CCAMLR SCIENTIFIC ABSTRACTS
1998

Commission for the Conservation of
Antarctic Marine Living Resources

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PREFACE

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

This volume contains abstracts of scientific papers presented in 1998. It corresponds to the Seventeenth 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(iii) scientific papers not intended for publication, which are listed as 'unpublished'; and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Unpublished papers must not be cited without written permission of the author(s).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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CCAMLR-XVII/BG/25
Beach litter accumulation and retention at sub-Antarctic Marion Island: trends in relation to long-line fishing activity. D.C. Nel and J.L. Hurford (Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7701, South Africa), 19 pp. (English, unpublished).

Standardised beach litter surveys at sub-Antarctic Marion Island for the period 1996 to 1998 are reported and compared to surveys done in 1984 and 1995, prior to the onset of unregulated illegal fishing in this area. An exponential increase in litter accumulation was noted in annual accumulation studies at designated beaches. Styrofoam pieces and plastic bottles showed the largest increases, while the amount of fishing equipment also doubled during this period. An increase in the number and proportion of Spanish-script items was noted, while French items only appeared after the onset of illegal fishing. Monthly accumulation showed a strong seasonal effect, which also corresponded to periods of reported illegal fishing. Most of the litter items that could be traced to their place of origin were from South America, while Oriental and French items also featured significantly. French items are noteworthy in light of reports of illegal fishing vessels using Port Louis, Mauritius, to land catches and resupply. A fast turnover rate of litter and very little accumulation effect was recorded in a beach litter retention study.

CCAMLR-XVII/BG/26
Marine pollutants and fishing gear associated with seabirds at sub-Antarctic Marion Island, 1996–1998: trends in relation to longline fishing activity. D.C. Nel and J.L. Hurford (Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7701, South Africa), 18 pp. *CCAMLR Science*, submitted (English).

Pollutants found in association with seabirds at sub-Antarctic Marion Island for the period May 1996 to April 1998 are reported. Standardised searches and incidental finds show a large increase between the 1996/97 and the 1997/98 field seasons. Fishing gear increased at a rate ten times higher than other (non-fishing) pollutants over this period. Sixty 'rope nooses', apparently used for suspending toothfish in blast freezers, and 23 toothfish hooks were found. Prior to this study only three hooks (all from the southern bluefin tuna longline industry) had been found in association with seabird nests at Marion Island. Fishery-related pollutants were found most frequently in association with wandering albatross nests, while 'other' (non-fishing) pollutants were found most frequently in association with grey-headed albatrosses and southern giant petrels. Three seabirds (a southern giant petrel, a northern giant petrel, and a sub-Antarctic skua) were found entangled in fishing gear, while five seabird carcasses (three wandering albatross chicks, one white-chinned petrel chick and a southern giant petrel adult) were found to contain ingested fishing gear. Ongoing efforts should be aimed at minimising this needless impact.

CCAMLR-XVII/BG/27
Results of synthesis of marine debris survey carried out at Cape Shirreff, Livingston Island in the austral summer 1997/98. D. Torres and D. Jorquera (Departamento Cientifico, Instituto Antártico Chileno, Luis Thayer Ojeda 814, Correo 9, Providencia, Santiago, Chile), 1 p. (English, unpublished).

Scientific Committee

SC-CAMLR-XV/BG/29
The status and trends of Antarctic and sub-Antarctic seabirds. Submitted by the SCAR Subcommittee on Bird Biology.

SC-CAMLR-XVII/BG/2 Rev. 1
Draft CEMP Tables 1 to 3. CCAMLR Secretariat, 20 pp. (English, unpublished).

SC-CAMLR-XVII/BG/3
Towards a closer cooperation between CCAMLR and the IWC. CCAMLR Observer (K.-H. Kock,

Germany), (Bundesforschungsanstalt für Fischerei, Institut für Seefischerei, Palmaille 9, 22767 Hamburg, Germany), 5 pp. (English, unpublished).

SC-CAMLR-XVII/BG/7 Rev. 1
Results of the *Dissostichus* spp. new fisheries projects in the Antarctic region (CCAMLR Statistical Subareas 48.1, 48.2 and 88.3). P.M. Arana and R. Vega (Escuela de Ciencias de Mar, Universidad Católica de Valparaíso, Casilla 1020, Valparaíso, Chile), 14 pp. *CCAMLR Science*, submitted (English).

During February and March 1998, a 43-day cruise of FV *Tierra del Fuego* was conducted as part of the New Fisheries Projects developed by Chile, primarily to establish the presence of *Dissostichus* spp. in CCAMLR Statistical Subareas 48.1, 48.2 and 88.3. Industrial longlines (Spanish system) were used for the operations, with variable quantities of fish hooks (1 440 to 4 320: No. 9 Mustad Kirby type), set mainly between depths of 600 and 2 550 m. Sardines (*Sardinops sagax*) and squids (*Illex argentinus*) were used as bait. The results of this research showed that Antarctic toothfish *(D. mawsoni)* were taken in waters around Peter I Island (68˚49'S), and from the Bellingshausen Sea (70˚38'S) to Clarence and Elephant Islands (61˚14'S), while Patagonian toothfish *(D. eleginoides)* were caught in waters from King George Island in the Antarctic–Pacific Ocean (61˚24'S) to the Scotia Sea in the Antarctic–Atlantic (58˚01'S). *Dissostichus* spp. were taken in small quantities in the three subareas, with values of only 5.7 g/hook (Subarea 88.3), 19.1 g/hook (Subarea 48.1) and 3.0 g/hook (Subarea 48.2), and an average over all areas of 11.1 g/hook.

SC-CAMLR-XVII/BG/8
Survey and monitoring of black petrels on Great Barrier Island 1997. E.A. Bell and J.L. Sim (Department of Conservation, PO Box 10-420, Wellington, New Zealand), 16 pp. (English, unpublished).

The black petrel *(Procellaria parkinsoni)* is a vulnerable endemic seabird, which breeds only on Little and Great Barrier Islands, New Zealand. During late January and February 1997, within the main breeding area around the highest point on Great Barrier Island, Hirakimata (Mount Hobson), 100 burrows that had adults present were selected as long-term study burrows. The burrows were either accessible through the entrance or easily excavated to reach their contents. Eighty-four of these burrows were used by breeding pairs, and the remainder by non-breeding adults. The three 1 600 m^2 census areas set up in 1996 around the summit were monitored over the 1997 breeding season. A total of 54 burrows were located within the census grids and 36 were being used by breeding pairs. A preliminary estimate extrapolated from the grid burrows shows the population consists of 4 500 breeding birds and at least 685 non-breeding birds.

Predation was noted in seven long-term study burrows, six eggs were either crushed or pushed out of the burrows by fighting adults, six eggs were infertile, and two eggs were also abandoned, giving an overall breeding success rate of 75%.

Of the 191 adults found in the long-term study burrows 39 were already banded and 152 were banded this season. Another 26 adults (four already banded) were caught at breeding sites around the summit area. Sixty-nine chicks were banded, 64 of these coming from the long-term study burrows. Most captured birds were weighed. The average adult weight at incubation was 775 g, the average weight of known non-breeders was 683 g and the average chick pre-fledging weight was 1 076 g.

No direct evidence of longline fishing effects was found in the Great Barrier Island breeding area, although one adult was found with a previously injured (now healed, but malformed) bill which is suspected to be the result of an old fishing injury. Fishing industry observers have witnessed black petrel by-catch this season although many of the birds were released unharmed. It continues to be important to study the Great Barrier Island black petrels to determine the dynamics of the population, in particular survivorship, mortality, productivity and breeding success.

SC-CAMLR-XVII/BG/9
Light-mantled sooty albatross on Campbell Island, 1995/96: a pilot

investigation. P.J. Moore (Department of Conservation, PO Box 10-420, Wellington, New Zealand), 18 pp. (English, unpublished).

A pilot census of light-mantled sooty albatross *Phoebetria palpebrata* nests was conducted on western Campbell Island in November 1995. An extrapolation from 292 nests counted on 19 km of coastline (more than 77 seen on offshore islands and 32 found in four inland areas) suggests that there were at least 1 600 nests on the island in 1995/96. Standard vantage points were established for future counts. Sixty nests were monitored, and 50% were still successfully rearing chicks in January/ February. Five nests at Beeman Hill and 12 nests at northwest Lyall Ridge were monitored more closely, and adults banded.

SC-CAMLR-XVII/BG/10

Oil, paint, marine debris and fishing gear associated with seabirds at Bird Island, South Georgia, 1997/98. C. Hill (British Antarctic Survey, Natural Environmental Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 16 pp. (English, unpublished).

This report describes and quantifies the occurrence of oil, paint, marine debris and fishing gear associated with seabirds at South Georgia. In this, the fifth year of standardised recording, a marked increase in the quantity of plastic debris associated with seabirds was evident; quantities of fishing gear remained within levels of previous years for all species (although the number of squid jigs associated with grey-headed albatrosses increased); feather soiling (by oil and paint) was observed on two wandering albatrosses; human food waste was associated with wandering albatrosses and plastic debris with black-browed albatrosses for the first time in this study.

SC-CAMLR-XVII/BG/11

Entanglement of Antarctic fur seals *Arctocephalus gazella* in man-made debris at Bird Island, South Georgia, during the 1997 winter and 1997/98 pup-rearing season. I.J. Staniland (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 22 pp. (English, unpublished).

Results of the survey of entanglements of Antarctic fur seals at Bird Island, South Georgia, for the eighth consecutive winter (1997) and tenth consecutive summer (1997/98) are reported here. Only seven seals were observed entangled in the winter, a drop of 59% from 1996. Four of these were adult females, a much higher proportion than in previous years. The number of entanglements in the summer was the lowest recorded to date, being 52% lower than in 1996/97. The percentage of entanglements in packaging bands was higher than in recent years, in both summer and winter. Only one seal sustained a severe injury in the winter, no such cases were observed in summer. The summer observations were mainly of juvenile fur seals, with equal numbers of each sex when identified. The observed drop in entanglements is encouraging, but the incidence of packaging bands as collars has not decreased. This highlights the need for sustained monitoring and continuing publicity aimed at preventing the disposal of debris at sea.

SC-CAMLR-XVII/BG/12

Entanglement of Antarctic fur seals *Arctocephalus gazella* in man-made debris at Signy Island, South Orkney Islands 1997/98. A.S. Lynnes (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 12 pp. (English, unpublished).

The results of the second annual survey of entanglement of Antarctic fur seals at Signy Island, South Orkney Islands, are reported for the 1997/98 summer season. There were six sightings of seals wearing neck collars of man-made debris, half the number reported in 1996/97. All of the animals involved were juvenile males, the main component of the population seen at Signy Island at this time of year. The prolonged presence of sea-ice around the South Orkney Islands probably accounted for the low number of fur seals that came ashore during the season. Data are compared with results from a parallel study undertaken at Bird Island, South Georgia, in 1997/98 where the number of

reported entanglements has also decreased. At Signy Island, fishing net was the most common entangling material (83%) and had increased in occurrence since the previous season. The percentage of entanglements in packaging bands (17%) had decreased since 1996/97. In contrast, the percentage of animals entangled in packaging bands at Bird Island was higher than in recent years and there was a decrease in the incidence of net fragments forming collars. Severe injury was being caused to 67% of seals with neck collars at Signy Island (nil at Bird Island), a slight drop (8%) from 1996/97. The decrease in observed entanglements is encouraging although the prevalence of packaging bands and the high incidence of synthetic line and fishing net highlights the need for CCAMLR Members to take further steps to ensure that vessels are aware of, and comply with, regulations prohibiting the disposal of debris in the Southern Ocean.

SC-CAMLR-XVII/BG/13
Southern royal albatross *Diomedea epomophora* census on Campbell Island, 4 January to 6 February 1996, and a review of population figures. P.J. Moore, J.J. Scott, L.J. Joyce and M. Peart (Department of Conservation, PO Box 10-420, Wellington, New Zealand), 27 pp. (English, unpublished).

A census of breeding southern royal albatross was undertaken at Campbell Island during the period from 4 January to 6 February 1996 in the 1995/96 breeding season. A total of 7 787 occupied nests was counted. Comparisons of different field census techniques and a measure of the rate of egg loss suggest that from 8 200 to 8 600 pairs were nesting in the 1995/96 breeding season. The count was 23% higher than in January/February 1995, much of which could be explained by some larger survey blocks being counted more thoroughly. Interpretation of population trend data from previous censuses is difficult because of the likely variability in counting effort between years. Nevertheless, numbers of nests have increased since the first census in January/February 1958, and increased or fluctuated since the 1970s. Accurate counts at study areas (1988 to 1996) show that numbers are currently increasing.

Workshop on Area 48

WS-Area48-98/4 Rev. 1
Do krill and salps compete? Contrary evidence from the krill fisheries. S. Kawaguchi, W.K. de la Mare, T. Ichii and M. Naganobu. *CCAMLR Science*, 5: 205–216, 1998 (English).

Salp by-catch and krill discolouration ('green' krill) caused by active feeding on phytoplankton were analysed using log-book data from Japanese krill trawlers operating near the Antarctic Peninsula. Interannual and seasonal variability of the timing, duration and intensity of salp blooms and the presence of green krill were analysed. No relationship between salp density and the proportion of green krill in the catches was evident when both salps and krill were taken together. In the Livingston Island area, the proportion of green krill was high only when salp density was extremely low. However, no clear relationship was observed in the Elephant Island area. Possible reasons for these phenomena are discussed.

WS-Area48-98/5
Relationships of Antarctic krill (*Euphausia superba* Dana) variability with fluctuations in westerly winds and ozone depletion in the Antarctic Peninsula area. M. Naganobu, K. Kutsuwada, Y. Sasai and S. Taguchi (Southern Ocean Living Resources Research Section, National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424 Japan), 1 p. (abstract only). *Journal of Geophysical Research*, submitted (English).

The assessment of environmental processes causing the variability of Antarctic krill (*Euphausia superba*) is important to understanding the Antarctic marine ecosystem. We have assessed the variability of krill recruitment and stock density in comparison with hypothesised environmental factors. We demonstrated the existence of a long-term relationship between Antarctic krill recruitment in the Antarctic Peninsula area and sea-level pressure gradients across Drake Passage

during the period 1982 to 1993. The years with high pressure gradients, meaning strong westerly winds, coincided with high levels of krill recruitment in 1981/82 (austral summer season), 1987/88 and 1990/91, while the years of extremely low values, meaning weak westerly winds, coincided with the extremely poor krill recruitment in 1982/83, 1983/84, 1988/89, 1991/92 and 1992/93. We also found significant correlations between krill stock density in the Antarctic Peninsula area and Antarctic ozone depletion during 1977 to 1994 (e.g. ozone hole area: $r = 0.844$, $p = 0.001$). This implied that the mean of krill stock densities after 1984/85, marked by abrupt ozone depletion, decreased drastically as compared with the mean before 1982/83. With a gently ascending gradient of ozone depletion, however, krill stock density seems to be slightly recovering year by year after 1990 indicated a minimum stock density. The association of krill variability with westerly winds and ozone depletion suggests that these phenomena are of critical importance to the function of the Antarctic Peninsula area ecosystem.

