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 2000. It corresponds to the Nineteenth 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(iii) scientific papers not intended for publication, which are listed as 'unpublished'; and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-XIX/BG/11 (background document number 11 submitted at the Nineteenth Meeting of the Scientific Committee); or WG-EMM-00/8 (document number 8 submitted at the 2000 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Unpublished papers must not be cited without written permission of the author(s).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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Scientific Committee

SC-CAMLR-XIX/BG/2
Entanglement of Antarctic fur seals *Arctocephalus gazella* in man-made debris at Bird Island, South Georgia, during the 1999 winter and the 1999/2000 pup rearing season. M.J. Jessopp and N.J. Aspey (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 21 pp. (English, unpublished).

Results of the survey of entanglements of Antarctic fur seals at Bird Island, South Georgia, for the 10th consecutive winter (1999) and 12th consecutive summer (1999/2000) are reported here.

Only six entangled seals were observed during the winter, representing a 53% decrease from 1998 and a 94% decrease on the highest previous total (1992). Four of these animals were entangled in plastic packaging bands, double that observed in the 1998 winter, and a return to the high levels observed before the CCAMLR prohibition on their use in 1994. The number of animals showing severe injuries was down on the 1998 winter.

The number of seals observed entangled in the summer was the second lowest recorded to date, being 42% lower than in the 1998/99 season. The proportion of adult animals affected was down 1% on the previous summer and constitutes the lowest total recorded. The proportion of animals showing severe injuries (21%) is down 4% on the previous year and is the second lowest total on record. The number of entanglements in polypropylene straps showed an increase of 12.5% on the 1998/99 season.

The low occurrence of entanglements in summer and winter has continued the downward trend since the peak in the early 1990s. Incidences of severe injury have also decreased. Entanglements in polypropylene bands comprise the major proportion of observations, despite the ban on their use introduced by CCAMLR. This highlights the need for sustained monitoring and continuing publicity aimed at preventing the disposal of debris at sea.

SC-CAMLR-XIX/BG/3
Entanglement of Antarctic fur seals, *Arctocephalus gazella*, in man-made debris at Signy Island, South Orkney Islands, 1999/2000. 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 fourth annual survey of entanglement of Antarctic fur seals at Signy Island, South Orkney Islands, are reported for the 1999/2000 summer season. There were five sightings of seals wearing neck collars of man-made debris. One additional sighting was of an animal that had been previously entangled but had lost its collar by the time of observation. All of the animals involved were juvenile males, the main component of the population in this area at this time of year. The number of sightings was the lowest ever recorded, a decrease of 50% compared to the previous season. This was despite the fact that the number of fur seals arriving at Signy Island in 1999/2000 was the highest observed since entanglement surveys began in 1996/97. Data are compared with results from a parallel study undertaken at Bird Island, South Georgia, in 1999/2000. These indicated that the number of entangled fur seals there had also decreased (by 42%) since 1998/99. Over the past four years, fluctuations in the incidence of entanglement between years at Bird Island have been mirrored at Signy Island. 'Severe' and 'very severe' injury was being caused to 60% of animals at Signy Island, which was the lowest on record. As usual this was higher (by 46%) than the proportion of fur seals sighted with the same injuries at Bird Island. This suggests that the majority of entangled fur seals arriving at Signy Island had been so for some time and are likely to have become entangled in other areas, such as South Georgia, where fishing activity is higher. Fishing net was the most common entangling material at Signy Island (60%), followed by packaging bands (20%) and a neck collar made of unknown material (20%). The proportion of animals entangled in packaging bands was the second lowest recorded, a decrease of 20% compared to the previous year. At

Bird Island, packaging bands were the most common entangling material, having increased by 12.5% since 1998/99. The continued presence of packaging bands, despite the CCAMLR restrictions imposed since 1995/96, may be due to their persistence in the environment or illegal unmonitored fishing activity. The decrease in the incidence of entanglement at Signy Island and Bird Island is promising. CCAMLR needs to continue this monitoring and its campaign against the disposal of man-made debris at sea.

