence being 25 to 30%. Considering that standard bottom trawls were used with a foot rope designed to avoid the capture of benthic animals (craboids included), it has been concluded that Ob Bank waters contain a large population of *P. aculeata.*

WG-FSA-96/16

Some specific characteristics of *Dissostichus eleginoides* biology in the vicinity of the Kerguelen Islands (Division 58.5.1). L.K. Pshenichnov (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine), 9 pp. (English and Russian, unpublished).

In recent years *Dissostichus eleginoides* has been the main target species of trawl and longline fisheries in the vicinity of the Kerguelen Islands. This paper is based on the results of research carried out by the author on board the fishing vessel *Poltava* in the 1991/92 summer season. Regular patterns in the size distribution of *D. eleginoides* by depth were observed in the fishing area on the northern slope of the shelf. Differences were noted in the diet of different size groups, reflecting the composition and quality of food available at different depths. *D. eleginoides* undertake seasonal (summer) vertical migrations to deeper waters. In April, fish were found at depths of 550 to 600 m, and from December to February at depths of 350 to 400 m. *D. eleginoides* primarily feed on fish and squid, however under certain conditions may switch to other food such as Hyperiidae, or sometimes incidental food items (benthic crustaceans, octopoda, waste from vessels). Seasonal changes were observed in the dietary composition of *D. eleginoides* at depths of 500 to 600 m: from December to February cold-water jellyfish (Salpae, Ctenophora, Scyphomedusae) comprise the basic staple diet, while in March to Aprilnatal-subtropic species of the squid *Chiroteuthis veranyi* are dominant.

WG-FSA-96/17

The by-catch of juvenile fish in midwater krill trawls in the South Georgia area from 1967 to 1990. M.M. Nevinsky and K. Shust (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia), 11 pp. (English, unpublished).

WG-FSA-96/18

By-catch of juvenile fishes. The Antarctic krill fishery. C.A. Moreno. In: Harvesting Krill: Ecological Impact, Assessment, Products and Markets. *Fisheries Centre Research Reports*, 3 (3): 26-34, 1995. (English).

One of the unsolved problems in krill exploitation has been the by-catch of fish larvae which use krill swarms as their habitat, or co-occur with krill. The detection of this problem began during the massive Antarctic krill exploitation of the 1980s. It has been recognised that the larvae of several fish species develop within krill swarms; however, few quantitative evaluations have been carried out which might supply evidence that this technological interaction is affecting the recovery of over-exploited populations or that commercial or non-commercial populations are diminishing.

WG-FSA-96/19

Results of studies of the by-catch of fish in the Ukrainian, Polish and Japanese krill fisheries in the South Orkney Islands, South Georgia and the South Shetland Islands. T. Iwami, Z. Cielniaszek and E.A. Pakhomov (Laboratory of Biology, Tokyo Kasei Gakuin University, 2600 Aihara, Machida, Tokyo 194-02, Japan), 21 pp. (English, unpublished).

Observations on the abundance of by-catch fishes were made during fishing operations for krill (*Euphausia superba* Dana) conducted by the Ukrainian trawler, *Grigory Kovtun*, in the vicinity of South Georgia (May to July, 1992), the Polish trawler *Lepus* on the fishing grounds of the South Orkney Islands and South Georgia (March to May 1993), and by the Japanese fishing vessels *Chiyo Maru No. 3* and *Chiyo Maru No. 5* in the South Georgia area (July to August 1992) and *Niitaka Maru* to the north of the South Shetland Islands (January to February, 1994) to determine the proportion of juvenile fish forms in krill concentrations. In the South Orkney Islands area, eight hauls were analysed and no by-catch of juvenile notothenioids was observed in the samples collected. In the area around South Georgia, six notothenioid species, including one unidentified bathydraconid fish, were found as by-catch juveniles during three surveys by different countries. Of the six species, *Lepidonotothen larseni* was the most abundant in the Polish and Japanese by-catch samples, and the estimated arithmetic mean of these samples was 11 ± 41 ind./tonne krill and 34 ± 88 ind./tonne krill respectively. In the Ukrainian sample, most by-catch juveniles were identified as *Champsocephalus gunnari* or *L. larseni*; the arithmetic mean of this sample was 785 ± 3 076 ind./tonne krill and 603 ± 2 790 ind./tonne krill respectively. Thirteen species, including four mesopelagic fish species, were found in 25 of the krill catches of the 99 net hauls examined for the South Shetland Islands area. Of by-catch fish from this area, juvenile *L. larseni* was the most abundant and its arithmetic mean was 10 ± 47 ind./tonne krill. In all the three areas, a relatively low by-catch of the family Myctophidae was observed. The abundance of by-catch fish may have been dependent on the density of krill concentration. A large incidental catch of juvenile fish occurred in hauls with a relatively low krill CPUE, and fish by-catch was not found or was rare in hauls from krill swarms of higher density.

WG-FSA-96/20

Precautionary measures for a new fishery on *Martialia hyadesi* (Cephalopoda, Ommastrephidae) in the Scotia Sea: an ecological approach. P.G. Rodhouse (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 25 pp. *CCAMLR Science*, (submitted) (English).

In anticipation of the development of a new fishery for the oceanic squid *Martialia hyadesi* in the Scotia Sea, a revision of annual consumption of the species by higher predators is presented, and a brief review provided of information, obtained from research fishing and commercial catches, on the life cycle and distribution. The species is consumed by seabirds, seals and whales, and the most reliable data are obtained from seabird sampling because comprehensive sampling can be carried out during the breeding season. A conservative estimate for total annual consumption by higher predators in the Scotia Sea is 245 000 tonnes compared with an upper estimate of 550 000 tonnes if less reliable data are included. *M. hyadesi* spawns in winter/spring, probably has a two-year life cycle and, in common with other ommastrephids, is semelparous. It is proposed that the timing and catches of the fishery should be highly conservative, and should be established taking into account the timing of breeding and consumption rates of the most sensitive of the dependent species. Most predators which have been studied consume *M. hyadesi* during the first year of the species' life cycle. Fishing on *M. hyadesi* after the chick-rearing season of the most sensitive predator (grey-headed albatross) would minimise competition locally and ensure that the fishery only exploited the stock after escapement from most higher predator species. It would also allow monitoring of predation on the stock prior to the fishing season as a form of

pre-recruit assessment. Closing the fishery before recruitment of the next generation would ensure availability of prey for higher predators for the following chick-rearing season. Preliminary data from a squid jigger undertaking research fishing around South Georgia in June 1996, under the auspices of CCAMLR, provide the basis for assessing realistic potential catch rates.