WS-Area48-98/6
A method for providing a statistical summary of CEMP indices.
I.L. Boyd and A. Murray (British Antarctic Survey, Natural Environment Research Council, Madingley Road, Cambridge CB3 0ET, United Kingdom), 11 pp. (English, unpublished).

WS-Area48-98/7
Ecosystem monitoring and management: past, present and future.
I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 15 pp. (English, unpublished).

WS-Area48-98/8
Interannual variability of the South Georgia marine ecosystem: biological and physical sources of variation in the abundance of krill.
E.J. Murphy, J.L. Watkins, K. Reid, P.N. Trathan, I. Everson, J.P. Croxall, J. Priddle, M.A. Brandon, A.S. Brierley and E. Hofmann. *FisheriesOceanography*, 7: 381–390, 1998 (English).

Interannual variability is a characteristic feature of the Southern Ocean ecosystem, yet the relative roles of biological and physical processes in generating these fluctuations are unknown. There is now extensive evidence that there are years when there is a very low abundance of Antarctic krill *(Euphausia superba)* in the South Georgia area, and that the variation affects much of the ecosystem with the most obvious impacts being on survival and breeding success of some of the major krill predators. The open nature of the South Georgia ecosystem means this variability has large-scale relevance. Fluctuations in year class success in parts, or all, of the population across the Scotia Sea, can generate large changes in the available biomass. The ocean transport pathways maintain the large-scale ecosystem structure by moving krill over large distances to areas where they are available to predator colonies. This large-scale physical system shows strong spatial and temporal coherence in the patterns of the interannual and sub-decadal variability. This physical variability affects both the population dynamics of krill and the transport pathways, emphasising that both the causes and the consequences of events at South Georgia are part of much larger-scale processes.

WS-Area48-98/9
Acoustic estimates of krill abundance at South Georgia, 1981 to 1998. A.S. Brierley, J.L. Watkins, C. Goss, M.T. Wilkinson and I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 15 pp. (English, unpublished.

Acoustic estimates of abundance of Antarctic krill, *Euphausia superba*, at South Georgia are presented for periods within 10 austral summers between 1981 and 1998. This time series includes some previously published estimates arising from cruises where the determination of krill density was a primary objective, and estimates derived for the first time here from acoustic data collected as a subsidiary task during other studies of the pelagic ecosystem at South Georgia. Krill abundance at the island fluctuated widely from year to year over this time, ranging from

≈2 to ≈150 gm^{-2} (wet weight). The 1982, 1991 and 1994 austral summer seasons were characterised by particularly low abundances of krill. For five of the years between 1990 and 1998 it was possible to calculate separate biomass estimates for the northeastern and northwestern ends of South Georgia. In four of these years biomass was higher to the east.

WS-Area48-98/10
Sea-surface temperature anomalies near South Georgia: relationships with the South Atlantic and the Pacific El Niño regions. P.N. Trathan and E.J. Murphy (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 41 pp. (English, unpublished).

The sea-surface temperature dataset of Reynolds and Smith (1994) was used to describe variability around South Georgia. High levels of autocorrelation were evident in the sea-surface temperature anomalies, with periodicity evident at a lag period of four years. To the north of the island significant autocorrelation was also evident at a lag period of one year; though this was restricted to an area that approximately encompassed the Georgia Basin. Cross-correlation analyses with indices describing the El Niño areas of the Pacific indicated that temperature fluctuations at South Georgia reflected temperature fluctuations in the Pacific. This link was separated temporally with the Pacific leading South Georgia by almost three years, and with the West Pacific showing the strongest correlations. These global teleconnections, however, did not completely explain the variability around South Georgia as temperature anomalies also reflected the variability in the Georgia Basin. The high levels of intra-annual variability at South Georgia were examined by means of Principal Component Analysis which indicated that seasonal differences between winter and summer were important. These arguments are developed to suggest that temporal variability in the onset of summer warming is potentially of great importance to the functioning of the ecosystem.

WS-Area48-98/11
Concordance of interannual fluctuations in densities of krill around South Georgia and Elephant Islands: biological evidence of same-year teleconnections across the Scotia Sea. A.S. Brierley, D.A. Demer, R.P. Hewitt and J.L. Watkins (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 13 pp. (English, unpublished).

Acoustic estimates of the densities of Antarctic krill, *Euphausiasuperba*, in areas around South Georgia (SG) and Elephant Island (EI) were compared for seven austral summers between 1981 and 1997. Estimated densities of krill at EI were most often higher than at SG, although this may simply have been a function of differences in survey and data analysis techniques used at each site. More interestingly, the magnitudes of abundance and between-year gradients of change of abundance at each site were mirrored by those at the other location; for example, 1991 and 1994 were years of very low krill density at both SG and EI. There was no apparent lag in changes in abundance at each site, and ranked between-year gradients of change in abundance at both locations were significantly correlated. These pronounced similarities suggest that densities of krill at both locations are directly linked, and may be impacted by the same gross physical and biological factors (e.g. recruitment, dispersal, etc.), acting over the same temporal and spatial scales. The observed concordance also implies that the pelagic ecosystems at these widely separated sites (approximately 1 500 km distant at opposite sides of the Scotia Sea) are not operating in isolation. Possible mechanisms linking krill population processes in the areas around South Georgia and Elephant Island are discussed.

WS-Area48-98/12
Indices of predator performance from Signy Island, South Orkney Islands, 1979 to 1997. A.S. Lynnes and A. Murray (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 22 pp. (English, unpublished).

WS-Area48-98/13
Indices of predator performance from South Georgia, 1976 to 1998.

D.R. Briggs, K. Reid, J.P. Croxall, I.L. Boyd and D.J. Brown (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 21 pp. (English, unpublished).

WS-Area48-98/14
Combined indices of predator performance at South Georgia, 1976 to 1998. K. Reid, D.R. Briggs, I.L. Boyd and J.P. Croxall (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 13 pp. (English, unpublished).

WS-Area48-98/15
Krill population dynamics at South Georgia 1991-1997, based on data from predators and nets. K. Reid, J.L. Watkins, J.P. Croxall and E.J. Murphy. *Marine Ecology Progress Series*, 117: 103–114, 1999 (English).

Central to understanding krill population dynamics is knowledge of their population structure. To examine this we used length-frequency distributions from 142 weeks of sampling (n = 23 996 krill) of three predator species breeding at South Georgia and 12 weeks of sampling (n = 10 252 krill) from scientific nets from the same area over the summers of 1991 to 1997. In comparing the five years with both predator and net samples, despite differing selectivities and spatio-temporal circumscriptions, both were sampling the same overall krill population. Greatest similarity results from comparing net samples with samples from Antarctic fur seal and macaroni penguin combined; least temporal variation occurs in predator samples from late summer (March). From the seven-year predator time series, within-year variation was greatest in 1991 and 1994, both years of low krill biomass at South Georgia. In both of these years large krill dominated during December but were completely replaced by small krill by February. The mean length of the March krill population showed a regular increase from 1991 to 1993, fell to a minimum in 1994 and thereafter increased steadily to 1997. Using these data in conjunction with putative size/age-group cohorts in the length-frequency distribution, we suggest that years of high mean krill length reflect failure of small krill to recruit into the population, producing a period of low krill biomass in the following year. Similar recruitment failure in the same years is evident in krill populations in the Antarctic Peninsula region to the south, indicating large-scale events. This supports suggestions of periodic fluctuations in krill production and recruitment which may relate directly to physical phenomena such as cycles in the distribution and extent of sea-ice.

WS-Area48-98/16
Environmental variability and the behavioural dynamics of Antarctic fur seals in the South Atlantic. I.L. Boyd (British Antarctic Survey, Natural Environment Research Council, Madingley Road, Cambridge CB3 0ET, United Kingdom), 23 pp. (English, unpublished).

Variability in the reproductive performance of marine predators may be a result of physical forcing by large-scale oceanographic variability. Time lags, remoteness from the epicentre of a physical process and the simultaneous action of multiple physical processes often mean that it is difficult to link variability in predator performance with specific measurements of oceanographic variability. This study examined variation in the foraging behaviour of lactating Antarctic fur seals *(Arctocephalus gazella)* over 15 years at the island of South Georgia in relation to major indices of southern hemisphere climate variation. Fur seal foraging trip duration was transformed into a normally distributed index of environmental variation. In a multiple regression analysis, the El Niño/ southern oscillation index (ENSO) and a measure of the annual sea-ice extent both had significant effects on the fur seal foraging index but both had the greatest effect when entered into regression models together. There was also a significant effect of the interaction between the ENSO and sea-ice indices on the fur seal foraging index. There was little effect of a krill recruitment index on the fur seal foraging index, either alone or when in combination with ENSO or sea-ice indices. Lagged cross-correlations showed that the ENSO and sea-ice indices had strong effects when

lagged by one year. This was supported by bivariate correlation between the monthly ENSO means and the fur seal foraging index. These results show that the foraging behaviour of fur seals in the Atlantic domain of the Southern Ocean is sensitive to the proximate physical forcing by a combination of physical variability occurring in the central tropical Pacific as well as in the Antarctic.

WS-Area48-98/17
Diet, provisioning and productivity responses of predators to differences in availability of Antarctic krill. J.P. Croxall, K. Reid and P.A. Prince *Marine Ecology Progress Series*, 117: 115–131, 1999 (English).

Knowledge of relationships between prey availability and predator performance is the key to using predators as indicators of the state of marine systems and assessing potential consequences of interactions between natural predators and man for common resources. Fluctuations in the abundance of Antarctic krill are believed to have substantial influences on the reproductive performance of krill-dependent top predator species in the Southern Ocean; few quantifications of such interactions exist. At South Georgia, in two years when acoustic surveys showed a major difference in krill abundance, we compared diet, provisioning of offspring and breeding success in four main predator species (two penguins, two albatrosses, with supporting data from Antarctic fur seal), whose dependence on krill typically ranges from 20 to 90%. The 10-fold difference in krill biomass between 1986 and 1994 was accompanied by: (i) 88 to 90% reduction in the mass of krill in predator diets (and some increase in the fish component); (ii) greater prey diversity for most species; (iii) reduced diet overlap between species; (iv) switching from krill to amphipods in macaroni penguin but no major dietary change in other species. Rates of provisioning offspring decreased by 90% in gentoo penguin and 40 to 50% in the other three species; this was due to reduced meal size in penguins (by 90% in gentoo and 50% in macaroni) and to doubling of foraging trip duration in albatrosses. Breeding success was reduced by 50% in grey-headed albatross (the species least dependent on krill), by 90% in black-browed albatross and gentoo penguin (only 3 to 4% of eggs producing fledged chicks) but only 10% in macaroni penguin, presumably reflecting its ability to switch to small prey unprofitable for the other species. However, all species (except for black-browed albatross) and particularly macaroni penguin produced fledglings significantly lighter than usual, probably affecting their subsequent survival. Some effects on adult survival could also be inferred. These results show a coherent, though complex, pattern of within- and between-species similarities and differences, mainly reflecting degree of dependence on krill, the feasibility of taking alternative prey and constraints on trip duration and/or meal size imposed by foraging adaptations (especially relating to travel speeds and diving abilities). The generality of these principles are explored through comparison with other studies, particularly Shetland Island seabirds.

WS-Area48-98/18 Rev. 1
Antarctic fur seal *(Arctocephalus gazella)* pup growth rates at Cape Shirreff, Livingston Island, South Shetlands: 1994/95 to 1997/98. R. Hucke-Gaete, V. Vallejos and D. Torres (Universidad Austral de Chile, Facultad de Ciencias, c/o Instituto de Zoología, Casilla 567, Valdivia, Chile), 17 pp. (English, unpublished).

Antarctic fur seal, *Arctocephalus gazella*, pup growth rates were measured using CEMP Standard Methods (C2 – Procedure B) over four consecutive austral summer seasons (1994/95 to 1997/98) at CEMP site and SSSI No. 32 Cape Shirreff, Livingston Island, South Shetlands. Every fortnight (15 days) 100 pups (50 of each sex) were weighed by cross-sectional sampling. Pup growth rates were determined from least square linear regression of weight against age. Strong correlation was found between variables for both sexes, and assumptions of linearity and homogeneity of variance proved to be adequate ($\alpha = 0.05$).

For the purposes of comparison we contrasted our data with values reported for Bird Island, South Georgia (1973 to 1987). Results of this comparison showed that male pups from Cape Shirreff have faster growth rates with less deviation from the mean, while females at both sites had very

similar growth rates. If these growth rate patterns remain similar for equal time series, it could make sense to suggest that Cape Shirreff's male pups grow faster in order to attain better body condition in order to cope with higher-latitude associated problems, although female data would not support this hypothesis.

The highest growth rate for males was attained in 1995, and for females in 1994. Conversely, the lowest growth rate for males was attained in 1994, and for females in 1995 and 1996. This could be explained by differential maternal expenditure between pup sexes, although Lunn and Arnould (1997) have suggested that this hypothesis is invalid. Further conclusions will have to be tested with larger datasets in order to establish possible differences in reproductive strategies between populations of *A. gazella.*

An important decrease in the population of *A. gazella* was observed during 1997/98. No evidence for an ENSO phenomenon influencing pup growth rates has been presented until now.

Pup growth rates might be influence indirectly by sea-ice extent, and directly by krill or salp dominance, since the highest male growth rate (1995/96) was attained when large sea-ice extent was reported, while the two lowest growth rates for males (1994/95 and 1996/97) were attained when less sea-ice was evident. This pattern is surprisingly not followed by females, who appear to have no relation with sea-ice variation.

Four years of data is apparently not enough to sustain all hypotheses described due to some incoherence between sexes, and conclusions drawn are necessarily tentative. Nevertheless, the data illustrate limitations of some hypotheses and give an insight into the variation of Antarctic fur seal reproductive performance at the Cape Shirreff CEMP site in relation to the local marine environment.

WS-Area48-98/19
Variation in condition of the mackerel icefish (draft only). I. Everson and K.-H. Kock (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 7 pp. (English, unpublished).