SC-CAMLR-XIX/BG/4
Anthropogenic feather soiling, marine debris and fishing gear associated with seabirds at Bird Island, South Georgia, 1999/2000. D. Roberts (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 15 pp. (English, unpublished).

This report describes and quantifies occurrences of oil, marine debris and fishing gear associated with seabirds at Bird Island, South Georgia. In this, the seventh year of standardised recording, an unprecedented quantity of hooks (both with and without longline attached) and monofilament longline originating from fishing vessels was recorded in association with wandering albatrosses. Quantities of fishing gear remained within the levels of previous years for all other species, except black-browed albatross, which increased by 133% from the previous maximum. Marine debris (the vast majority of which were plastics) showed increases of 75% and 93% from the previous maxima for wandering albatross and grey-headed albatross respectively. The recently noted trend of black-browed albatrosses regurgitating marine debris continued. A single wandering albatross feather-soiled by oil was observed. Human food waste was associated with wandering albatrosses and giant petrels.

SC-CAMLR-XIX/BG/5
Beach debris survey – Main Bay, Bird Island, South Georgia, 1998/99. N.J. Aspey (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 12 pp. (English, unpublished).

The ninth year of surveys of beached man-made debris at Bird Island, South Georgia, revealed a total of 213 items, 51% less than the total of 430 items in 1997/98 and the second lowest total noted. The winter (April–September) total was 66% lower than in 1997/98 and is the lowest total since 1990. The number of items collected in summer was 172, a decrease of 45% from the 1997/98 total of 310. Nylon line, identical to that attached to longline gear, accounted for 51% of items.

The lower levels of debris collected in the winter months is encouraging, although the totals of summer debris still remain at least three times the level of those observed in the early 1990s and provide continued cause for concern, suggesting that CCAMLR needs to enhance its campaign to reduce the amount of man-made debris being jettisoned into the Southern Ocean.

SC-CAMLR-XIX/BG/6
Beach debris survey – Signy Island, South Orkney Islands, 1999/2000. A.S. Lynnes and J.R. Shears (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 19 pp. (English, unpublished).

During the 1999/2000 austral summer the 10th annual beach debris survey was carried out at Signy Island, South Orkney Islands. Debris was cleared each month between November and March from three study beaches. The debris was counted, measured and classified by type, material, mass and size categories. A total of 55 items weighing 10.78 kg was collected. The number of items was 35% less than 1998/99, and the second lowest ever recorded. The total mass of the waste recovered has decreased by 17% since 1998/99 but was still the second highest since 1995/96. Plastic waste was predominant, as in previous seasons, although the proportion of plastic items (38%) was the lowest ever recorded and follows a declining trend since 1996/97. The proportion of polypropylene packaging bands

removed was also the lowest recorded (18%) and may indicate that the ban on their use on board fishing vessels brought into force by CCAMLR in 1995/96 has been effective and should continue. Classifying the waste by source revealed that 60% had come from ships or fishing vessels and 7% were from the Signy Research Station. The rest comprised wood (11%) and items whose source was not obvious (22%). Of particular concern was the quantity of polystyrene foam which accounted for 31% of all items recovered and 46% of items small enough to be ingested by seals and seabirds. The proportion of polystyrene foam items washed ashore has been increasing since 1996/97. It is recommended that CCAMLR advise its Members to use alternative, less persistent forms of packing material where possible. With the exception of 1998/99, the quantity of waste recorded at Signy Island has been showing a declining trend since 1993/94. This is promising. The longevity of plastics and other materials with a high resistance to degradation in the marine environment remains a problem and highlights the need for continued monitoring to ensure that vessels' crews are aware of, and comply with, regulations prohibiting the disposal of debris at sea.