WG-FSA-96/21
Research fishery for the squid *Martialia hyadesi* at South Georgia conducted by the Korean-registered vessel *Ihn Sung 101* (June 1996): scientific observer's report.
A.F. González and P.G. Rodhouse (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 16 pp. (English, unpublished) (Abstract not available).

WG-FSA-96/22
Report on scientific observations on board the Chilean longliner *Puerto Ballena* in Statistical Subarea 48.3 from March to May 1996.
K.-H. Kock and J. Selling (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany), 15 pp. (English, unpublished).

Scientific observation under the CCAMLR Scheme of International Scientific Observation was conducted on board the Chilean longliner *Puerto Ballena* fishing for Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 from March to May 1996. Details of the cruise are provided. Biological investigations included length, sex, maturity and weight measurements of *D. eleginoides*, estimation of the finfish by-catch, estimation of a factor for the conversion of product to fresh weight for *D. eleginoides* and assessment of the incidental mortality of seabirds associated with longline operations. The *D. eleginoides* catch comprised mainly specimens 70 to 130 cm in length, with the proportion of females in the catch exceeding those of males in fish larger than 110 cm. Length at sexual maturity and length at first spawning differed considerably between males and females, with males reaching maturity at a much smaller length. Black-browed albatrosses and white-chinned petrels were the most abundant species around the vessel when longlines were set. About 44% of the longlines were set during daylight hours. Consequently, black-browed albatrosses made up a considerable portion of the seabird by-catch. A by-catch of 159 dead seabirds was reported by the scientific observer and the crew, with black-browed albatrosses and white-chinned petrels forming the bulk of the by-catch. In addition, a number of albatrosses, giant petrels and white-chinned petrels were hooked alive during hauling and released alive. Sperm whales and killer whales were the most common marine mammals observed around the vessel. In some cases killer whales caused a considerable loss of fish from the lines.

WG-FSA-96/23
Suggestions to modify the CCAMLR scientific observer cruise log.
K.-H. Kock and J. Selling (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany), 3 pp. (English, unpublished).

WG-FSA-96/24
The biology and ecology of mackerel icefish (*Champsocephalus gunnari*) - an Antarctic fish species which lacks haemoglobin.
K.-H. Kock and I. Everson (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany), *Comp. Biochem. Physiol.*, in press. (English).

The mackerel icefish (*Champsocephalus gunnari*) is common in the coastal fish fauna of the seasonal pack-ice zone and the islands to the north of it. Separated into a number of stocks, its distribution ranges from the Scotia Arc region, namely South Georgia, in the Atlantic Ocean sector, to the Kerguelen-Heard Plateau in the Indian Ocean sector. Mackerel icefish have been heavily exploited since the beginning of the 1970s, with reported annual catches exceeding 50 to 100 000 tonnes in some years. *C. gunnari* has many characteristics typical of Antarctic fish species with respect to life history characteristics, such as egg size, fecundity and growth. These fall well within the range of other sympatric red-blooded notothenioids: eggs are large and yolky. Egg diameter, egg production per gram of body weight and growth

performance at South Georgia and the Kerguelen Islands were comparable to similar-sized notothenioids and channichthyids. Stocks of *C. gunnari* have a number of biological characteristics in common, such as feeding mode and food, early life history, and growth in the first years of life. However stocks in sub-Antarctic waters differ in reproductive characteristics, such as length and age at first spawning, natural mortality and life expectancy, from those on more southerly grounds. They may grow to more than 60 cm and may reach an age of 13 to 15 years. However, in the vicinity of South Georgia and the Kerguelen Islands, fish apparently do not reach this growth potential (fully). Their ability to reproduce at an early age coupled with a comparatively high fecundity and growth performance may mean that the stocks of *C. gunnari* in sub-Antarctic waters have far more resilience and a greater capacity to rebuild than species with the slower reproductive rates common in other notothenioids.

WG-FSA-96/25
Scientific observer database. CCAMLR Secretariat, 1 pp. (English, unpublished).

WG-FSA-96/26
Observer IMALF data analysis. CCAMLR Secretariat, 4 pp. (English, unpublished).

WG-FSA-96/27
Results of RV *Dr Eduardo Holmberg* 1996 fish survey in Subarea 48.3. E. Marschoff, B. Gonzalez, J. Calcagno, G.A. Shandikov, F. López, A. Madirolas and R. Reta (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 25 pp. (English, unpublished).

The survey comprised 56 bottom trawls taken in Subarea 48.3. Of these, four were not taken into account because of equipment malfunctions or short duration of trawling. About 80% of the hauls (41), were taken over the South Georgia shelf while the remainder (11) were taken in the Shag Rocks area; 65% of the hauls were intended to be taken in the same haul positions as in the 1994 and/or the 1995 survey. Mean densities of fish were estimated by considering the spatial aggregation of stations in a nested ANOVA model. An increase over last year's values was observed in the densities of several species, particularly *Champsocephalus gunnari* from the South Georgia shelf. The age and size structure of this species in the whole of Subarea 48.3 were more evenly distributed this year than was observed during last year's cruise, but the younger part of the population was still predominant in samples (fish at age four years and below comprised 99.6% at South Georgia and 69.2% at Shag Rocks).

WG-FSA-96/28 Rev. 1
Diet composition and observations on the reproduction of *Champsocephalus gunnari* in Subarea 48.3 in March/April 1996, RV *Dr Eduardo Holmberg* survey. E. Barrera-Oro, R. Casaux and E. Marschoff (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 20 pp. (English, unpublished).