WS-Area48-98/20
Population structure and recruitment indices of *Euphausia superba* around South Georgia from 1989 to 1998. J.L. Watkins (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 19 pp. *CCAMLR Science*, submitted (English).

During the period 1989 to 1998, a total of seven research cruises were carried out by the British Antarctic Survey in the region of South Georgia. Although net samples were taken during all cruises, the sampling protocols were not always optimised to obtain estimates of krill density from nets, and so a composite index of recruitment has been derived where the density is derived from acoustic survey data and the length frequency has been derived from net samples. Although comparisons of this composite index with a net-derived length-density distribution show substantial differences, it is thought that the composite index is less likely to be biased by one or two very large samples and is therefore valid. Analysis of this composite index reveals that in the period prior to 1994 the number of 1+ krill found around South Georgia was very low ($R1 < 0.07$); in contrast between 1994 and 1998 the number of 1+ krill found in the population increased with a very successful recruitment year being attributable to krill spawned in 1994/95. While the dominant size class in the South Georgia population is year 2+, years of poor krill abundance at South Georgia seem to occur when the 3+ size class is missing from the population.

WS-Area48-98/21 Rev. 1
IWC whale data indices for CCAMLR Area 48 Workshop. S. Reilly, C. Allison, H. Kata and D. Borchers, 14 pp. (English, unpublished).

Working Group on Ecosystem Monitoring and Management

WG-EMM-98/4 Rev. 2
CEMP indices 1998: summary of anomalies and trends. Secretariat, 83 pp. (English, unpublished).

WG-EMM-98/5
Revision of the fishery–foraging overlap model. Secretariat, 10 pp. (English, unpublished).

WG-EMM-98/6
Development of standard methods for collecting environmental data. Secretariat, 18 pp. (English, unpublished).

WG-EMM-98/7 Rev. 2
Report on fine-scale krill data for the 1996/97 season. CCAMLR Secretariat, 19 pp. (English, unpublished).

WG-EMM-98/8
Status and trends of Antarctic seals. Report of SCAR, 9 pp. (English, unpublished).

WG-EMM-98/9
Human activity and disturbance: building an Antarctic site inventory. R. Naveen. *Foundations for Ecological Research West of the Antarctic Peninsula. Antarctic Research Series*, 70: 389–400, 1996 (English).

There have been numerous human intrusions in the Antarctic Peninsula and west of the Peninsula. The region is where many Antarctic research stations are situated, and also where the bulk of Antarctic shipboard tourism takes place. A brief summary of this human history in Antarctica reveals a wide range of real and possible disturbances. Potential impacts from human activities continue to exist – and are expected to increase – because of the growing number of expedition tour operators and of the number of trips being offered. In this context, the soon-to-be-effective Antarctic Environmental Protocol is intended to provide a new measure of protection by ensuring that tourism, science and all other human activities do not have adverse impacts on the Antarctic environment, nor on the value of Antarctica and its associated and dependent ecosystems for the conduct of scientific research. The Protocol requires environmental assessments to be prepared before any such activities take place, and efforts have begun to create a database and inventory of information that assists in both the preparation and the evaluation of these assessments.

WG-EMM-98/10
Comments of the Antarctic site inventory project on the application of the Standard Method A6 'penguin breeding success'. CCAMLR Secretariat, 4 pp. (English, unpublished).

WG-EMM-98/11
Monitoring changes in coastal fish populations by analysis of pellets of the Antarctic shag *Phalacrocorax bransfieldensis*: a new proposed standard method. R.J. Casaux and E. Barrera-Oro (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 9 pp. (English, unpublished).

WG-EMM-98/12
The principal results of YugNIRO complex studies in the Indian sector of the Antarctic. V.I. Bondarenko, V.A. Bibik, V.V. Gerasimchook, E.P. Goubanov, A.V. Romanov and B.G. Trotsenko (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea Ukraine), 11 pp. (English and Russian, unpublished).

In 1997 YugNIRO reached its 30th year of fisheries studies in the Antarctic. The ideology and methodology underlying the studies carried out over this period have two characteristic features. Firstly, complex monitoring: in addition to determining the commercial potential of fish species and krill, studies of the Antarctic ecosystem with its non-biological components are also carried out. Secondly, the development of scientific bases for conducting rational fisheries is an essential part of YugNIRO's work.

WG-EMM-98/13
Preliminary results of biological studies of the First Ukrainian Antarctic expedition in Subarea 48.2 in

March 1997. V.A. Bibik (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea Ukraine), 8 pp. (English and Russian, unpublished).

In March to early April 1997 biological, oceanographic and geological studies were carried out on the Ukrainian scientific research vessel *E. Krenkel* in Subarea 48.2. Similar observations (though far fewer) were carried out in Subarea 48.1. The preliminary results of biological studies made it possible to characterise the status of the krill population and other functionally-significant components of the plankton community.

WG-EMM-98/14

VNIRO program on remote monitoring of oceanographic conditions in fishing areas of the world ocean (the southwestern Atlantic and the southeastern Pacific). G.P. Vanyushin, T.B. Barkanova and A.A. Troshkov (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia), 20 pp. (English, unpublished).

This paper describes a program of application of satellite and ship-monitoring data on the dynamics of the sea-surface temperature (SST) in fishing areas for various time scales (week, month, year etc.). Sample monitoring of fishing areas in the southwestern Atlantic and the southeastern Pacific includes the use of: a set of maps of weekly mean SST and monthly mean SST; maps of gradients, trends, differences and anomalies of SST; analysis of these maps while studying monthly mean and interannual variability of SST; results of comparison of maps of monthly mean SST in various years and mean long-term SST data for the respective periods. Applications are determined for various SST maps and results of their analyses in the process of forecasting fishing conditions.

WG-EMM-98/15

Diet and foraging effort of Adélie penguins in relation to pack-ice conditions in the southern Ross Sea. D.G. Ainley, P.R. Wilson, K.J. Barton, G. Ballard, N. Nur and B. Karl (H.T. Harvey and Associates, PO Box 1180, Alviso, Ca. 95002, USA), 38 pp. (English, unpublished).

We investigated the diet and aspects of foraging effort among Adélie penguins (*Pygoscelis adeliae*) breeding at three colonies on Ross Island, in the south-western Ross Sea – Capes Royds, Bird and Crozier – during the chick provisioning period of three austral summers, 1994/95, 1995/96 and 1996/97. During the study period, pack-ice cover differed in waters offshore of these colonies, by colony, season and year. Diet differed among colonies only slightly. The fish *Pleuragramma antarcticum* was the most important prey, especially during years or periods within years when little pack-ice was present. With respect to krill, which composed the remainder of the diet, juvenile *Euphausia crystallorophias* were consumed predominantly in a year of heavy pack-ice cover; more adult krill were consumed in two years when pack-ice was sparse. Foraging trip duration differed by colony, season and year and was related directly to distance from the colony to the nearest pack-ice. The amount of food brought to chicks increased as trip duration increased, to a point (two days), but then decreased as duration increased further (up to four days). On the basis of data on mass of parents and of meal sizes to chicks, it appeared that on longest trips more of the food gathered by parents was used for self maintenance; on longest trips, parents lost body mass. For this penguin species, successful foraging during chick rearing, the period when adult foraging is most intense, appears to depend on the proximity of pack-ice to nesting colonies.

WG-EMM-98/17

Decline of Antarctic fur seal (*Arctocephalus gazella*) population at SSSI No. 32, South Shetlands, Antarctica during 1997/98: a discussion of possible causes. R. Hucke-Gaete, D. Torres, A. Aguayo and V. Vallejos (Universidad Austral de Chile, Facultad de Ciencias, c/o Instituto de Zoología, Casilla 567, Valdivia, Chile), 14 pp. (English, unpublished).

Little is known of what happened to the population of Antarctic fur seals (*Arctocephalus gazella*) in the Antarctic Peninsula region, specifically on the South Shetland archipelago, after the exploitation period. We compiled historical information

for Cape Shirreff and San Telmo Islets, located on the northern tip of Livingston Island, where the most important colony of this species on the South Shetlands breeds. An ecosystem monitoring program began in 1991, and this has provided detailed population data and other relevant information. Counts have been conducted each season, differentially counting sex and age categories to assess total population. We present an up-to-date logistic model that describes pup population increase from 1965/66 to 1997/98. During this past season, however, a notable population decrease was observed; reasons for this occurrence seem unclear since observed pup mortality was lower than in previous seasons, and leopard seal (*Hydrurga leptonyx*) predation was also lower than last year. We hypothesise that large-scale fluctuations in physical oceanographic features (like the current El Niño Southern Oscillation event and related sea-ice extent influence) might be changing krill abundance and distribution, in turn affecting local predator reproductive performance. Hucke-Gaete et al. (1998) report that pup growth rates for the 1997/98 season do not reflect an El Niño event, although lower mean weights are reported. Nevertheless, we expect to see during the following split season (1998/99) a further decrease in pup production, lower weights in pups, and a considerable decrease in total population due to emigration to better foraging areas.

WG-EMM-98/18

Occurrence of Antarctic krill (*Euphausia superba*) concentrations in the vicinity of the South Shetland Island: relationship to environmental parameters. T. Ichii, K. Katayama, N. Obitsu, H. Ishii and M. Naganobu. *Deep-Sea Research*, I (45), in press (English).

The influence of abiotic and biotic parameters on the occurrence of Antarctic krill (*Euphausia superba*) concentrations were studied in the waters north of the South Shetland Islands, a major krill fishing ground in the Antarctic, during the 1990/91 austral summer. From early to mid-summer krill density increased and showed distinct offshore–inshore differences in abundance and maturity stages. In mid-summer, krill density was low in the oceanic zone (8 gm^{-2}) and higher in the slope frontal zone (36 gm^{-2}), being highest along the shelf break (131 gm^{-2}) in the inshore zone. Krill were in the reproductive stage in the oceanic and frontal zones, but non-reproductive in the inshore zone. Water circulation, food and frontal features were considered important environmental factors determining the occurrence of high krill concentrations in these waters. Drifting buoys indicated that the surface water circulation in areas of krill concentrations was characterised by a sluggish current with eddies along the shelf break in the inshore zone and a shear current in the frontal zone, thus enhancing the residence time for krill. Diatom abundance in both the frontal and inshore zones increased from early to mid-summer, improving krill feeding conditions. Gravid females were closely associated with the frontal zone, showing that the latter may also be a favoured spawning area because of the higher probability of survival for embryos and larvae, in addition to enhanced opportunities for their transport to nursery grounds by prevailing currents. In the waters north of the South Shetland Islands, krill appeared to be highly adapted for exploitation of the rich food resources of the frontal/inshore zone, taking advantage of oceanographic features that led to their retention in these zones.

WG-EMM-98/19

The possibility of practical utilisation of krill target strength (TS) obtained on the basis of in situ EK-500 measurements. S.M. Kasatkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 15 pp. *CCAMLR Science*, submitted (English).

This paper presents a comparative analysis of krill length distribution in the survey area obtained using trawl and acoustic methods. The acoustic estimate of krill length composition was obtained on the basis of the empirical model of Greene et al. (1991) using estimates of in situ target strength (TS) at a frequency of 120 kHz, as measured with an EK-500 echosounder (split-beam principle). Krill was caught using an RT 74/448 commercial trawl. It was shown that differences between krill length distributions predicted from the acoustic model of Greene et al. (1991) and

those from trawl catches were considerable (statistically significant). Moreover, krill length estimates obtained using the acoustic method were significantly lower (20–25%) than those obtained from catch analysis. The use of trawl and acoustic methods to estimate krill length in echosurveys, which in practice meant obtaining in situ TS measurements using the EK-500 and calculating $TS_{calc.}$ on the basis of krill length composition in catches, caused significant differences in krill density estimates obtained for the same population. In some cases these differences were as high as 200%. The significance of trawl samples in assessing krill length composition during echosurveys was demonstrated.

WG-EMM-98/20
Catchability of midwater trawls in relation to the krill fishery. S.M. Kasatkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 15 pp. *CCAMLR Science*, submitted (English).

The correlation between midwater trawl catchability and its construction, trawling regime and the distribution of krill aggregations in the study area is discussed. It is shown that while trawl selectivity affects krill length composition in each trawl sample, trawl catchability affects the estimation of total krill length distribution obtained on the basis of trawl samples from different catches in the study area. Several approaches to trawl sample processing are discussed. It is shown that the total distribution of krill length, obtained by weighting of trawl samples (usually 200 ind.) against the catch, may differ considerably (statistically significant) from that calculated on the basis of trawl samples weighted against the catch and corrected taking into account the trawl catchability for each haul. The example of trawl sample processing for the study area off Elephant Island is presented. The difference of total krill length distribution, calculated using various methods, results, respectively, in differences of density estimates by 48%.

WG-EMM-98/21
Some comments on the procedure of krill target strength assessment in echosurveys. S.M. Kasatkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 16 pp. *CCAMLR Science*, submitted (English).

The impact of midwater trawl selectivity and catchability upon TS and TS_{1kg} estimates in echosurveys is discussed. It is known that krill abundance and biomass estimation should be considered as two independent tasks with different requirements to midwater trawling in echosurveys. Application of the proposed method of mean weighted TS_{1kg} estimation provides a biomass estimate determined only by MSBS (or MVBS) acoustic parameter distribution and independent of the midwater trawl's selectivity and catchability. Krill abundance estimation in relation to TS values requires another approach to echosurveys, since in this case two independent tasks need to be carried out: assessment of MSBS (MVBS) acoustic parameter distribution and krill length (weight) distribution in the study area. The latter requires a suite of problems to be resolved, which makes it possible to consider the trawl as a measuring system. However, the information obtained in that case provides not only a value of total krill abundance, but also of krill biomass and abundance by length classes as well as other demographic parameters of krill.

WG-EMM-98/22
SCAR Bird Biology Subcommittee Ad Hoc Working Group on Seabirds at Sea Methodology. SCAR, 2 pp. (English, unpublished).

WG-EMM-98/24
Hydroacoustic and net krill sampling methods Area 48 survey (decisions and recommendations of the Scientific Committee and its working groups). CCAMLR Secretariat, 46 pp. (English, unpublished).

WG-EMM-98/25
Report from the Steering Committee for the Synoptic Survey of Area 48. Steering Committee, 22 pp. (English, unpublished).

WG-EMM-98/26
Report of the 1996 APIS Survey Design and Implementation Workshop. SCAR, 16 pp. (English, unpublished).

WG-EMM-98/27
Report of the meeting of the SCAR Group of Specialists on Seals. SCAR, 39 pp. (English, unpublished).