SC-CAMLR-XIX/BG/10
New data on anti-*Brucella* antibodies detection in *Arctocephalus gazella* from Cape Shirreff, Livingston Island, Antarctica. O. Blank, P. Retamal, D. Torres and P. Abalos (Departamento Científico, Instituto Antártico Chileno, José Robert 0289, Punta Arenas, Chile), 13 pp. *CCAMLR Science*, submitted (English).

This paper describes new evidence of *Brucella* spp. antibodies in Antarctic fur seals *(Arctocephalus gazella)* from Cape Shirreff, Livingston Island, South Shetlands, Antarctica. Eighty-six *A. gazella* body fluid samples, comprising 79 blood samples, 1 pleural fluid, 1 peritoneal fluid and 5 pericardic fluid samples, were collected from 9 dead and 77 live animals. Body fluid samples were tested by the Rose Bengal test (RB), the Competitive Enzymoimmunoassay (c-ELISA) test and the Competitive Enzymoimmunoassay 'COMPELISA®' test. Antibodies against *Brucella* spp. were detected in one sample with the RB test and in five of the 86 samples tested (5.8%) with the c-ELISA test.

These results confirm the serological evidence of *Brucella* infection in *A. gazella* from Antarctica, suggesting the utility of the extra-vascular fluid for serological research in this matter. It also recognises the c-ELISA test as the best option in this serological search. Further research should be carried out at other locations in Antarctica and other areas in the Southern Hemisphere, in order to determine the extent of the problem, but it is suggested that *Brucella* has a wide distribution and is probably found worldwide. Finally, this serological evidence of *Brucella* infection underscored the importance of evaluating the incidence of infectious disease in Southern Ocean fauna. However, it is not possible to relate it to any antropogenic event in Antarctica, since *Brucella* has not yet been isolated and there are no previous studies on this subject on the Antarctic continent.

SC-CAMLR-XIX/BG/11
The direct influence of fishing and fishery-related activities on non-target species in the Southern Ocean with particular emphasis on longline fishing and its impact on albatrosses and petrels – a review. K.-H. Kock (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany), 44 pp. *Reviews in Fish Biology*, submitted (English).

Finfishing in the Southern Ocean began more than 30 years ago at South Georgia and the Kerguelen Islands. Although the fishery extended further south for a few years in the second half of the 1970s, South Georgia and the Kerguelen Islands remained the most important fishing grounds until 1996/97. Longlining for *Dissostichus eleginoides* began in 1985/86 and remained restricted to South Georgia and the Kerguelen Islands for more than 10 years. Catches rarely exceeded 12 000 tonnes in one season. The fishery, however, is important because the fish are valuable and high prices are being paid. The Commission for the Conservation of Antarctic Marine Living Resources

(CCAMLR) is regulating fishing in the Southern Ocean. CCAMLR received first information on this fishery and its possible high by-catch of albatrosses and larger petrels in 1990.

From 1996/97 onwards, illegal fishing expanded dramatically within a single season. Only limited control could be exerted in those areas which were under national jurisdiction. A number of detrimental effects from fishing activities could be seen on marine life, in particular birds and mammals. Estimated catches in the illegal fishery amounted to several tens of thousands birds per season with apparent little reduction over the first four seasons. The sudden development of the illegal, unreported and unregulated (IUU) fishery placed a great strain on CCAMLR's fishery management. Vessels fishing legally gradually improved their compliance with CCAMLR conservation measures over the last couple of years. This may be insignificant compared to the potential in the IUU fisheries but testifies to the potential to make significant improvement using simple mitigation methods.

After setting precautionary catch limits in 1997, CCAMLR was able to adopt a 'Catch Documentation Scheme' (CDS) in November 1999 which came into force on 7 May 2000. Mauritius, the main port where IUU fish was landed, was willing to accede to CCAMLR and adopt the CDS. An International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries adopted by the FAO in June 1999 and various activities of governmental and non-governmental groups also seemed likely to address the problem more effectively with the assistance of the fishing industry.