The diet composition of the icefish *Champsocephalus gunnari* caught in Subarea 48.3 in March/April 1996 was analysed using frequency of occurrence (F%) and coefficient 'Q' (%) methods. Krill was by far the main food around South Georgia and Shag Rocks (F = 85%, Q = 99%). Other prey items, known as an important alternative food in years of krill scarcity, were observed only occasionally (*Themisto gaudichaudii*, F = 18%, Q = 1% at South Georgia; mysids, F = 11%, Q = 1.1% at Shag Rocks) or in negligible amounts (*Thysanoessa* sp.). Many of the stomachs sampled in the sampling area (56%) were found to be empty, i.e. even more than in 1991 and 1994, the years of krill shortage. An analysis of ovarian maturation stages showed that a high proportion of mature fish (79%) were 1996 spawners, a fact which may be related to a large availability of food, i.e. krill. It is suggested that krill was present in the region at levels equivalent to years of historical high abundance.

WG-FSA-96/29
Diet composition of *Dissostichus eleginoides* in Subarea 48.3, RV *Dr Eduardo Holmberg* survey, March/April 1996. E. Barrera-Oro,

R. Casaux and E. Marschoff (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 13 pp. (English, unpublished).

A diet analysis of the Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 in March/April 1996 was carried out by 'frequency of occurrence' (F%) and 'coefficient' 'Q' (%) methods. The samples consisted chiefly of immature specimens, with predominant length ranges of 30 to 70 cm (TL). Fish was by far the main food at Shag Rocks and South Georgia (63% as sole prey). Krill appeared to be a secondary food, although its importance was overestimated by the 'frequency of occurrence' method. Cephalopods and mysids occurred rarely in the stomach and only at Shag Rocks and South Georgia respectively. *Lepidonotothen kempi*, *Champsocephalus gunnari* and *Chaenocephalus aceratus* constituted the main fish prey and their variability between Shag Rocks and South Georgia depended on their local abundance. The greater proportion of fish had full or nearly full stomachs (62% in total), suggesting that feeding intensity of the species was high.

WG-FSA-96/30

Spatial distribution of *Champsocephalus gunnari* in Subarea 48.3: some implications for parameter estimation. E. Marschoff, B. Gonzalez and J. Calcagno (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 4 pp. (English, unpublished).

The results of three consecutive cruises to Subarea 48.3 were analysed. A significant variance component associated with the formation of clusters of stations was found, as well as a general trend of increasing fish densities since 1994. The significant variance component obtained for clusters formed with trawl stations at intervals of 8 n miles implies that considering all stations as independent (as in the estimation of the variance of the mean density) might result in a gross underestimation of variance. The spatial pattern of density across years might be applied to construct a model of density variability to minimise the variance of estimates of regional parameters.

WG-FSA-96/31

Incidental mortality of seabirds associated with longline fishing in Subarea 48.3 - preliminary results of scientific observations on board the Chilean longliner *Puerto Ballena* from March to May 1996. K.-H. Kock and J. Selling (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany), 15 pp. (English, unpublished).

Estimates of the number of seabirds taken incidentally in longline fisheries on Patagonian toothfish (*Dissostichus eleginoides*) are still based on limited information. This paper reports observations on the by-catch of seabirds during a cruise of the Chilean longliner *Puerto Ballena* in Subarea 48.3. A total of 118 dead black-browed albatrosses, 3 dead grey-headed albatrosses and 46 dead white-chinned petrels were reported by the observer and crew members. In addition 21 black-browed albatrosses, 4 giant petrels, 1 white-chinned petrel and 1 unidentified penguin were hooked and released alive. Our preliminary analysis confirmed results from last year that black-browed albatrosses are particularly at risk when longlines are set during the day and/or the streamer line is malfunctioning. If line setting had been restricted to night-time as in accordance with Conservation Measure 29/XIV (CCAMLR, 1995), the number of black-browed albatrosses and white-chinned petrels taken incidentally would have been substantially lower. The by-catch of both black-browed albatrosses and white-chinned petrels appeared to decline towards the end of April/beginning of May. The estimated total catch for all observed sets was 312 black-browed albatrosses and 213 white-chinned petrels. This estimate should be regarded as tentative as there are still problems associated with extrapolating observed numbers of dead seabirds from a subsample of hooks to the total number of hooks in a set: these problems warrant further investigation. However, even if we consider the number of dead birds recorded by the observer and by crew members as a minimum estimate, these figures appear far too high to be sustainable by both black-browed albatross and white-chinned petrel populations in the area.

WG-FSA-96/32
Intersessional work on the incidental mortality of seabirds in longline fisheries. CCAMLR Secretariat, 7 pp. (English, unpublished).

WG-FSA-96/33
Prevalences of parasitised and hyperparasitised crabs near South Georgia: summary of a manuscript submitted to the *Journal of Animal Ecology*. G. Watters (Southwest Fisheries Science Center, PO Box 271 San Diego, Ca. 92038, USA). *Journal of Animal Ecology*, (submitted) (English).

WG-FSA-96/34
Preliminary analyses of data collected during experimental phases of the 1994/95 and 1995/96 Antarctic crab fishing seasons. G. Watters (Southwest Fisheries Science Center, PO Box 271 San Diego, Ca. 92038, USA), 22 pp. *CCAMLR Science*, (submitted) (English).

Data collected on board the FV *American Champion* during phases 1 and 2 of the experimental crab fishery were analysed using generalised additive models and depletion estimators. Results from the generalised additive models show that the density of fishable *Paralomis spinosissima* is highest off the northern coast of South Georgia and at depths between about 100 and 300 fathoms. The phase 1 results suggest that it would not be appropriate to extrapolate local estimates of abundance to the whole of Subarea 48.3 solely on the basis of depth-specific seabed area; extrapolations must take into account location. Linear models fitted to CPUE and cumulative catch data from the phase 2 depletion experiments did not have significant negative slopes. The insignificant regressions were probably a result of inter-haul variability in CPUE and crab movement and suggested that depletion estimators will not be appropriate tools for estimating local abundances of *P. spinosissima*. Approximately 6 000 crabs were tagged and released during phase 2. Four of the tagged crabs were recovered, and these crabs were at liberty for about one to five weeks. The recaptured crabs moved at rates between 0.08 and 0.25 n miles/day. Mark-recapture estimates of standing stock and density were made for the area around the third phase 2 depletion square. The assumptions of the mark-recapture model were probably violated, but attempts were made to account for biased sampling of recaptured crabs and the movement of crabs away from their release sites. Density estimates from the mark-recapture data were in the order of 50 000 to 100 000 crabs n mile^2, and there was a lot of uncertainty associated with these estimates. In general, the experimental harvest regime was successful. The regime provided important information about crab distribution and facilitated evaluation of local depletion estimators for use in stock assessment, but the Working Group on Fish Stock Assessment (WG-FSA) may wish to re-evaluate the design of phase 2.