WG-EMM-98/28
Foraging trip duration in male and female macaroni penguins at Bouvetøya. F. Mehlum, K. Isaksen and V. Bakken (Norwegian Polar Institute, PO Box 5072 Majorstua, N-0301 Oslo, Norway), 11 pp. (English, unpublished).

The CEMP standard methods for monitoring foraging trip duration in macaroni penguins recommend using only males. However, males attend the chicks at the nest during most of the brooding period, while females make frequent foraging trips. We analysed data from 17 males instrumented with VHF transmitters in the middle of the brooding period (chick age 12 to 18 days) and 17 females instrumented at the start of the creching period. The first trip usually lasted several nights, whereas subsequent trips were shorter (average 21.8 h). Female foraging trips averaged 27.2 h. No apparent changes in the foraging trip duration of either sex as a function of date were recorded during the creching period. Female attendance periods in the colony were shorter (average 11.9 h) than those of males (average 21.4 h), and females made more foraging trips than males. These results suggest that females might be more appropriate than males as the subjects when monitoring foraging trip duration. In addition, the fact that females spent more time foraging and conducted more foraging trips than males might suggest that female foraging trip duration is more sensitive to changes in prey availability.

WG-EMM-98/29
Green krill – the indicator of micro- and nano-size phytoplankton availability to krill. S. Kawaguchi, T. Ichii and M. Naganobu (National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424 Japan), 9 pp. (English, unpublished).

Size-fractionated chlorophyll-a concentrations of surface seawater were measured (pico-, nano- and micro-size fractions) during commercial krill operations in waters north of the South Shetland Islands from late December 1991 to mid-February 1992. The proportion of green krill had significant regressions with chlorophyll-a concentrations in micro- and nano-size fractions. This result shows the importance of micro- and nano-size phytoplankton as a food source for Antarctic krill.

WG-EMM-98/30
Status of the Polish FIBEX acoustic data from the west Atlantic. P.N. Trathan, J. Kalinowski and I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 11 pp. *CCAMLR Science*, submitted (English).

Acoustic data from the Polish FIBEX survey in the west Atlantic were examined to check the consistency of krill abundance estimates against the results of the other FIBEX survey vessels. The results indicated that there was a high level of consistency between the results from the Polish vessel and those from the other vessels that operated in the Peninsula region and in the west Atlantic.

WG-EMM-98/31
Pursuit of polynyas in the Ross Sea, Antarctica. M. Naganobu, T. Tanaka, Y. Okada, N. Kimura and S. Matsumura (National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424 Japan), 12 pp. (English, unpublished).

Polynyas accelerate oceanic and atmospheric processes. We are also of the view that polynyas influence biological activity. We studied daily transition of polynyas in the Ross Sea, Antarctica, from 1978 to 1994 using images of sea-ice concentrations provided by satellite microwave observations. A typical polynya existed in the inner area of the Ross Sea in November of each year. The shape of the polynya changed remarkably over several days. The polynyas have a range of approximately 500 km from the Antarctic coast to the entrance of the Ross Sea. The polynyas usually opened to the northern oceanic water late in December each year except 1982, 1988 and 1992.

WG-EMM-98/32
Krill distribution in the western Atlantic sector of the Southern

Ocean during 1983/84, 1984/85 and 1987/88 based on the results of Soviet mesoscale surveys conducted using an Isaacs-Kidd midwater trawl. V.A. Sushin and K.E. Shulgovsky (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 20 pp. *CCAMLR Science*, submitted (English).

In this paper we consider the results of three mesoscale surveys covering a wide area of krill distribution between the Antarctic Peninsula and South Georgia Island. Surveys including from 158 to 202 stations were carried out by Soviet research vessels in the summer–autumn periods of 1983/84 and 1987/88 and in the spring of 1984/85 across a standard grid of stations according to the standard method used for Isaacs-Kidd midwater trawls operating in the layer 0 to 100 m. Overall krill biomass distribution (g/1 000 m^3) and its mean values were analysed by subareas (48.1, 48.2 and 48.3) and for the whole study area. Survey results confirm current understanding of the general pattern of krill distribution and drift in the western part of the Atlantic sector of the Antarctic (e.g. Priddle et al., 1988; Makarov, 1996). The greatest degree of spatial–temporal stability in the krill distribution field with higher biomass of aggregations was observed in the western part of the area stretching from the Antarctic Peninsula to the eastern part of the South Orkneys area. The greatest variability of krill distribution on the spatial–temporal scale of the survey which is characterised by a change in biomass of more than two orders of magnitude in different seasons, was observed in the South Georgia region and adjacent waters of the Scotia Sea (Subarea 48.3). The possibility of krill transportation into the region of South Georgia is considered. It is shown that the absence of krill in the island region during the 1983/84 season was caused exclusively by unfavourable oceanological conditions (lack of water flow from southern areas). It is also demonstrated that the absence of krill in the eastern part of the Scotia Sea may cause it to be absent from the South Georgia region regardless of oceanological conditions (spring–summer period 1983/84). The possibility of recruitment of the krill stock to the South Georgia region from the central part of the Scotia Sea is considered. Analysis of variability of mean biomass by area and season indicates that patterns of krill abundance and biomass recently observed in Subarea 48.1 (Siegel et al., 1997, 1998) are not representative of the survey area as a whole. The total biomass index in the study area during all seasons remained at a constant level (76.5–101.7 g/1 000 m^3).

WG-EMM-98/33

Proportional recruitment indices of Antarctic krill from Japanese fisheries data in Subareas 48.1, 48.2 and 48.3 from 1980 to 1997. S. Kawaguchi, T. Ichii and M. Naganobu (National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424 Japan), 28 pp. (English, unpublished).

Proportional recruitments (R1 and R2) were calculated for Subareas 48.1, 48.2 and 48.3 from logbook data from Japanese commercial krill trawlers covering the period 1980 to 1997. Interannual patterns of R1 and R2 in Subarea 48.1 generally showed similar trend to values around Elephant Island reported by Siegel et al. (1998). However, the values in this study, especially R1, were extremely smaller than those of Siegel et al. (1998). This may be due to net selectivity and/or incomplete coverage of the distribution of small krill by commercial fisheries. Interannual patterns of R1 and R2 in Subarea 48.2 were somewhat similar to the pattern for Subarea 48.1. However, because of inconsistency of fishing periods and occasionally small sample sizes, interpretation of trends in this subarea should be done very carefully. In Subarea 48.3, R1 values showed evidence of recruitment from two year classes, which coincided with the year classes of strong proportional recruitment in Subarea 48.1. However, we noted the complexity of length composition in this subarea.

WG-EMM-98/34

Phytoplankton standing stocks in relation to krill in Antarctic waters. X.N. Verlecar, R. Vijayakumar, F. Saldhana and L. Martins (National Institute of Oceanography, Dona Paula, Goa 403 004, India), 11 pp. (English, unpublished).

During the First Indian Antarctic Krill Expedition investigations of krill trawling operations in the Southern Ocean were accompanied by phytoplankton and zooplankton studies. The study area, which lies between latitude 56°–61°17'S and longitude 30°–40°E, is characterised by cold surface waters with temperatures ranging from 0 to 3°C and high nutrient content. Phytoplankton cell counts in surface waters ranged from (1.92 to 21.89) x 10^4 cells/litre. Phytoplankton cells represented 33 species, consisting of 32 diatoms and one dinoflagellete. *Chaetoceros* and *Nitzschia* spp. were the dominant phytoplankton organisms. The other common diatoms present during the studies were *Navicula*, *Rhizosolenia*, *Leptocylindrus* and *Corethron criophilum*. The calm sea state prevailing from 27 January to 11 February favoured the proliferation of certain phytoplankton species attaining bloom condition. Zooplankton biomass showed wide fluctuation, with values ranging from 9.8 to 303.7 ml/100 m^3. While the total catch per (IKMT) trawl ranged from 0.2 to 2 400 kg, the percentage of krill occurrence varied from 0 to 100% at stations sampled. The fluctuations in phytoplankton and zooplankton standing stocks followed a similar trend. The marked drop in phytoplankton and zooplankton in the region of krill swarms, however, demonstrated active feeding by the latter on these planktonic communities. The results indicate that areas favouring phytoplankton blooms and zooplankton abundance could be possible sites for locating krill fisheries in the Southern Ocean.

WG-EMM-98/35

Studies on zooplankton with special reference to krill from the Indian Ocean sector of the Southern Ocean. K.L. Bhat, R. Vijayakumar and V. Jaya Sree (National Institute of Oceanography, Dona Paula, Goa 403 004, India), 15 pp. (English, unpublished).

The distribution, abundance and species composition of zooplankton collected during the First Indian Antarctic Krill Expedition were studied. Zooplankton biomass values ranged from 9.79 to 303.62 ml/100 m^{-3} ($x = 142.14 \pm 77.02$). High standing stock values were recorded in the study area where copepods, chaetognaths, euphausiids and salps were the dominant taxa. Copepoda formed the major constituent of the zooplankton community and the population density ranged from 650 to 7 209/100 m^{-3} of zooplankton catch. Swarms of krill and salps, the primary cause of high standing zooplankton stock, were observed during the study period (austral summer). The prevailing physical parameters could be important factors influencing the higher standing stock of various zooplankton groups. The study revealed that the present investigation site is a potential krill fishing ground.

WG-EMM-98/36

Hydroacoustic assessment of krill in Area 58 of the Indian Ocean sector of the Antarctic region. Z. Klusek and A. Anrose (Institute of Oceanology, Polish Academy of Sciences, 81–718 Sopot, Poland), 25 pp. *CCAMLR Science*, submitted (English).

The biomass density of krill, and its spatial and depth distribution are presented on the basis of acoustically-registered krill swarms along a 1 097-n-mile transect in Area 58 of the Indian Ocean sector of the Antarctic region. The mean density of krill biomass between 60°00'S and 61°00'S and 34°00'E and 40°00'E was recorded as 0.6 $t.km^{-2}$. Krill was not observed north of 60°00'latitude. Factors which influence the abundance of krill in the area are discussed. Different forms of krill swarms observed during the survey are illustrated and defined.

WG-EMM-98/37

Biology, distribution and abundance of Antarctic krill (*Euphausia superba*) and by-catch. A. Anrose, Z. Klusek, M.K.R. Nair and M.R. Bhoopendranath (Fishery Survey of India, Royapuram, Madras 600 013, India), 22 pp. *CCAMLR Science*, submitted (English).

During the First Indian Antarctic Krill Expedition (FIKEX), krill samples were collected from 34 stations in Area 58 of the Indian Ocean sector of the Antarctic region between latitude 57°53'S–61°13'S and longitude 30°02'E–40°05'E. These were analysed on board FORV *Sagar Sampada* for the study of biology, distribution and

abundance. The samples were collected for a period of 18 days from 26 January to 12 February 1996. Three types of gear were used, viz Isaacs-Kidd Midwater Trawl (IKMT), 49.5-m krill midwater trawl (Cosmos trawl, Denmark) and 42-m krill midwater trawl (Polish). The length-frequency analysis indicated a bimodal distribution with 19–20 mm and 53–54 mm as the most abundant sizes in Area 58. The average sex ratio of male and female *Euphausia superba* was observed to be 1:1.17, although this differs from swarm to swarm. The feeding intensity was high in 47% of krill and moderate in 25% of krill analysed. It indicates the feeding condition of krill and availability of food in the area surveyed. Maturity stage IV (fully matured) was dominant among both sexes, followed by stage V (spawned), indicating spawning period. Of the total recorded catch of 12.47 tonnes, krill constituted 45.6% and the by-catch 54.4%. The by-catch included salps 54%, Antarctic squid 0.07%, jellyfish 0.02% and finfish 0.13%.

WG-EMM-98/38

Investigations on midwater trawling for krill (*Euphausia superba*) in the Southern Ocean. M.R. Bhoopendranath, M.K.R. Nair, A. Anrose and V.C. George (Central Institute of Fisheries Technology, Cochin 682 029, Kerala, India), 12 pp. (English, unpublished).

This paper summarises the results of harvesting operations for Antarctic krill (*Euphausia superba*) in Area 58 in the Indian Ocean sector of the Southern Ocean during the First Indian Antarctic Krill Expedition (27 December 1995 to 10 March 1996) on board FORV *Sagar Sampada*. Eighteen hauls were made using a 2.5-m Isaacs-Kidd Midwater Trawl (IKMT) in the area 59°00' to 61°08'S; 30°04' to 40°04'E from 27 January to 12 February 1996. Krill were caught in waters south of 60° parallel (60°43' to 61°00'S), between 32°00' and 34°05'E. Krill were present in 33.3% of hauls. Major species obtained were krill (8%) and salps (92%). Trawling operations targeted at Antarctic krill were conducted using a 42-m commercial midwater krill trawl sourced from Poland and a 49.5-m experimental midwater krill trawl of Danish origin. A total catch of 12 470 kg was landed during the 16 directed hauls. This included 5 637 kg Antarctic krill (*Euphausia superba*), 6 738 kg salps, 35 kg jellyfish, 12 kg juvenile krill, 2.2 kg lanternfish, 5.7 kg squid and 2.7 kg other fish. Krill constituted 46% of the total catch while salps constituted 54%. The average krill catch was 354.6 kg.haul^{-1}. In the area of operations (57°53'–61°13'S and 31°40'–36°31'E) krill were caught between 60°48'–61°13'S and 31°19'–34°14'E. Better catches (>1 000 kg.haul^{-1}) were obtained between 60°40'–61°13'S and 33°34'–34°14'E.

WG-EMM-98/39

Studies on Antarctic krill (*Euphausia superba*): biochemical and processing aspects. C.N. Ravishankar and K. Ashok Kumar (Central Institute of Fisheries Technology, Cochin 682 029, Kerala, India), 9 pp. *CCAMLR Science*, submitted (English).

Antarctic krill harvested from the Southern Ocean during the First Indian Antarctic Krill Expedition was processed on board FORV *Sagar Sampada* and the biochemical parameters of frozen stored samples were studied. The mince and various other products were prepared. The chemical composition is similar to other related species. The fluoride in the shell migrated into the meat when stored frozen to a degree of 44% after three months.

WG-EMM-98/40

The development of products from Antarctic krill and test marketing. M.K.R. Nair, S. Girija, K.K. Muhammad Basheer and M.K. Venue (Integrated Fisheries Project, Kochi 682 016, India), 29 pp. (English, unpublished).

Antarctic krill (*Euphausia superba*) harvested during the First Indian Antarctic Krill Expedition was subjected to primary processing such as freezing, preparation of minced meat etc. on board the vessel. On shore these primary products were further processed into several value-added products which included dried, canned, frozen and other specialty products and by-products. Biochemical, bacteriological and organoleptic assessments of many products were carried out. The details of the work carried out and the results obtained are summarised in this paper.

WG-EMM-98/41
Krill products for human consumption (*Euphausia superba*). J. Joseph, V. Muraleedharan, R. Thankamma and C.N. Ravishankar (Central Institute of Fisheries Technology, Cochin 682 029, Kerala, India), 6 pp. (English, unpublished).

Studies were conducted to produce different products using krill meat stored for two months at -30°C and one month at -20°C. Dried krill of good quality could be prepared by blanching in boiling 5% Na C1 solution for five minutes and then sun drying. Incorporation of krill mince, even at a level of 10% to fish mince, during production of surimi and fish paste affected quality. Though a prawn-like flavour was detected on mixing krill mince with fish mince during preparation of fish cutlets and fish burgers, a bitter after taste resulted at the 10% level and a bitter taste at the 20% level or above. The swelling property of the fish wafer was affected by the incorporation of krill mince.

WG-EMM-98/42
Biochemical investigations on Antarctic krill (*Euphausia superba*). M.R. Raghunath, T.V. Shankar, A.G. Radhakrishnan, S. Mathew, K. Ammu, C.N. Ravishankar, K. Jayan and L. Jose (Biochemistry and Nutrition Division, Central Institute of Fisheries Technology, Matsyapuri PO, Kochi 682 029, Kerala, India), 21 pp. *CCAMLR Science*, submitted (English).

Antarctic krill (*Euphausiasuperba* Dana) caught during the First Indian Krill Expedition 1996 was processed on board into whole krill, peeled tail meat and whole krill mince. These products were analysed for trace metals, fluoride, pesticides, lipids, cholesterol and fatty acid composition. Autolysis at various pH and temperature levels as well as thermal coagulation of krill mince heated rapidly while suspended in various media were also studied. Fluoride content was 212 ppm in whole krill. Trace metals were below toxic levels while no pesticides were detected. Krill tail meat had small amount of lipids and cholesterol (0.81 and 0.033% respectively). The lipids were rich in C18:1, C20:5 and C22:6 fatty acids. Autolytic activity at pH 3–4 and 8–10 was predominant in whole krill at 20 and 40°C, but autolysis in tail meat was much less in comparison. Nearly 80% of the soluble proteins in krill suspension could be precipitated by rapid heating.

WG-EMM-98/43
Otolith size in the mackerel icefish. I. Everson and B. Bendall (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 10 pp. *CCAMLR Science*, submitted (English), (abstract not available).

WG-EMM-98/44
The Area 48 synoptic survey: an adaptive survey design. J.L. Watkins, A. Murray and I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 5 pp. (English, unpublished).

WG-EMM-98/45
Evaluation of de la Mare's composite standardised index for generating a simple time-series summary of many long-term datasets on Antarctic predators: consequences of missing values and criteria for inclusion of predator parameters. A.J. Constable (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 20 pp. *CCAMLR Science*, submitted (English).

In 1997 de la Mare presented a statistic (labelled the Combined Standardised Index at the Workshop on Area 48) to WG-EMM for generating a simple time-series index of many long-term datasets on Antarctic predators. The value of the index in a given year is dependent on the specific parameters present in that year. In this respect, the robustness of the index is dependent on that subset of parameters being representative of all the parameters for that year. Clearly, this will depend on how correlated the parameters are to each other. This paper reports on a Monte Carlo simulation study that helps specify general criteria for the inclusion of predator parameters in the index with regard to the potential effects of missing values as well as the degree of correlation between parameters. These trials found that, for inclusion in the index, parameters should be positively correlated with all other parameters and preferably

with correlations greater than 0.3. If this criterion is met then these results indicate that a time series of three years for the full matrix of eight parameters used in this study is sufficient for determining the correlation coefficients. These criteria need to be accepted with caution. Further work is required to assess the effects of sampling variability on the performance of the index. Also, this work needs to account for the characteristics of the current CEMP database and to assess which of the available parameters might be included in the index. A general challenge is to determine how to incorporate parameters that are highly negatively correlated to the other parameters in analyses of the effects of prey availability and the environment on predators. The latitude given to accepting some parameters in the index needs to be evaluated in the wider context of being able to make correct decisions based on the index despite the uncertainties or variability in the behaviour of those parameters.

WG-EMM-98/46
CCAMLR Standard Method A3b. P.R. Wilson (Manaaki Whenua – Landcare Research, Private Bag 6, Nelson, New Zealand), 3 pp. (English, unpublished).

WG-EMM-98/47
Some suggestions for acoustic protocols for the synoptic survey of FAO Area 48. D.A. Demer (Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), 4 pp. (English, unpublished).

WG-EMM-98/48
A model at the level of the foraging trip for the indirect effects of krill (*Euphausia superba*) fisheries on krill predators. M. Mangel and P.V. Switzer. *Ecological Modelling*, 105: 235-256, 1998 (English).

We present a model at the level of the foraging trip for the effects of a fishery on krill (*Euphausia superba*) predators, using the Adélie penguin (*Pygoscelis adeliae*) as a model organism. The model involves: (i) the description of the biomass and spatial distribution 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. 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. Furthermore, there is a 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. After fledging, offspring survival depends in part upon the amount of krill delivered to them during the feeding periods. We use empirical data to estimate parental and offspring needs and a standard life history model to set the upper limits for survival. Parental survival after breeding depends upon the krill deficiency (relative to needs) that parents accumulate while feeding their young. A sensitivity analysis of the breeding model shows that the predictions are robust for parameters about which little is known, to the functional forms relating krill abundance to offspring and parent survival, 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 and reductions in adult survival are also linear functions of krill catch, with but 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 capacity for harvest, rather than when fishing begins.

WG-EMM-98/49
AMLR 1997/98 field season report: objectives, accomplishments and tentative conclusions. USA (Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), 18 pp. (English).

WG-EMM-98/50
Interannual variability of krill, salp and other zooplankton populations in the South Shetland Island area during austral summer 1993–1998. V. Loeb, W. Armstrong, R.P. Hewitt and V. Siegel (Moss Landing Marine Laboratories, Moss Landing, Ca., USA), 38 pp. (English, unpublished).

The summer 1998 AMLR field season followed late-forming but spatially extensive winter sea ice in the Antarctic Peninsula region. Overall krill length/maturity composition reflected poor recruitment from the past two years. Unusually small juvenile krill in 1998 suggested that survival success was limited to late-spawned eggs and larvae in 1997. Delayed spawning and few larval krill in 1998 were associated with extremely high salp abundance. *Salpa thompsoni* abundance was similar to levels during the 1993 'salp year'. The magnitude of this salp bloom may have resulted from a large overwintering 'seed' population developed the preceding autumn. Presence of large numbers of another salp species, *Ihlea racovitzai*, was unique to AMLR surveys and indicated faunal input from the east.

Comparisons of January and February 1998 survey data with data from previous AMLR field seasons showed recurring patterns of species abundance relationships that allowed definition of different ecological regimes identified here as 'copepod years', 'salp years' and 'transition periods'. The four- to five-year periodicity of 'salp years' over the past 15 years is discussed with respect to the Antarctic Circumpolar Wave (ACW).

WG-EMM-98/51
Acoustic estimates of krill density at South Georgia during 11 austral summers between 1981 and 1998. A.S. Brierley, J.L. Watkins, C. Goss, M.T. Wilkinson and I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 16 pp. *CCAMLR Science*, submitted (English).

Acoustic estimates of densities of Antarctic krill, *Euphausia superba*, at South Georgia are presented for 11 austral summers between 1981 and 1998. Krill density at the island fluctuated widely from year to year over this time, ranging from ≈2 to ≈150 gm^{-2} (wet weight). The 1982, 1991 and 1994 austral summer seasons were characterised by particularly low abundances of krill. For five of the summers between 1990 and 1998 it was possible to calculate separate density estimates for northeastern and northwestern ends of South Georgia, and in four of these seasons density was higher to the east.

WG-EMM-98/52
Natural fluctuations in the abundance of krill taking into account global climate changes in the southern hemisphere: forecasting possibilities. K. Shust (VNIRO, 17a, V. Krasnoselskaya, Moscow 107140, Russia), 16 pp. (English, unpublished).

Biological and hydrological studies of the ecosystem conducted in the Atlantic sector of the South Ocean in recent years have made it possible for scientists to establish a rather clear relationship among the winter and spring ice-cover variations, summer water surface temperature, and 'success' in the reproduction of krill (*Euphausia superba*) and salp (*Salpa thompsoni*) (SC-CAMLR-XV, Annex 5; SC-CAMLR-XVI, Annex 4).

The analysis of multiannual observations (1977–1997) conducted by Siegel (Siegel et al., 1997) and other researchers in Subarea 48.1 showed good correlation between the strong year classes of krill and severe winters when the ice cover extended considerably northwards compared to the multiannual average level, and which is associated with late thawing of ice. By contrast, poor generations of krill were formed during the years when the winter position of the ice edge was south of the average multiannual level. The abundance of salp rose sharply in the areas of krill distribution in summer during years of moderate winter and higher surface temperature. Salp occurred in large numbers constantly both in scientific and commercial fishing gear. Poor year classes of krill and upsurges in the abundance of salp were recorded in seasons 1982/1983 and 1988/1989 (Siegel and Loeb, 1995), i.e. during the years of development of El Niño, which causes warming in Subarea 48.1 and can also affect the reproductive capacity of krill.

WG-EMM-98/53
The Area 48 synoptic survey: three possible approaches. J.L. Watkins, A. Murray and I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 9 pp. (English, unpublished).

Working Group on Fish Stock Assessment

WG-FSA-98/4
Data and resources available to WG-FSA-98. CCAMLR Secretariat, 3 pp. (English, unpublished).

WG-FSA-98/6
Comparison of seabed areas. CCAMLR Secretariat, 4 pp. (English, unpublished).

WG-FSA-98/7
Introduction to the CCAMLR intranet. CCAMLR Secretariat, 2 pp. (English, unpublished).

WG-FSA-98/8
Inventory of CCAMLR datasets. CCAMLR Secretariat, 3 pp. (English, unpublished).

WG-FSA-98/9
Scientific observations of trawl operations during the 1997/98 season. CCAMLR Secretariat, 4 pp. (English, unpublished).

WG-FSA-98/10
A summary of observations on board longline vessels operating within the CCAMLR Convention Area. CCAMLR Secretariat, 13 pp. (English, unpublished).

WG-FSA-98/11
Fish by-catch in krill fisheries. CCAMLR Secretariat, 8 pp. (English, unpublished).

WG-FSA-98/12
Fishery data reporting requirements for 1999. CCAMLR Secretariat, 42 pp. (English, unpublished).

WG-FSA-98/13
Fecundity of Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 (around South Georgia). M.M. Nevinsky and A.N. Kozlov (Federal Research Institute of Fisheries and Oceanography, VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia), 13 pp. *CCAMLR Science*, submitted (English).

The absolute and relative fecundity of Patagonian toothfish (*Dissostichus eleginoides*) inhabiting areas around South Georgia and Shag Rocks were studied. The absolute fecundity of toothfish specimens in relation to their size ranged from 56 900 to 567 500 eggs, averaging 152 900 eggs. Values of relative individual fecundity of toothfish varied from 4 100 to 13 000 eggs (averaging 8 190 ± 1 730 eggs) per kilogram of fish body weight. Our studies, and the analysis of previously published data, indicate that *D. eleginoides*, like most of the Notothenioids characterised by large eggs, can be classified as a fish species which has a high absolute fecundity and a low relative fecundity.

WG-FSA-98/14
Surface areas of seabed within the 500 m isobath for regions within the South Shetland Islands (Subarea 48.1). C.D. Jones, S.N. Sexton and R.E. Cosgrove III (National Oceanic and Atmospheric Administration, National Marine Fisheries Service, US Antarctic Marine Living Resources Program, PO Box 271, La Jolla, Ca. 92038, USA), 7 pp. *CCAMLR Science*, submitted (English).

Bathymetric maps of two major areas within the South Shetland Islands were generated using several integrated bathymetric databases. These areas comprise the lower South Shetland Island chain from King George Island to Smith Island, and the region around Elephant Island. From the integrated datasets, areas of seabed within the 500 m isobath for six levels of depth strata (0–50 m, 51–100 m, 101–200 m, 201–300 m, 301–400 m, 401–500 m) were computed. Areas were calculated based on true surface area of seabed, incorporating seafloor slope.

WG-FSA-98/15
Results from the 1998 bottom trawl survey of Elephant Island and the lower South Shetland Islands (Subarea 48.1). C.D. Jones, K.-H. Kock and S. Wilhelms (National Oceanic and Atmospheric Administration, National Marine Fisheries Service, US Antarctic Marine Living Resources Program, PO Box 271, La Jolla, Ca. 92038, USA), 31 pp. (English, unpublished).

Bottom trawl surveys were conducted by the United States Antarctic Marine Living Resources (US AMLR) program in two major regions of the South Shetland Islands: Elephant Island and the lower South Shetland Islands from King George Island to Livingston Island. Information on species composition, catch levels, size composition and condition are described and compared between the two regions. Maturity ogives were constructed for five species of finfish: *Champsocephalus gunnari, Gobionotothen gibberifrons, Chaenocephalus aceratus, Chionodraco rastrospinosus* and *Lepidonotothen squamifrons.* Estimates of length at sexual maturity and length at first spawning are computed and compared with previous estimates and other populations.

WG-FSA-98/16 Rev. 1
Do the males of *Dissostichus eleginoides* grow faster, or only mature before females? C.A. Moreno (Instituto de Ecología y Evolución, Universidad Austral de Chile, Casilla 567, Valdivia, Chile), 8 pp. (English, unpublished).

Data on maturity obtained by scientific observers on board the ships *Argos Helena* and *Cisne Verde* during August 1997 and utilised by WG-FSA in 1997 to build maturity ogives, was age-transformed applying the age–size relationship obtained from the specific equations for each sex to samples taken from around South Georgia. The results show that the differences are due to maturity-at-age and not to the growth rate. Based on this sample of 434 females and 398 males, it is concluded that males reach maturity at a minimum of four years of age, and females at a minimum of 10 years, with 100% of males being mature at 12 years and of females at 21 years.

WG-FSA-98/17
Standing stock biomass of eight species of finfish around Elephant Island and the lower South Shetland Islands (Subarea 48.1) from the 1998 US AMLR bottom trawl survey. C.D. Jones, K.-H. Kock and S. Wilhelms (National Oceanic and Atmospheric Administration, National Marine Fisheries Service, US Antarctic Marine Living Resources Program, PO Box 271, La Jolla, Ca. 92038, USA), 14 pp. (English, unpublished).