WG-FSA-96/35
Estimation of size at maturity and calculation of an appropriate size limit for male *Paralomis formosa*. G. Watters (Southwest Fisheries Science Center, PO Box 271 San Diego, Ca. 92038, USA), 11 pp. (English, unpublished).

A number of weighted smoothing splines were fitted to data on carapace length and size-specific, median chela height of *Paralomis formosa*. The second derivative of the spline which made the best tradeoff between quality of fit and smoothness was used as an estimate of morphometric size at maturity. Bootstrapping techniques provided a bias-corrected estimate of morphometric size at maturity ($\hat{S}_{BC}$) equal to a carapace width of 80 mm, and Pr (72 mm ≤ $\hat{S}_{BC}$ ≤ 90 mm) ≈ 0.95. The spline modelling technique appears to overcome some of the philosophical and statistical problems associated with estimating size at maturity by fitting linear models to log-transformed morphometric data (see Somerton, 1980a and 1980b), but improvements could be made to make the spline technique more robust to outliers in Y-space (crabs with regenerating claws). Given the uncertainty in $\hat{S}_{BC}$ and the lack of information about body size growth rates, a wide range of alternative size limits are likely to be feasible options for managing the *P. formosa* fishery, but, despite the availability of new data and the

arbitrary nature of the current size limit on this species, there does not seem to be a sufficiently strong biological reason to revise the size limit regulation established in Conservation Measure 91/XIV, paragraph 10.

WG-FSA-96/36
By-catch of fish during a 1995/96 deep-sea longline experimental fishing cruise off the Kerguelen Islands (Division 58.5.1). G. Duhamel and P. Pruvost (Museum national d'histoire naturelle, Laboratoire d'ichtyologie générale et appliquée, 43 rue Cuvier, 75231 Paris Cedex 05, France), 13 pp. *CCAMLR Science*, (submitted) (English, original document presented in French).

An experimental longline fishing cruise was carried out from February to April 1996 in deep waters (300 - 1 700 m) off the Kerguelen Islands (Division 58.5.1) with the aim of identifying by-catch species in directed fishing for *Dissostichus eleginoides*. Ten species of finfish were recorded as by-catch species, making up 36.1% of the total number of fish landed, a significant proportion of the catch. The dominant species in the by-catch were the grenadier *Macrourus carinatus* and two skates of the genus *Bathyraja*: *B. eatonii* and *B. irrasa.* The mora *Antimora rostrata* is also a common by-catch species. Other species were rare, but it should be noted that the effect of two large shark species, *Somniosus microcephalus* and *Lamna nasus*, taking *D. eleginoides* from the longlines should not be ignored. Geographical and bathymetrical differences in the distribution of by-catch species were noted. (The distribution of by-catch species was observed to vary in relation to geographical and bathymetrical factors). Abundance levels were also affected by these factors. The length frequency distributions observed suggested that some by-catch species, particularly grenadiers and skates, could be fished commercially should a deep-sea fishery develop in the future.

WG-FSA-96/37
Data availability for WG-FSA-96. CCAMLR Secretariat, 3 pp. (English, unpublished).

WG-FSA-96/38
Estimates of absolute recruitment for Patagonian toothfish (*Dissostichus eleginoides*) around Heard Island. W. de la Mare and R. Williams (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 5 pp. (English, unpublished).

Estimates of absolute numbers of recruits to the stock of Patagonian toothfish around the Heard Island region are calculated from density-at-length data derived from stratified trawl surveys. The estimates are referred to the four-year-old age class. The parameters for a log normal recruitment distribution suitable for use in a population model are calculated.

WG-FSA-96/39
Abundance of Patagonian toothfish at Macquarie Island estimated from tagging studies during the 1995/96 fishing season. W. de la Mare and R. Williams (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 8 pp. (English, unpublished).

This note describes a successful method for tagging *Dissostichus eleginoides* and presents an analysis of a tag-recapture experiment carried out during the Macquarie Island fishery for this species during the 1995/96 season. Simple population and tag accumulation models are used to account for the tags being released at various times throughout the season, and the effects of the removals by fishing. By assuming that recaptures have a Poisson distribution, maximum likelihood estimates are obtained for the pre-fishing abundance of the population in the season of 996 000 fish. However, this is adjusted to 901 000 fish if a small number of recovered but unreported tags are taken into account.

WG-FSA-96/40
Extract from Russian observer's report on Korean vessel *Ihn Sung 66*. A.N. Kozlov (VNIRO, 17 V. Krasnoselskaya, Moscow 107140, Russia), 1 pp. (English, unpublished).

WG-FSA-96/41
Interim report of activities of WG-FSA's correspondence group on

fish by-catch in krill fisheries. CCAMLR Secretariat, 3pp. (English, unpublished).

WG-FSA-96/42

Comparison between age readings from scales and otoliths of the toothfish *Dissostichus eleginoides* from South Georgia. M.C. Cassia (Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP) cc 175, 7600 Mar del Plata, Argentina), 12 pp. *CCAMLR Science*, (submitted) (English).

From a comparison of scale and otolith age readings of 105 specimens of *Dissostichus eleginoides* from the South Georgia region (Subarea 48.3), it was found that readings matched in 43.81% of cases. Results of the Wilcoxon test for paired data (TS = 0.256, n = 59) of the remaining 56.19% did not show significant differences between scale and otolith readings. However, otoliths frequently appeared totally opaque, making their readings impossible, while the scale images were always clear. Scales are considered to be most appropriate for age determination of *D. eleginoides*, because scale readings do not underestimate the age and they are also less time-consuming to obtain, and therefore more cost-effective. Linear and exponential relationships of both otolith radius/fish length and scale radius/fish length were calculated for 105 specimens between 38 and 223 cm total length. Values of growth parameters of the generalised von Bertalanffy equation estimated from 1 000 data in the present paper are: L_t = 207.01[1-e-0.0748 {t+0.2898}]; where L∞ = 207.01 cm, K = -0.0748 and t_0 = +0.2898. Maximum age was estimated to be 24 years. This is very close to the maximum age of 22.8 years calculated from Taylor's formulae which relate maximum observed age to natural mortality.