In March 1998, the United States Antarctic Marine Living Resources (US AMLR) program conducted bottom trawl surveys of the two major regions of the South Shetland Islands: Elephant Island and the lower South Shetland Islands from King George Island to Livingston Island. Estimates of total stock biomass and spawning stock biomass were computed for six species: *Champsocephalus gunnari, Gobionotothen gibberifrons, Notothenia coriiceps, Chaenocephalus aceratus, Chionodracorastrospinosus* and *Lepidonotothen squamifrons*. Estimates of total stock biomass only were computed for two additional species: *Lepidonotothen larseni* and *Notothenia rossii*. Biomass was estimated for both regions separately, and combined as one system using previous and updated estimates of seabed areas for Elephant Island and the lower South Shetland Islands.

WG-FSA-98/18
Validation of the Generalised Yield Model. CCAMLR Secretariat, 11 pp. (English, unpublished).

WG-FSA-98/19
Seabird observations in Subareas 48.1, 48.2 and 88.3 and proposal for a new streamer line design. A. Benavides and P.M. Arana (Laboratorio de Ecofisiología, Facultad de Ciencias, Universidad de Chile, Casilla 114-D, Santiago, Chile), 12 pp. (English, unpublished).

A 43-day cruise on FV *Tierra del Fuego* took place in February and March 1997, as part of the New Fisheries Project developed by Chile in Statistical Subareas 48.1, 48.2 and 88.3. During this research study every measure currently in force was used to

prevent incidental seabird mortality and, in addition bird observations were made in each of the 52 sets with the Spanish-designed longlines. The streamer line suggested by CCAMLR was not appropriate during windy conditions, so an alternative design was tested using mesh sacks as secondary elements, which proved more efficient due to their simpler construction and increased visibility. No birds were reported to be caught or killed during the fishing activities. During the entire cruise a total of 436 birds were observed. The most abundant species was *Diomedea melanophrys*, with 204 sightings, followed by *Oceanities oceanicus*, with 77; *Catharactalönnbergi*, with 40; and *Diomedea chrysostoma*, with 37. The highest relative abundance was found in Subarea 48.1 with 11.1 birds/haul, followed by Subareas 48.2 and 88.3 with 7.6 and 5.0 birds/haul respectively. The highest number of species was found in Subarea 48.1 where 19 species were observed and the least in Subarea 48.2, where only four species were present.

WG-FSA-98/20
Fishing with pots in the Antarctic region (CCAMLR Statistical Subareas 48.1, 48.2 and 88.3). P.M. Arana and R. Vega (Escuela de Ciencias del Mar, Universidad Católica de Valparaíso, Casilla 1020, Valparaíso, Chile), 23 pp. (English, unpublished).

Results of the February/March 1998 exploratory and experimental fishing operations using pots are described. This research was part of the New Fisheries Project undertaken by Chile, with the purpose of determining the presence of *Dissostichus* spp. in Subareas 48.1, 48.2 and 88.3. In each location where industrial bottom longlines were used, six pots were lowered, three at each end of the fishing gear, with a distance of approximately 90 m between pots. The pots were lowered to a depth of 290 to 1 920 m. A total of 300 pots of four different designs were used. Approximately 1 kg of either whole salted sardines (*Sardinops sagax*) or squid (*Illex argentinus*) were used. According to the total weight obtained with pots, the main resources were Antarctic crab (*Paralomis anemerae*) (28%), striped-eyed rockcod (*Lepidonotothen kempi*) (17%), eelpout (*Lycenchelys bellingshauseni*) (13%) and smalleye moray cod (*Muraenolepis microps*) (11%). In numbers, individuals caught most were amphipods (55%), Antarctic crab (*P. anemerae*) (110.7 g/pot), striped-eye rockcod (*L. kempi*) (67.4 g/pot) and eelpout (*L. bellingshauseni*) (51.2 g/pot). In general, *P. Anemerae* was captured in all researched subareas, with a higher yield in Subarea 48.2 (548.8 g/pot).

WG-FSA-98/21
Introduction to the Generalised Yield (GY) model since WG-FSA in 1997. A.J. Constable and W.K. de la Mare (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 32 pp. (English, unpublished).

WG-FSA-98/22
Modifications to the Generalised Yield (GY) Model since WG-FSA in 1997. A.J. Constable and W.K. de la Mare (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 1 p. (English, unpublished).

WG-FSA-98/23
Estimates of age for samples of *Dissostichus eleginoides* and *Dissostichus mawsoni* from CCAMLR Subarea 88.1. P. Horn (National Institute of Water and Atmospheric Research Ltd, PO Box 14-901, Kilbirnie, Wellington, New Zealand), 4 pp. (English, unpublished).

WG-FSA-98/24
Report on progress in developing underwater setting devices for pelagic longline vessels. J. Molloy (Department of Conservation, PO Box 10-420, Wellington, New Zealand), 6 pp. (English, unpublished).

WG-FSA-98/25
Annual review of by-catch in southern bluefin tuna and related tuna longline fisheries in the New Zealand 200 n mile Exclusive Economic Zone. S.J. Baird, M. Francis, L. Griggs and H. Dean (National Institute of Water and Atmospheric Research Ltd,

PO Box 14-901, Kilbirnie, Wellington, New Zealand), 17 pp. (English, unpublished).

WG-FSA-98/26
Otolith and body size relationships in the mackerel icefish. I. Everson, B. Bendall and A. Murray (British Antarctic Survey, Madingley Road, Cambridge, CB3 0ET, United Kingdom), 15 pp. (English, unpublished).

A large sample of otoliths from the mackerel icefish, *Champsocephalus gunnari*, was measured and weighed and their effectiveness as predictors of fish length and mass estimated. The two measures, otolith chord and otolith mass, provide good predictors of fish length, the latter being slightly better. The same measures did not predict total fish mass as accurately because fish mass is affected by fish condition, feeding status and maturity stage.

WG-FSA-98/27
Size at sexual maturity of Patagonian toothfish. I. Everson and A. Murray (British Antarctic Survey, Madingley Road, Cambridge, CB3 0ET, United Kingdom), 10 pp. *CCAMLR Science*, submitted (English).

Analyses of size at sexual maturity have been undertaken on samples of Patagonian toothfish caught in the commercial fishery within CCAMLR Subarea 48.3. The results for 1996 indicate that L_{m50} occurs at 75 to 80 cm total length for male and 98 to 100 cm for female fish. In 1997 the results for male fish were essentially the same. For female fish there is evidence that in 1997 a significant proportion (25 to 43%) of the sexually mature fish were not coming into spawning condition. This introduces a bias leading to the overestimation of L_{m50} by conventional methods. Further analysis allowing for this bias indicates that the L_{m50} for female fish in 1997 was no different to that for 1996.

WG-FSA-98/28
Research underway on New Zealand seabirds vulnerable to fisheries interactions. New Zealand, 3 pp. (English, unpublished).

WG-FSA-98/29
Seabird mortality on longlines in Australian waters: a case study of progress and policy. R. Gales, N. Brothers, T. Reid, D. Pemberton and G.B. Baker (Tasmanian Parks and Wildlife Service, PO Box 44A, Hobart 7001, Tasmania, Australia), 39 pp. (English, unpublished).

Seabird by-catch arising from longline fishing is known to kill tens of thousands of seabirds each year, and is now acknowledged as representing the most pervasive threat to seabirds, particularly albatrosses, causing widespread declines in populations across the world. However the extent of seabird mortality is poorly known for most of the world's longline fisheries. Most information on bird by-catch in the Southern Oceans comes from the Australian and New Zealand regions. The 10-year evolution of the seabird by-catch issue in the Australian Fishing Zone (AFZ), where the magnitude of the impact of longline fishing on seabirds was first documented, is presented as a case study. Most of the birds killed in the tuna longline fishery operating around Australia are albatrosses and include species recently listed as threatened and endangered. Analyses of trends in seabird catch rates by Japanese longliners in the AFZ over 10 years show an apparent fall from the 1988 by-catch figure of 0.4 birds/1 000 hooks to levels of between 0.1 to 0.2 birds/1 000 hooks. Based on current fishing levels, these recent rates equate to between 1 000 and 3 500 birds being killed each year. Although the initial fall in by-catch rate was achieved rapidly, the rate has plateaued, or risen slightly since then, indicating that there may have been changes to fishing practices or equipment which are detrimental to efforts to minimise seabird by-catch and/or that adoption of mitigation methods has been slow. This is a cause for concern, given that awareness of the seabird by-catch issue has risen rapidly in 10 years.

In analysing seabird by-catch data it is important to understand the limitations of observer-derived datasets. In particular, large amounts of data are necessary to gain clear insights into the suite of species impacted by a fishery, and the effect of different fishing gear, environmental variables, and the mitigation measures

employed. In many cases, it is unlikely that such data will be available for a fishery. To overcome some of these problems, we recommend the retention of all seabird carcasses for accurate identification and processing of samples, and also a pragmatic approach to the assessment and implementation of mitigation measures.

The implementation and efficacy of the existing mitigation measures are discussed, together with the approach taken by Australia in preparing a Threat Abatement Plan to mitigate the threat posed to seabirds by oceanic longline fishing. Recognising the need for international action to address the decline in albatross populations, the Australian Government is pursuing such action through international fora such as the Convention on the Conservation of Migratory Species of Wild Animals, the Ecologically Related Species Working Group of the Commission for the Conservation of Southern Bluefin Tuna and the Working Group on Incidental Mortality Arising from Longline Fishing of the Commission for the Conservation of Antarctic Marine Living Resources.

WG-FSA-98/30

Seabird interactions with longline fishing in the AFZ: 1997 seabird mortality estimates and 1988–1997 trends. N. Brothers, R. Gales and T. Reid (Department of Environment and Land Management, Parks and Wildlife Service, GPO Box 44A, Hobart 7001, Tasmania, Australia), 56 pp. (English, unpublished).

WG-FSA-98/31

Seabird mortality in the Japanese tuna longline fishery around Australia, 1988–1995. R. Gales, N. Brothers and T. Reid. *Biological Conservation*, 0: 1–20, 1998 (English).

Large numbers of seabirds are killed each year within the Australian Fishing Zone (AFZ) by Japanese longline vessels targeting tuna. In recent years the estimated rate of seabird by-catch in the AFZ has been in the order of 0.15 birds/1 000 hooks, translating to mortalities of 1 000 to 3 500 birds per year. These estimates are absolute minima, as not all birds killed remain on hooks to be observed when the lines are hauled aboard the vessels. The observed seabird catch rate varies annually, seasonally and by area. Most birds are killed: (a) during the summer fishing season (October to March), even though most fishing effort occurs in winter; (b) when longlines are set during the day; (c) in the waters around southern Australia. Uncertainties in the observed catch rates prevent confident assessment of trends, but seabird catch rates do not appear to be showing a sustained decrease. The process of incidental collection of seabird by-catch data (by observers whose priority is to carry out fish-sampling tasks) renders the seabird by-catch data inadequate for reliable assessment of trends in total numbers of birds killed over time. Sixteen seabird species of birds killed on longlines in the AFZ have been identified. These include black-browed (*Diomedea melanophris*), shy (*D. cauta*), grey-headed (*D. chrysostoma*), yellow-nosed (*D. chlororhynchos*) and wandering albatrosses (*D. exulans*), flesh-footed shearwaters (*Puffinus carneipes*) and white-chinned petrels (*Procellaria aequinoctialis*). Seventy-four per cent of birds killed were albatrosses and the species composition of the by-catch varied with season and area. Most species of birds killed were characterised by unequal representation of sex and age cohorts, and these unequal representations were not consistent between fishing grounds or seasons.

WG-FSA-98/32

The influence of environmental variables and mitigation measures on seabird catch rates in the Japanese tuna longline fishery within the Australian fishing zone, 1991–1995. N. Brothers, R. Gales and T. Reid. *BiologicalConservation*, in press (English).

Long term fisheries observer data were used to analyse the influence of a range of environmental variables and mitigation measures upon catch rates of seabirds in the Japanese pelagic longline fishery. In the Australian Fishing Zone (AFZ) seabirds were most likely to be caught on longlines that were set during summer, in southern areas of the zone, and during daylight hours. However, interpretation of changes in catch rates resulting from the use of mitigation measures or from weather effects

were problematic due to the interrelationships between the many measured factors. Interpretation and accurate assessment was further complicated by ongoing changes to fishing practices and equipment, and due to changes of the priority that fisheries observers placed on the collection of seabird data. The data relating to factors affecting seabird by-catch which is currently collected incidentally by fisheries observers are not sufficiently robust to allow confidence in statistical assessments alone to examine the efficacy of mitigation measures. Dedicated observations may allow for more confident determination of the reasons why seabirds were or were not caught, and to what degree mitigation measures are effective. The use of these observations in combination with the analyses suggested seabird by-catch rates may be lowered by the use of bird lines, bait throwing machines and thawed baits. However, appropriate use and deployment of these measures are critical if they are to be effective. Further work is required to better understand the effect of these measures, and their effect upon the catch rate of target and non-target species.

WG-FSA-98/33
Foraging movements of the shy albatross *Diomedea cauta* breeding in Australia; implications for interactions with longline fisheries. N. Brothers, R. Gales, A. Hedd and G. Robertson *Ibis*, 140: 446–457, 1998 (English).

Satellite telemetry was used to identify the foraging zones of Shy Albatrosses *Diomedea cauta* breeding at two sites off Tasmania, Australia (Albatross Island in western Bass Strait and Pedra Branca to the south) to assess their level of interaction with longline fisheries. Adult birds from both colonies fed locally both in and outside the breeding season. Breeding birds from Albatross Island foraged over the Australian continental shelf or slope waters off northwest Tasmania, while those from Pedra Branca foraged between the colony and the southeastern edge of the continental shelf. The distances travelled by the birds and the duration of their foraging trips varied during the breeding cycle and tended to decrease as eggs approached hatching. Adults which were tracked near the end of the breeding season (March-April, n = 7 birds) deserted their chicks prematurely, and while dispersing further than incubating or brooding birds, they remained over the continental shelf and slope waters off southeast Australia. Home range analyses indicated 41% overlap between foraging zones of birds during successive breeding stages. Dispersal during the postbreeding period extended the foraging zones with less overlap between individuals (10% for Albatross Island and 19% for Pedra Branca). The recent contraction of the Japanese Southern Bluefin Tuna longline fishery to the south and east coasts of Tasmania has resulted in extensive overlap with adult shy Albatrosses from Pedra Branca, but appears to pose a minimal threat to adult birds from Albatross Island. Coupled with the concomitant increase in the Australian domestic tuna longlining industry, adult Shy Albatrosses from southern Tasmania (Pedra Branca and the Mewstone) are vulnerable to incidental capture throughout their annual cycle.

WG-FSA-98/34 Rev. 2
Comments of the Working Group on Fish Stock Assessment on the FAO International Plan of Action on the Reduction of Incidental Catch of Seabirds in Longline Fisheries. CCAMLR Secretariat, 4 pp. (English, unpublished).

WG-FSA-98/35
Examination of the CCAMLR toothfish GLM. G.P. Kirkwood and D.J. Agnew (Renewable Resources Assessment Group, Imperial College, 8 Prince's Gardens, London SW7 1NA, United Kingdom), 16 pp. (English, unpublished).

Various elements of the Generalised Linear Model (GLM) used to standardise toothfish CPUE in Subarea 48.3 are investigated. Problems with crossover between the essentially summer fishery of 1992/1993 prosecuted by Russian vessels and the winter fishery of 1995 onwards prosecuted by other nationalities, coupled with the existence of the experimental fishery in 1994, lead us to suggest that future analyses should be restricted to GLMs based on winter data alone. Unfortunately, this does result in there being no data for

1993, one of the most successful summer seasons. The relationship between CPUE and depth is also explored, and this leads to some suggestions about the distribution of toothfish of different sizes on the shelf slope. A winter GLM, which includes a depth factor, is described and is used in a discussion of the recent declines in CPUE seen in Subarea 48.3.

WG-FSA-98/36
Progress in Australian initiatives for the conservation of albatrosses. G.B. Baker, N. Montgomery and A. McNee (Environment Australia, GPO Box 8, Canberra 2601, ACT, Australia), 5 pp. (English, unpublished).

WG-FSA-98/37
Review of biological characteristics of the Antarctic toothfish (*Dissostichus mawsoni*) and its distribution in Antarctic waters. CCAMLR Secretariat, 17 pp. (English, unpublished).

Results of published studies on the biology, biomass and distribution of the Antarctic toothfish (*Dissostichus mawsoni)* were reviewed. The review focused on those aspects of the species which are of importance for the assessment of its biomass and identification of its stocks. The trophodynamics of *D. mawsoni* are mentioned only in brief. Most published materials refer to studies conducted during the 1970s and 1980s. References in current publications on new studies of this species are scarce. A list of references is appended.

WG-FSA-98/38
Information on longline fisheries to the north of the Convention Area. CCAMLR Secretariat, 6 pp. (English, unpublished).

WG-FSA-98/39
Preliminary results of investigations into the stock structure of Patagonian toothfish (*Dissostichus eleginoides*) around Macquarie Island. A. Reilly, B. Ward and R. Williams (CSIRO, Division of Marine Research, Hobart 7000, Tasmania, Australia), 7 pp. (English, unpublished).

Studied on DNA microsatellites and a tagging program both provide information on the degree of interchange of *Dissostichus eleginoides* (Patagonian toothfish) between two sites 40 n miles apart near Macquarie Island. Five DNA microsatellite loci were identified that showed polymorphism levels appropriate for population structure analysis, and two of these gave results that suggest samples from the two sites are not homogeneous at the 5% probability level. While the other three loci did not demonstrate significant spatial heterogeneity, combined results across all five loci again indicated heterogeneity at the 5% probability level. Results from tagging experiments support the inference from the genetic analyses that interchange of fish between the two sites is very low. Of 469 recaptures at both sites combined, only one fish had moved between sites. As the DNA analysis has so far only been performed on small numbers of fish and loci these results must be regarded as preliminary, but if confirmed by further study the implication of very localised stocks of *D. eleginoides* will have a great effect on the management of commercial fisheries for this species.

WG-FSA-98/40
Determination of age, growth and population characteristics of Patagonian toothfish *Dissostichus eleginoides* based on otoliths. J.M. Kalish and T.A. Timmiss (Division of Botany and Zoology, Australian National University, Canberra 0200, ACT, Australia), 21 pp. (English, unpublished).

WG-FSA-98/41
Register of collections of otolith and scales of *Dissostichus eleginoides*. R. Williams (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 2 pp. (English, unpublished).

WG-FSA-98/42
Seabird by-catch in the Patagonian toothfish longline fishery at the Prince Edward Islands: 1997/1998. P.G. Ryan and M.G. Purves (Percy FitzPatrick Institute, University of Cape Town, Rondebosch 7701, South Africa), 15 pp. (English, unpublished).

Longline fishing for Patagonian toothfish, *Dissostichus eleginoides*, in the South African Exclusive Economic Zone

around the Prince Edward Islands commenced in 1996. This paper summarises seabird by-catch during the year July 1997 to June 1998. Data on seabird by-catches were obtained from fishery observers aboard all 11 sanctioned fishing trips, representing a fishing effort of 4.3 million hooks. This is 13% more than the number of hooks reported set in 1996/97, but total effort probably declined during 1997/98 as a result of a decrease in the number of unsanctioned vessels operating in the area. Observers reported 498 birds of five species killed. White-chinned petrels, *Procellaria aequinoctialis*, predominated (96%), followed by giant petrels, *Macronectes* spp., (3%), with yellow-nosed mollymawks, *Thalassarche chlororhynchos*, and crested penguins, *Eudyptes* spp., each contributing <1% of birds killed. Average seabird by-catch rate by sanctioned vessels was 0.117 birds/ 1 000 hooks, less than half that reported in 1996/97. The greatest improvement in by-catch relative to 1996/97 was among mollymawks, and resulted primarily from a decrease in daytime setting and increased use of tori or streamer lines.

Most bird deaths occurred during setting. There was considerable variance between vessels (range among trips: 0.000 to 0.456 birds/1 000 hooks), with <2% of sets accounting for more than half (52%) the birds killed. Much of the variance could be explained in terms of fishing season, time of setting, wind strength during setting, and distance from the Prince Edward Islands. Moon phase did not appear to explain much variation in bird mortality. Allowing for these factors, some vessels caught more birds than others. Although the fishery is restricted to setting lines between nautical dusk and dawn, 15% of sets took place during the day or straddled dawn/dusk. In addition, the effective use of streamer lines was not possible for all sets due to weather conditions. Despite considerable improvements relative to the 1996/97 season, further efforts are needed to ensure that fishers adhere to permit requirements and only set lines at appropriate times and when conditions permit the effective deployment of streamer lines. Consideration should be given to closing the fishery during February to mid-March when white-chinned petrels are caught in greatest numbers.

WG-FSA-98/43
Seabirds and the Patagonian toothfish longline fishery: fishing methods and operational issues. G. Robertson (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 19 pp. *CCAMLR Science*, submitted (English).

The effects on seabird conservation of vessels using Mustad (single line) and Spanish system (double line) fishing methods were examined in the Patagonian toothfish longline fishery. Vessels had similar effects in attracting seabirds during line setting. The Mustad system vessel almost always hauled the line in a vertical position from the sea, which exposed few hooks to seabirds. The Spanish system vessel often hauled the line at a sharp angle to the sea, which exposed numerous hooks to direct attack by seabirds as well as increasing the risk of accidental hooking. The Spanish system vessel dumped offal close to the line hauling site which exposed birds to risk of accidental hooking. The Mustad system vessel dumped offal away from line hauling site, a practice that seemed risk-free for seabirds. The Mustad and Spanish system fishing methods are described and operational issues affecting seabird behaviour and survival are discussed.

WG-FSA-98/44
Seabirds and the Patagonian toothfish longline fishery: longline sink rates and implications for seabird conservation. G. Robertson (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 23 pp. *CCAMLR Science*, submitted (English), (abstract not available).

WG-FSA-98/45
Priorities for seabird research in the Patagonian toothfish longline fishery. G. Robertson (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 3 pp. (English, unpublished), (abstract not available).

WG-FSA-98/46
Task group on reporting forms and instructions for scientific observations on board longline fishing vessels. CCAMLR Secretariat, 7 pp. (English, unpublished).

WG-FSA-98/46 Addendum
Task group on reporting forms and instructions for scientific observations on board longline fishing vessels. CCAMLR Secretariat, 3 pp. (English, unpublished).

WG-FSA-98/47
Study on stratification scheme efficiency when trawl surveying off South Georgia. P.S. Gasiukov and R.S. Dorovskikh (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 16 pp. (English, unpublished).

WG-FSA-98/48
Report of the longline research cruise in the southeast Atlantic and in CCAMLR Subarea 48.6 and Division 58.4.4. L.J. López Abellán and J.F. González Jiménez (Centro Oceanográfico de Canarias, Instituto Español de Oceanografia, Islas Canarias), 25 pp. *CCAMLR Science*, submitted (English).

A bottom-longline research cruise was carried out between 22 October and 1 December 1997. During this survey several seamounts were surveyed south of Africa close to the Antarctic Convergence (Meteor Bank) and in the CCAMLR region (Shona, Spiess, western slope of Bouvet Island, Ob and Lena Banks). The sampling method consisted of longline fishing operations using perpendicular transects to the isobaths, fishing in different depth strata using one or two sets, from the shallower waters down to depths of between 1 500 and 2 000 m. Catches in number were generally dominated by toothfish (*D. eleginoides*), with 2 822 individuals (83.24%). Species of the genus *Macrourus* was the second most abundant (248 individuals). The total catch by weight was 21.43 tonnes, of which 20.502 tonnes (95.63%) was toothfish. The seamounts showed substantial differences as to bottom topography, species composition of the catches, and relative abundance and size structure of *D. eleginoides* found on each of them. This makes it difficult to extrapolate results for geographical areas about which no prior information is available. Lengths of individuals of *D. eleginoides* living in the shallower depth strata affect their length structure in deeper waters. The general trend of length increasing with depth seems somehow to be disturbed by localised changes or alterations related to bottom topography. The sex ratio of *D. eleginoides* does not significantly vary from 1:1 up to a total length of around 90 cm, which corresponds to the onset of the sexual maturity for males. This could be related to the beginning of migratory movements that make them inaccessible to fishing with bottom longlines. As a result females account for 70% of individuals of more than 90 cm in total length. The stratum with the highest catch per unit effort was that of 600 to 800 m though absolute values varied between areas (413.06 kg/ 1 000 hooks on Ob and Lena Banks, 225.10 kg/1 000 hooks on Meteor Bank and 58.16 kg/1 000 hooks in Subarea 48.6). Total catch per unit effort by region also differed from region to region, ranging from a maximum value of 359.1 kg/1 000 hooks on Ob and Lena Banks and a minimum of 185.25 kg/ 1 000 hooks on Meteor Bank.

WG-FSA-98/49
Brief review of the biology of *Dissostichus mawsoni*. A.L. DeVries and J.T. Eastman (University of Illinois, USA), 12 pp. (English, unpublished).

Toothfish of the genus *Dissostichus* are the largest finfish in the Southern Ocean, with a maximum size of over 100 kg. *D. eleginoides* is found predominantly north of the Antarctic Polar Front, whereas *D. mawsoni* lives in colder waters south of the Polar Front. There may be some areas where the ranges of the two species overlap. *D. eleginoides* has been fished commercially in sub-Antarctic waters for approximately 20 years. Interest in developing a commercial fishery for *D. mawsoni* in Antarctic waters has been expressed in recent years. Little is known, however, about most aspects of the life history of *D. mawsoni*. The purpose of this paper is to summarise aspects of its life history which are known and to identify

aspects which need further investigation. An annotated bibliography for *D. mawsoni* is provided as Appendix 1.

WG-FSA-98/50
Calculation of seabed areas for Subarea 88.1. New Zealand, 3 pp. (English, unpublished).

WG-FSA-98/51
Longline sink rates on a bottom autoline vessel in New Zealand (draft). N.W. McL. Smith (Department of Conservation, CSL Programme, 58 Tory Street, Wellington, New Zealand), 26 pp. (English, unpublished).

Longline sink rates were investigated using time depth recorders on a bottom autoline vessel FV *San Aotea* in New Zealand. The objective of the project was to determine line sink rate, and the effect of the addition of weights to the line on its sink rate.

The vessel used Mustad autoline equipment which is designed to sink without weights, so non-weighted longline line sink rate data were collected initially to give an information baseline. Further trials were then conducted using additional weights as would be used in normal fishing operations to test the effectiveness of weighting the longline as a method of accelerating line sink rate and thus avoiding incidental capture of seabirds. A new rapid attachment method for time depth recorders was also developed and is documented.

The study found the middle of an unweighted longline of this design sinks to 10 m in a mean time of 63.0 seconds (n = 11, CV 16.7%), compared with the start of the longline which takes a mean time of 31.1 seconds (n = 11, CV 30.4%) to reach 10 m. The tori line aerial section covered the longline for a mean time of 26.3 seconds (n = 25, CV 13.6%).

The longline weighting trials indicate that the weighting regime used had no detectable effect on the overall line sink rate. However, observation indicated that the weighting regime did have quite noticeable effects on line sink rate for 20 to 40 m either side of the attached weight. Given the data collected on line sink times and tori line coverage it would seem that we need quicker sink rates to substantially decrease the incidental mortality of seabirds during autoline fishing.

WG-FSA-98/52
Criteria for ageing the otoliths of *Dissostichus eleginoides* from South Georgia (Subarea 48.3) and an analysis of ageing precision. J.R. Ashford and S. Wischniowski (Applied Marine Research Laboratory, Old Dominion University, 1034 West 45th Street, Norfolk, Va. 23529, USA), 26 pp. *CCAMLR Science*, submitted (English).

A prerequisite for validation of an ageing technique is a clear set of consistent ageing criteria. Two sets of criteria are presented for ageing the otoliths of *Dissostichus eleginoides*, one (C1) developed from previous work on the same species; the other (C2) adapted from generalised criteria used to age high-latitude fish from the northwest Pacific Ocean. Microstructural features were found to occur at several scales and vary both within and between otoliths. Pairwise comparisons of repeat readings by one observer and readings by two observers showed considerable inconsistency in ageing, reflecting the complexity of the otolith structure. Ageing using criterion C1 was more precise than ageing using C2. Both sets of criteria indicated *D. eleginoides* to be a long-lived fish, but C2 indicated that captured fish may be mostly young, between three and nine years old. The low precision for ageing *D. eleginoides* indicates that techniques of maintaining ageing consistency without bias and within standardised limits of variation are likely to be important.

WG-FSA-98/53
A summary of the commercial fishery for mackerel icefish, *Champsocephalus gunnari*, in Subarea 48.3 during the 1997/98 season. G. Parkes, A. King and C.D. Jones (MRAG Americas Inc., 5445 Mariner Street, Suite 303, Tampa, Florida 33609, USA), 7 pp. (English, unpublished).