WG-FSA-96/43

A comparison of the feeding ecology of *Dissostichus eleginoides* on the Argentine continental shelf and around South Georgia (Subarea 48.3). S.B. García de la Rosa, F. Sánchez and D. Figueroa (Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), cc 92 (9410) Ushuaia, Argentina), 30 pp. *CCAMLR Science*, (submitted) (English).

The diet of Patagonian toothfish (*Dissostichus eleginoides*) was investigated at two offshore areas in the southwestern Atlantic: on the Argentinian continental shelf/slope between 46°-56°S and 60°-64°W, and off South Georgia between 53°-55°30' and 37°-47°W. On the Argentinian continental shelf/slope, the length of *D. eleginoides* ranged from 30 to 95 cm total length (TL) which corresponds to the juvenile stage. Off South Georgia, the size distribution included both juvenile and adults stages, and ranged between 18 and 212 cm TL. Diets were compared by fish size and sex, and the feeding status of this species is discussed. *D. eleginoides* is a mixed species carnivore, feeding principally on fish and secondarily on crustaceans, and the diet varies in relation to fish size and water depth. *D. eleginoides* feed on fish and cephalopods, and the principal fish species in their diet, off the Argentinian continental shelf, were nototheniids (*Patagonotothen ramsayi*), eelpouts (*Iluocoetes fimbriatus*) and southern blue whiting (*Micromesistius australis*). Off South Georgia, adult *D. eleginoides* preyed on fish of the Zoarcidae and Moridae families, on Antarctic dragonfish (Bathydraconidae) and crocodile icefish (Channichthyidae), and on Decapoda, while juveniles consumed krill and various species of Nototheniidae, myctophids and Channichthyidae. The main difference in diets between the two areas was the occurrence of crustaceans in stomachs of *D. eleginoides* caught off South Georgia, and their absence in the diet of fish from the Argentinian continental shelf/slope.

WG-FSA-96/44

Sexual ratio of *Dissostichus eleginoides* from longline samples: a partial indicator of reproductive migration in Subarea 48.3. C.A. Moreno, J. Guerra and A. Zuleta (Instituto de Ecología y Evolución, Universidad Austral de Chile, Casilla 567, Valdivia, Chile), 7pp. *CCAMLR Science*, (submitted) (English).

The examination of the sexual ratio of *Dissostichus eleginoides* between the first week of March and the third week of July

1996, in Subarea 48.3 shows that the sex ratio departs from the expected 1:1 ratio in that females are more abundant in longline samples, except during May, when the males, having just reached maturity, join the female population. After the first week of June, the sex ratio reverts to having a greater proportion of females. Because longlines remain close to the benthic habitats for most of the time, this finding suggests that either females remain in higher proportion in the habitat sampled by longlines because males move to other habitats, that females are more vulnerable to longline fishing techniques, or that both sexes rise in the water column to spawn. None of these hypotheses could be tested using the fishery data.

WG-FSA-96/46
Refinements to the general yield model for use at WG-FSA-96. A. Constable (School of Aquatic Science and Natural Resources Management, Deakin University, PO Box 423, Warrnambool, Victoria 3280, Australia), 11 pp. (English, unpublished).

WG-FSA-96/47
Short report on trip 9604, *American Champion*, August/September 1996. L. Koen (Sea Fisheries Research Institute, Private Bag X2, Roggebaai 8012, South Africa), 2 pp. (English, unpublished).

WG-FSA-96/48
Dependence of catches of *Dissostichus eleginoides* on environmental factors inside Division 58.5.1 (Kerguelen Island) - (Conservation Measure 29/XIV). A.S. Petrenko (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine), 4 pp. (English, unpublished).

WG-FSA-96/49
Report on the operation of the Ukrainian fleet inside Division 58.5.1 (Kerguelen Island) during the period 1991 to 1996. E. Goubanov, A.S. Petrenko and V.V. Krakatitsa (YUGRYBPOISK, I. Kozlov 6 str., Kerch 334514, Crimea, Ukraine), 5 pp. (English, unpublished).

WG-FSA-96/50
Report on the estimation and avoidance of incidental mortality of marine resources of Antarctic region in Division 58.5.1 (Kerguelen Island) - (Conservation Measure 29/XIV). E. Goubanov and A.S. Petrenko (YUGRYBPOISK, I. Kozlov 6 str., Kerch 334514, Crimea, Ukraine), 1 pp. (English, unpublished).

WG-FSA-96/51 Rev. 1
Observer logbooks (trawl fisheries). CCAMLR Secretariat, 18 pp. (English, unpublished).

WG-FSA-96/52
Extract from report on scientific observation during the Patagonian toothfish (*Dissostichus eleginoides*) fishery on board SRTM *Itkul* in Subarea 48.3 in the period from 17 March to 17 July 1996. A.K. Zaitsev (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine), 6 pp. (English, unpublished).

WG-FSA-96/53
A method to estimate fish growth parameters using hard structure without back-calculation. A. Aubone and D.R. Hernández (Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP) cc 175, 7600 Mar del Plata, Argentina), 15 pp. (English, unpublished).

A method of estimating the parameters from the length-age relationship from the radius of the structure used in age determination (i.e. otolith, scale) was used to estimate age. It is assumed that there is a linear relationship between the radius of the structure and body size. The methodology for estimating both parameters and the covariance matrix of their estimators, in the specific case of the von Bertalanffy growth model, is outlined. An example is given, using real data. The results obtained using our method are compared to those obtained using R. Lee's classic back-calculation.

WG-FSA-96/54
A shore-based randomised sampling design used in the artisanal longline fishery for *Dissostichus eleginoides*

off central Chile. J. Ashford, P.S. Rubilar and C. Jones (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 7 pp. (English, unpublished).

A shore-based design used to sample sports fisheries was adapted to sample otoliths from targeted individuals caught in the artisanal longline fishery for *Dissostichus eleginoides* off northern Chile. Observers were stationed dockside and at a processing factory. A 14-day sampling frame was used, divided into primary sampling units of days/area and secondary sampling units of three- and eight-hour periods. Compared to shipboard sampling, the design allowed more flexibility in allocation of observer effort and cut time wasted during poor fishing or travel to fishing grounds. However, data on catch date, location and depth cannot be independently verified, nor can data taken on by-catch or incidental mortality of higher predators.

WG-FSA-96/55

Determination of stock structure and movement at age in Patagonian toothfish (*Dissostichus eleginoides*) through laser-based analysis of otoliths - a report on progress. J. Ashford, I. Everson and C. Jones (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 5 pp. (English, unpublished).

WG-FSA-96/56

A randomised sampling design used in the longline fishery for *Dissostichus eleginoides* in the southern Indian Ocean. J. Ashford and G. Duhamel (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 8 pp. (English, unpublished).

A randomised cluster design was used successfully to sample otoliths from targeted individuals taken by individual longlines in the fishery for *Dissostichus eleginoides*. The line was divided into constituent baskets of line; we used the line as the sampling frame, and baskets as the primary sampling units. The design allows representative samples to be taken while a line is being hauled; it offers the potential of little disruption to commercial activities and reductions in observer effort needed to achieve known levels of confidence.

WG-FSA-96/57

Loss of hooks during longline fishing in Subarea 48.3. G. Parkes and J.C. Jones (Marine Resources Assessment Group, 47 Prince's Gate, South Kensington, London SW7 2QA United Kingdom), 8 pp. (English, unpublished).

WG-FSA-96/58

Data on juvenile fish surveys within South Georgia. Zh.A. Frolkina (AtlantNIRO, 5 Dimitry Donskoy Street, Kaliningrad 236000, Russia), 31 pp. *CCAMLR Science*, (submitted) (English).

Data from six juvenile fish surveys around South Georgia were analysed. It was found that the most abundant species in catches made using a midwater trawl designed to catch juvenile fish were *Champsocephalus gunnari* and *Lepidonotothen larseni*. In general, various species of the Nototheniidae family (10 species), the Myctophidae family (7 species) and the Bathydraconidae family (5 species) were present in the catches. Data on the size composition of the most abundant species, as well as on their size composition and geographical distribution and depth, are given.

WG-FSA-96/59

Experimental acoustic estimation of the biomasses of bathypelagic fish species from the South Georgia and Shag Rocks shelf areas with sampling by trawl (RV *Atlantida*, February 1996). V.M. Vorobyov, P.A. Bukatin, V.A. Severin, Zh.A. Frolkina, V.Yu. Sunkovich, M.I. Polischuk, V.N. Shnar and A.M. Abramov (AtlantNIRO, 5 Dimitry Donskoy Street, Kaliningrad 236000, Russia), 60 pp. (English, unpublished).

This paper describes an experimental acoustic survey in shelf areas off South Georgia and Shag Rocks in Subarea 48.3 aimed at assessing the abundance and distribution of demersal fish. Data on the location of trawl stations, length composition of catches, the percentage of various fish species in trawl samples, as

well as data from biological and oceanological research, are presented. An analysis of data carried out of *in situ* target strengths of icefish (*Champsocephalus gunnari*), the proportion of this species in trawl catches, trawling speed and fish length-weight relationship are the factors which affect the general estimation of icefish biomass.

WG-FSA-96/60
Distribution of young icefish in the South Georgia shelf area based on data from surveys of juvenile fish. Zh. A. Frolkina and I.A. Trunov (AtlantNIRO, 5 Dimitry Donskoy Street, Kaliningrad 236000, Russia), 43 pp. *CCAMLR Science*, (submitted) (English).

Results obtained from juvenile fish surveys in Subarea 48.3 are presented. In the period from 1984 to 1990 AtlantNIRO carried out six juvenile fish surveys. Forty fish species from 15 families were found in catches made using a midwater trawl designed to target juvenile fish. Data are given on distribution, length composition, vertical diurnal migrations and catches of juvenile *Champsocephalus gunnari* in krill fisheries.

WG-FSA-96/61 Rev. 1
Report of the First meeting of the CCSBT's Working Group on Ecologically Related Species. (Wellington, New Zealand, 18 to 20 December 1995), 19 pp. (English).

WG-FSA-96/62
Recent information related to seabird by-catches on the high seas. T. Polacheck and A. Betlehem (CSIRO Marine Laboratories, Department of Industry, Science and Technology, GPO Box 1538, Hobart, Tasmania 7001, Australia), 13 pp. (English, unpublished).

WG-FSA-96/63
Some observations on seabird by-catches from Australian longline fishing vessels. W. Whitelaw (CSIRO Marine Laboratories, Department of Industry, Science and Technology, GPO Box 1538, Hobart, Tasmania 7001, Australia), 4 pp. (English, unpublished).

Seabirds are incidentally caught during tuna longline operations in the southern oceans and the by-catch from these fisheries has been identified as a significant source of mortality for a number of albatross species (Brothers, 1991; Vaske, 1991; Gales, 1993; Murray et al., 1992, 1993; CCAMLR, 1994; Barea et al., 1994; Klaer and Polacheck, 1995). To date no information has been available on possible seabird by-catch by Australian tuna longline vessels. During 1994 and 1995, CSIRO has been deploying scientific technicians and observers on a small number of longline vessels in conjunction with various research activities on tuna biology and fisheries. As part of these research activities, these individuals collected standard catch and effort data, including information on seabird by-catch. The purpose of this report is to document the data collected to date.

WG-FSA-96/64
Summary tables of available information on seabird by-catch by Australian tuna longline vessels. T. Polacheck (CSIRO Marine Laboratories, Department of Industry, Science and Technology, GPO Box 1538, Hobart, Tasmania 7001, Australia), 2 pp. (English, unpublished).

WG-FSA-96/65
Trends in tuna longline fisheries in the southern oceans and implications for seabird by-catch. T. Polacheck and G. Tuck (CSIRO Marine Laboratories, Department of Industry, Science and Technology, GPO Box 1538, Hobart, Tasmania 7001, Australia), 26 pp. (English, unpublished).