During the 1997/98 season, one vessel, the Chilean-registered stern trawler *Betanzos*, fished commercially for mackerel icefish at South Georgia (Subarea 48.3)

using a midwater trawl for 10 days between 25 December 1997 and 5 January 1998. The total catch of *C. gunnari* was 5.04 tonnes, made in 34 hauls. 67% of this catch was taken in just two hauls, confirming the hypothesis that the distribution of this species is patchy. Most of the catch was made up of fish between 22 and 30 cm long. Fish of this size range have previously been shown to be ages two and three. The catch of species other than *C. gunnari* amounted to only 0.21 tonnes. The vessel's fishing master had no experience of fishing for icefish and was not well briefed before the short trip to South Georgia. It is unclear whether the poor catches by the FV *Betanzos* were due to a low standing stock of the target species, or the inexperience of the fishing master.

WG-FSA-98/54
A revised estimate of short-term yield for the mackerel icefish (*Champsocephalus gunnari*) off Heard Island based on a trawl survey in 1998. A.J. Constable and R. Williams (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 5 pp. (English, unpublished).

A random stratified trawl survey of mackerel icefish in two populations (Plateau and Shell Bank) in the vicinity of Heard Island enabled a revised estimate of yield for the coming two seasons in 1999 and 2000. While the abundances of icefish are lower in 1998 than in 1997, the age 3 and age 4 cohorts are still sufficiently strong to provide for a yield greater than estimates of the long-term precautionary yield. Estimates of yield for the Heard Island Plateau population are 732 tonnes for 1999 and 518 tonnes for 2000. These figures may need to be re-evaluated in light of known catches in the 1998 season since the survey. Estimates of yield were not made for Shell Bank given the very low abundance of this population. Unlike the previous three years, the age 2 cohort in 1998 is very weak and is expected to contribute little to the biomass in subsequent years. If recruitment to age 2 in 1999 is also weak then the fishery in 2000 will be predominantly on age 5 fish. After this time, catch limits may need to be set at an estimate of a long-term precautionary level and be maintained thereafter unless a further survey showed recruitment of abundant cohorts.

WG-FSA-98/55
Pooled length-density data for assessments of yield from by-catch species around Heard Island. R. Williams and A.J. Constable (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 2 pp. (English, unpublished).

WG-FSA-98/57
Trends in relative abundance of fjord *Notothenia rossii, Gobionotothen gibberifrons* and *Notothenia coriiceps* in trammel net catches at Potter Cove, South Shetland Islands. E. Barrera-Oro, E.R. Marschoff and R.J. Casaux (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 14 pp. (English, unpublished).

A monitoring program of demersal fish in inshore sites of the South Shetland Islands has continued in Potter Cove from 1991 to 1998, covering a continuous sampling period of 15 years and in Harmony Cove, Nelson Island, in the austral summer 1995/96. The decline in trammel net catches of fjord fish of the species *Notothenia rossii* and *Gobionotothen gibberifrons* in relation to the non-commercially fished *Notothenia coriiceps*, which was already reported for the period from 1983 to 1990 in a previous study, is still evident. These results are supported by our knowledge of the diet of the piscivorous Antarctic shag *Phalacrocorax bransfieldensis* in the South Shetland/ Antarctic Peninsula area in this decade. The most likely explanation for the decrease in recruitment to the inshore sub-populations of *N. rossii* and *G. gibberifrons* in the last 15 years is the effect of the offshore commercial fishery in the area in the late 1970s. This interpretation is consistent with the information on the historical offshore commercial fishing and with the results of scientific surveys in the area.

WG-FSA-98/58
Depth distribution and spawning pattern of *Dissostichus eleginoides*

at South Georgia. D.J. Agnew, L. Heaps, C.D. Jones, A. Watson, K. Berkieta and J. Pearce (Renewable Resources Assessment Group, 8 Prince's Gardens, London SW7 1NA, United Kingdom), 13 pp. *CCAMLR Science*, submitted (English).

Trends in mean length and maturity stage of toothfish were examined using observer data from the 1998 toothfish season. Toothfish are distributed down the shelf slope in relation to their size, an approximately linear relationship existing between depth and fish length. A statistically significant pattern of changing mean length at depth with month was detected, suggesting movement of animals both up and down the slope at particular times of the year. Months with a high mean length at depth are May and August, and those with a low mean length at depth are April and July. Examination of maturity data suggests that in addition to a major spawning event in late July/August, there may be a small spawning event in April/May. Detailed examination of maturity-at-depth data suggest that mature males move downslope and females move upslope to meet at breeding areas defined by slope position (between 800 and 1 200 m depth) and not by geographical position. Pre-spawning animals appear to be distributed all around the South Georgia and Shag Rocks shelf slopes. Spent animals of both sexes appear to move upslope to shallower water, and are concentrated to the northeast of Shag Rocks. Few spent fish were found around South Georgia. This concentration of large postspawning fish may have some consequences for management of the fishery.

WG-FSA-98/60

A protocol for randomised sampling of longlines in the Southern Ocean fishery for *Dissostichus eleginoides*: system of international scientific observation, CCAMLR. J.R. Ashford, G. Duhamel and M.G. Purves (Applied Marine Research Laboratory, Old Dominion University, 1034 West 45th Street, Norfolk, Va. 23529, USA), 23 pp. (English, unpublished).

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WS-Area48-98/8 5
WS-Area48-98/9 5
Francis, M.
WG-FSA-98/25 23
Gales, R.
WG-FSA-98/29 24
WG-FSA-98/30 25
WG-FSA-98/31 25
WG-FSA-98/32 25
WG-FSA-98/33 26
Gasiukov, P.S.
WG-FSA-98/47 29
George, V.C.
WG-EMM-98/38 17
Gerasimchook, V.V.
WG-EMM-98/12 10
Girija, S.
WG-EMM-98/40 17
González Jiménez, J.F.
WG-FSA-98/48 29
Goss, C.
WG-EMM-98/51 20
WS-Area48-98/9 5
Goubanov, E.P.
WG-EMM-98/12 10
Griggs, L.
WG-FSA-98/25 23
Heaps, L.
WG-FSA-98/58 32
Hedd, A.
WG-FSA-98/33 26
Hewitt, R.P.
WG-EMM-98/50 20
WS-Area48-98/11 6
Hill, C.
SC-CAMLR-XVII/BG/10 3
Hofmann, E.
WS-Area48-98/8 5
Horn, P.
WG-FSA-98/23 23
Hucke-Gaete, R.
WG-EMM-98/17 11
WS-Area48-98/18 Rev. 1 8
Hurford, J.L.
CCAMLR-XVII/BG/25 1
CCAMLR-XVII/BG/26 1
Ichii, T.
WG-EMM-98/18 12
WG-EMM-98/29 14
WG-EMM-98/33 15
WS-Area48-98/4 Rev. 1 4
Isaksen, K.
WG-EMM-98/28 14
Ishii, H.
WG-EMM-98/18 12
Jaya Sree, V.
WG-EMM-98/35 16
Jayan, K.
WG-EMM-98/42 18
Jones, C.D.
WG-FSA-98/14 21
WG-FSA-98/15 22
WG-FSA-98/17 22
WG-FSA-98/53 30
WG-FSA-98/58 32
Jorquera, D.
CCAMLR-XVII/BG/27 1
Jose, L.
WG-EMM-98/42 18
Joseph, J.
WG-EMM-98/41 18
Joyce, L.J.
SC-CAMLR-XVII/BG/13 4
Kalinowski, J.
WG-EMM-98/30 14
Kalish, J.M.
WG-FSA-98/40 27
Karl, B.
WG-EMM-98/15 11
Kasatkina, S.M.
WG-EMM-98/19 12
WG-EMM-98/20 13
WG-EMM-98/21 13
Kata, H.
WS-Area48-98/21 Rev. 1 9
Katayama, K.
WG-EMM-98/18 12
Kawaguchi, S.
WG-EMM-98/29 14
WG-EMM-98/33 15
WS-Area48-98/4 Rev. 1 4
Kimura, N.
WG-EMM-98/31 14
King, A.
WG-FSA-98/53 30
Kirkwood, G.P.
WG-FSA-98/35 26
Klusek, Z.
WG-EMM-98/36 16
WG-EMM-98/37 16
Kock, K.-H.
SC-CAMLR-XVII/BG/3 1
WG-FSA-98/15 22
WG-FSA-98/17 22
WS-Area48-98/19 9

Kozlov, A.N.
WG-FSA-98/13 21
Kutsuwada, K.
WS-Area48-98/5 4
Loeb, V.
WG-EMM-98/50 20
López Abellán, L.J.
WG-FSA-98/48 29
Lynnes, A.S.
SC-CAMLR-XVII/BG/12 3
WS-Area48-98/12 6
Mangel, M.
WG-EMM-98/48 19
Marschoff, E.R.
WG-FSA-98/57 31
Martins, L.
WG-EMM-98/34 15
Mathew, S.
WG-EMM-98/42 18
Matsumura, S.
WG-EMM-98/31 14
McNee, A.
WG-FSA-98/36 27
Mehlum, F.
WG-EMM-98/28 14
Molloy, J.
WG-FSA-98/24 23
Montgomery, N.
WG-FSA-98/36 27
Moore, P.J.
SC-CAMLR-XVII/BG/13 4
SC-CAMLR-XVII/BG/9 3
Moreno, C.A.
WG-FSA-98/16 Rev. 1 22
Muhammad Basheer, K.K.
WG-EMM-98/40 17
Muraleedharan, V.
WG-EMM-98/41 18
Murphy, E.J.
WS-Area48-98/10 6
WS-Area48-98/15 7
WS-Area48-98/8 5
Murray, A.
WG-EMM-98/44 18
WG-EMM-98/53 21
WG-FSA-98/26 24
WG-FSA-98/27 24
WS-Area48-98/12 6
WS-Area48-98/6 5
Naganobu, M.
WG-EMM-98/18 12
WG-EMM-98/29 14
WG-EMM-98/31 14
WG-EMM-98/33 15
WS-Area48-98/4 Rev. 1 4
WS-Area48-98/5 4
Nair, M.K.R.
WG-EMM-98/37 16
WG-EMM-98/38 17
WG-EMM-98/40 17
Naveen, R.
WG-EMM-98/9 10
Nel, D.C.
CCAMLR-XVII/BG/25 1
CCAMLR-XVII/BG/26 1
Nevinsky, M.M.
WG-FSA-98/13 21
Nur, N.
WG-EMM-98/15 11
Obitsu, N.
WG-EMM-98/18 12
Okada, Y.
WG-EMM-98/31 14
Parkes, G.
WG-FSA-98/53 30
Pearce, J.
WG-FSA-98/58 32
Peart, M.
SC-CAMLR-XVII/BG/13 4
Pemberton, D.
WG-FSA-98/20 24
Priddle, J.
WS-Area48-98/8 5
Prince, P.A.
WS-Area48-98/17 8
Purves, M.G.
WG-FSA-98/42 27
WG-FSA-98/60 32
Radhakrishnan, A.G.
WG-EMM-98/42 18
Raghunath, M.R.
WG-EMM-98/42 18
Ravishankar, C.N.
WG-EMM-98/39 17
WG-EMM-98/41 18
WG-EMM-98/42 18
Reid, K.
WS-Area48-98/13 7
WS-Area48-98/14 7
WS-Area48-98/15 7
WS-Area48-98/17 8
WS-Area48-98/8 5
Reid, T.
WG-FSA-98/29 24
WG-FSA-98/30 25
WG-FSA-98/31 25
WG-FSA-98/32 25
Reilly, A.
WG-FSA-98/39 27
Reilly, S.
WS-Area48-98/21 Rev. 1 9
Robertson, G.
WG-FSA-98/33 26
WG-FSA-98/43 28
WG-FSA-98/44 28
WG-FSA-98/45 28
Romanov, A.V.
WG-EMM-98/12 10

Ryan, P.G.
WG-FSA-98/42 27
Saldhana, F.
WG-EMM-98/34 15
Sasai, Y.
WS-Area48-98/5 4
Scott, J.J.
SC-CAMLR-XVII/BG/13 4
Sexton, S.N.
WG-FSA-98/14 21
Shankar, T.V.
WG-EMM-98/42 18
Shulgovsky, K.E.
WG-EMM-98/32 15
Shust, K.
WG-EMM-98/52 20
Siegel, V.
WG-EMM-98/50 20
Sim, J.L.
SC-CAMLR-XVII/BG/8 2
Smith, N.W. McL.
WG-FSA-98/51 30
Staniland, I.J.
SC-CAMLR-XVII/BG/11 3
Sushin, V.A.
WG-EMM-98/32 15
Switzer, P.V.
WG-EMM-98/48 19
Taguchi, S.
WS-Area48-98/5 4
Tanaka, T.
WG-EMM-98/31 14
Thankamma, R.
WG-EMM-98/41 18
Timmiss, T.A.
WG-FSA-98/40 27
Torres, D.
CCAMLR-XVII/BG/27 1
WG-EMM-98/17 11
WS-Area48-98/18 Rev. 1 8
Trathan, P.N.
WG-EMM-98/30 14
WS-Area48-98/10 6
WS-Area48-98/8 5
Troshkov, A.A.
WG-EMM-98/14 11
Trotsenko, B.G.
WG-EMM-98/12 10
Vallejos, V.
WG-EMM-98/17 11
WS-Area48-98/18 Rev. 1 8
Vanyushin, G.P.
WG-EMM-98/14 11
Vega, R.
SC-CAMLR-XVII/BG/7 Rev. 1 2
WG-FSA-98/20 23
Venue, M.K.
WG-EMM-98/40 17
Verlecar, X.N.
WG-EMM-98/34 15
Vijayakumar, R.
WG-EMM-98/34 15
WG-EMM-98/35 16
Ward, B.
WG-FSA-98/39 27
Watkins, J.L.
WG-EMM-98/44 18
WG-EMM-98/51 20
WG-EMM-98/53 21
WS-Area48-98/11 6
WS-Area48-98/15 7
WS-Area48-98/20 9
WS-Area48-98/8 5
WS-Area48-98/9 5
Watson, A.
WG-FSA-98/58 32
Wilhelms, S.
WG-FSA-98/15 22
WG-FSA-98/17 22
Wilkinson, M.T.
WG-EMM-98/51 20
WS-Area48-98/9 5
Williams, R.
WG-FSA-98/39 27
WG-FSA-98/41 27
WG-FSA-98/54 31
WG-FSA-98/55 31
Wilson, P.R.
WG-EMM-98/15 11
WG-EMM-98/46 19
Wischniowski, S.
WG-FSA-98/52 30