WG-FSA-96/66
By-catch of albatrosses and other seabirds by Japanese longline fishing vessels in the Australian fishing zone from April 1992 to March 1995. N. Klaer and T. Polacheck (CSIRO Marine Laboratories, Department of Industry, Science and Technology, GPO Box 1538, Hobart, Tasmania 7001, Australia). *Emu*, (submitted) (English).

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SC-CAMLR-XIV/BG/1
Catches in the Convention Area 1994/95. CCAMLR Secretariat, 3 pp. (English, unpublished).

SC-CAMLR-XIV/BG/6
Seabird interactions with trawling operations at Macquarie Island. R. Williams (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), *CCAMLR Science*, 3: 93-99, 1996 (English).

SC-CAMLR-XIV/BG/8
Entanglement of Antarctic fur seals *Arctocephalus gazella* in man-made debris at Bird Island, South Georgia during the 1994 winter and 1994/95 pup-rearing season. T.R. Walker (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 19 pp. (English, unpublished).

SC-CAMLR-XIV/BG/9
Marine debris and fishing gear associated with seabirds at Bird Island, South Georgia, 1994/95. N. Huin (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 10 pp. (English, unpublished).

SC-CAMLR-XIV/BG/10 Rev. 1
Final report of scientific observations of commercial krill harvest aboard the Japanese fishing vessel *Chiyo Maru No. 2*, 19 January to 2 March 1995. W.R. Armstrong, USA, 17 pp. (English, unpublished).

SC-CAMLR-XIV/BG/12
Captures accidentelles d'oiseaux marins autour de Kerguelen (division 58.5.1), campagne 94-95. D. Capdeville (Centre d'Etudes Biologiques de Chizé, 79360 Villiers-en-Bois, France), *CCAMLR Science*, 3: 93-99, 1996 (English).

SC-CAMLR-XIV/BG/15
YugNIRO profile data set on the Southern Ocean. B.G. Trotsenko and V.N. Yakovlev (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine), 6 pp. (English, unpublished).

SC-CAMLR-XIV/BG/17
Entanglement of pinnipeds at Marion Island. G. Hofmeyr and M. Bester (Department of Zoology and Entomology, University of Pretoria, Pretoria 0002, South Africa), 6 pp. (English, unpublished).

SC-CAMLR-XIV/BG/18
Records of entangled birds at Marion Island 1986 to 1995. J. Cooper and O. Huyser (African Seabird Group, P.O. Box 34113, Rhodes Gift 7707, South Africa), 5 pp. (English, unpublished).

SC-CAMLR-XIV/BG/21
Cephalopods occupy the ecological niche of epipelagic fish in the Antarctic Polar Frontal Zone. P.G. Rodhouse and M.G. White (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 11 pp. (English, unpublished).

SC-CAMLR-XIV/BG/22 Rev. 1
Recent information relevant to squid resources in the Convention Area. P.G. Rodhouse (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 7 pp. (English, unpublished).

SC-CAMLR-XIV/BG/23
Convención para la conservación de los recursos vivos marinos antárticos (CCRVMA) informe final de marea. Argentina, 10 pp. (Spanish, unpublished).

SC-CAMLR-XIV/BG/24
Instituto nacional de investigación y desarrollo pesquero programa de observadores informe final de la marea. (Argentina), 5 pp. (Spanish, unpublished).

SC-CAMLR-XIV/BG/25
Instituto nacional de investigación y desarrollo pesquero programa de observadores científicos de la CCRVMA informe final de la marea. Argentina, 7 pp. (Spanish, unpublished).

SC-CAMLR-XIV/BG/26
Informe del observador científico Argentino embarcado a bordo del palangrero *Puerto Ballena* (Chile). Argentina, 3 pp. (Spanish, unpublished).

SC-CAMLR-XIV/BG/30
Report of biologist observer on commercial vessel RKTS *General Petrov* April to August 1994. Ukraine, 7 pp. (English, unpublished).

SC-CAMLR-XIV/BG/32
Report of the biologist observer on vessel RKTS *General Petrov* - March to July 1995. Ukraine, 14 pp. (English, unpublished).

SC-CAMLR-XIV/BG/33
An environmental information and modelling system (EIMS) for sustainable development. V.H. Marín (EIMS Project, Depto. Cs. Ecológicas, Facultad de Ciencias, Universidad de Chile, Casilla 653 Santiago, Chile), 3 pp. (English, unpublished).

SC-CAMLR-XIV/BG/35
Brief report on scientific observation under CCAMLR scheme on commercial vessel SRMT *Itkul* - 25 April to 19 June 1995. Ukraine, 9 pp. (English, unpublished).

SC-CAMLR-XIV/BG/37
The deepest of ironies: genetic resources, marine scientific research and the international deep sea-bed area. IUCN, 5 pp. (English, unpublished).

Working Group on Ecosystem Monitoring and Management

WG-EMM-95/4
Krill distribution variability and fishery conditions within the local ground of Subarea 48.3 in June 1991. S.M Kasatkina (AtlantNIRO, 5 Dimitry Donskoy Street, Kaliningrad 236000, Russia), 14 pp. (English and Russian, unpublished).

WG-EMM-95/5
Growth of krill around the South Orkney Islands in 1989/90. V.I. Latogursky (AtlantNIRO, 5 Dimitry Donskoy Street, Kaliningrad 236000, Russia), 20 pp. (English and Russian, unpublished).

WG-EMM-95/8
Comparison of equal-area cylindrical and circular piston transducers. K.G. Foote (Institute of Marine Research, PO Box 1870, N 5-24 Bergen, Norway), *ICES J. mar. Sci.*, 52: 67-75, 1995 (English).

WG-EMM-95/9
Performance of an acoustic sonde design. K.G. Foote (Institute of Marine Research, PO Box 1870, N 5-24 Bergen, Norway), 11 pp. (English, unpublished).

WG-EMM-95/10
Developments in the calculation of CEMP indices 1995. CCAMLR Data Manager (23 Old Wharf, Hobart, Tasmania 7000, Australia), 8 pp. (English, unpublished).

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Calculation of indices of sea-ice concentration using digital images from the National Snow and Ice Data Centre. D.J. Agnew (Renewable Resources Assessment Group, ICCET, Imperial College, 8 Prince's Gardens, London SW7 1NA, United Kingdom), 10 pp. (English, unpublished).

WG-EMM-95/12 Rev. 1
Index part 1: Introduction to the CEMP indices 1995. CCAMLR Secretariat, 16 pp. (English, unpublished).

WG-EMM-95/13 Rev. 1
Index part 2: CEMP indices tables of results 1995. CCAMLR Secretariat, 27 pp. (English, unpublished).

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Index part 3: CEMP indices figures 1995. CCAMLR Secretariat, 26 pp. (English, unpublished).

WG-EMM-95/15
Recruitment of Antarctic krill (*Euphausia superba*) and possible causes for its variability. V. Siegel and V. Loeb (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, 22767 Hamburg, Germany), 25 pp. (English, unpublished).

WG-EMM-95/16
Hydrographic conditions around Elephant Island during austral spring 1994. M. Stein (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, 22767 Hamburg, Germany), 34 pp. (English, unpublished).

WG-EMM-95/17
Some thoughts on precautionary measures for the krill fishery. I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), *CCAMLR Science*, 3: 1-11, 1996 (English).

WG-EMM-95/18
Preliminary results on the composition and abundance of the krill stock in the southern Bellingshausen Sea (Antarctic, Subarea 88.3). V. Siegel (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, 22767 Hamburg, Germany), 11 pp. (English, unpublished).

WG-EMM-95/19
On the examining of krill flux. R.R. Makarov (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia), 9 pp. (English, unpublished).

WG-EMM-96/20
The organisation of environmental monitoring in Antarctica. Submitted by SCAR to the XVIIIth ATCM, 9 pp. (English, unpublished).

WG-EMM-95/21
Indices of body condition and body composition in female Antarctic fur seals (*Arctocephalus gazella*). J.P.Y. Arnould (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 26 pp. (English, unpublished).

WG-EMM-95/22
Heart rate and oxygen consumption of exercising gentoo penguins. R.M. Bevan, A.J. Woakes, P.J. Butler and J.P. Croxall (School of Biological Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, United Kingdom), *Physiological Zoology*, 68: 855-877, 1995 (English).

WG-EMM-95/23
Temporal scales of foraging in a marine predator: implications for interpreting the distribution of prey. I.L. Boyd (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 33 pp. (English, unpublished).

WG-EMM-95/24
Individual variation in the duration of pregnancy and birth date in Antarctic fur seals: the role of environment, age and fetal sex. I.L. Boyd (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 24 pp. (English, unpublished).

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Swimming speed and allocation of time during the dive cycle in Antarctic fur seals. I.L. Boyd, K. Reid and R.M. Bevan (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 38 pp. (English, unpublished).

WG-EMM-95/26
Population demography of Antarctic fur seals: the costs of reproduction and implications for life-histories. I.L. Boyd, J.P. Croxall, N.J. Lunn and K. Reid (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), *Journal of Animal Ecology*, 64: 505-518, 1995 (English).

WG-EMM-95/27
Diet of the king penguin (*Aptenodytes patagonica*) during

three summers at South Georgia. C.O. Olsson and A.W. North (Department of Zoology, Stockholm University, S-106 91 Stockholm, Sweden), 37 pp. (English, unpublished).

WG-EMM-95/28
The diet of Antarctic fur seals (*Arctocephalus gazella*) during the breeding season at South Georgia. K. Reid and J.P.Y. Arnould (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 32 pp. (English, unpublished).

WG-EMM-95/29
The diet of antarctic fur seals (*Arctocephalus gazella*) during winter at South Georgia. K. Reid (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 30 pp. (English, unpublished).

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Ecosystem monitoring and management, past, present and future. I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 14 pp. (English, unpublished).

WG-EMM-95/32
Stomach flushing of Adélie penguins (CEMP Method A8). J. Clarke (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia), 8 pp. (English, unpublished).

WG-EMM-95/33
Adélie penguin chick deaths investigated. K.R. Kerry, J. Clarke, H. Gardner, R. Murphy, F. Hume and P. Hodum (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia), *Anare News Autumn 1995*, 18-20.

WG-EMM-95/34
Transect spacing for acoustic surveys. I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 4 pp. (English, unpublished).

WG-EMM-95/39
On the consequences of differentiating between adult and sub-adult survival rates in the krill-predators model. R.B. Thomson and D.S. Butterworth (Department of Applied Mathematics, University of Cape Town, Rondebosch 7700, South Africa), 22 pp. (English, unpublished).

WG-EMM-95/40
Can the length composition of krill in predator diets provide information on the age-dependence of krill natural mortality? R.B. Thomson and D.S. Butterworth (Department of Applied Mathematics, University of Cape Town, Rondebosch 7700, South Africa), 10 pp. (English, unpublished).

WG-EMM-95/41
Krill catch within 100 km of predator colonies from December to March (the critical period-distance). CCAMLR Secretariat, 3 pp. (English, unpublished).

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Improvements to the Adélie penguin-krill predator-prey model. R.B. Thomson and D.S. Butterworth (Department of Applied Mathematics, University of Cape Town, Rondebosch 7700, South Africa), 20 pp. (English, unpublished).

WG-EMM-95/43
A hydroacoustic survey of Antarctic krill populations in Division 58.4.1. S. Nicol (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia), 7 pp. (English, unpublished).

WG-EMM-95/45
Determining sex of Adélie penguins from timing of incubation shift. K.R. Kerry, J. Clarke and E. Franchi (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia), 3 pp. (English, unpublished).

WG-EMM-95/46
Draft: differences in the foraging strategies of male and female Adélie

penguins. J. Clarke, K.R. Kerry and E. Franchi (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia), 17 pp. (English, unpublished).

WG-EMM-95/47
Adélie penguin monitoring program at Edmonson Point, Ross Sea region. E. Franchi, J. Clarke, R. Lawless, K.R. Kerry and S. Focardi (Dipartimento di Biologia Ambientale, Universita di Siena, Via delle Cerchia 3, 53100 Siena, Italy), 14 pp. (English, unpublished).

WG-EMM-95/48
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WG-EMM-95/49
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