SC-CAMLR-XIX/BG/26
Beach debris survey at Artigas Antarctic Scientific Station (BCAA) on King George Island and at T/N Ruperto Elichiribehety Antarctic Scientific Station (ECARE) on the Antarctic Peninsula in the 1999/2000 season. Delegation of Uruguay, 5 pp. (Spanish, unpublished).

Working Group on Ecosystem Monitoring and Management

WG-EMM-00/4
Report of the national observer on work carried out aboard the vessel *Konstruktor Koshkin* in Subarea 48.2 in May–June 1999. V. Bibik (YugNIRO, Kerch, Crimea, Ukraine), 15 pp. (English, unpublished).

This report contains data on krill catch and size composition, and also on the by-catch of juvenile fish caught in each of the five fine-scale divisions of the area around the South Orkney Islands fished by the Ukrainian vessel. Weather and ice conditions during the operational period are also described.

WG-EMM-00/5
Ecosystem studies carried out during the second Ukrainian marine Antarctic expedition in Subareas 48.1 and 48.2 in 1998. V. Bibik and P. Gozhik (YugNIRO, Kerch, Crimea, Ukraine), 8 pp. (English, unpublished).

The second Ukrainian Marine Multidisciplinary Antarctic Expedition (UMCAE) on board the scientific research vessel *Ernst Krenkel* took place in 1998 in the western part of the Atlantic sector of the Antarctic. The expedition was organised by the Ukrainian Antarctic Centre of the Ukrainian Ministry of Science and Technology.

Preliminary analysis of the data revealed some specific features of environmental conditions, krill population status and other functionally important components of the pelagic ecosystems in the study areas.

The following observations were made in Subarea 48.2: low water temperatures, a large number of icebergs (these factors combined mark the navigational season of 1998 as abnormally cold), stock recruitment (for the first time in recent years), low abundance of krill larvae and plenty of salps, whose abundance and biomass was 1.6 times higher than in 1997).

In Subarea 48.1, differences in krill size composition and biomass at fishing sites near Elephant Island and King George

Island were revealed. At Elephant Island the bulk of catches comprised krill of size group 3 (probably 1995 cohort), while at King George Island krill of size groups 2 and 3 were predominant.

WG-EMM-00/6 Rev. 1
Krill distribution patterns in the Atlantic sector of the Antarctic during the CCAMLR-2000 Survey.
V. Siegel, S. Kawaguchi, F.F. Litvinov, V. Loeb and J.L. Watkins (Sea Fisheries Research Institute, Palmaille 9, D-22767 Hamburg, Germany), 16 pp. (English, unpublished).

The international CCAMLR-2000 Survey was conducted to obtain an updated estimate of large-scale krill biomass in the South Atlantic sector of the Antarctic. Four vessels from Japan, Russia, the UK and the USA participated in the study during which 22 parallel hydroacoustic transects and four small-scale shelf grids were investigated. Standard net tows were carried out during midnight and midday stations. Additional samples were taken by opening–closing nets for the identification of acoustic targets. Analyses of the combined datasets from the net sampling program indicate that krill distribution was characterised by three distinct geographical clusters of length-frequency distributions. Small- to medium-sized juvenile and subadult krill mainly occurred east of the South Orkney Islands. Adult krill, predominantly smaller than 50 mm mean length, dominated in a band to the north of the first cluster, while adult krill larger than 50 mm mean length were found to the north of cluster 2, but at the same time were mostly restricted to the area west of the South Orkney Islands. Implications of stock composition and distribution patterns for stock assessment are discussed.

WG-EMM-00/8
Changes in the diet of the South Georgia shag *Phalacrocorax georgianus* at the South Orkney Islands along four consecutive years.
R. Casaux and A. Ramón (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 9 pp. (English, unpublished).

The diet of the South Georgia Shag *Phalacrocoraxgeorgianus* at Laurie Island, South Orkney Islands, was examined by analysing 337 pellets (regurgitated casts) collected during the 1995, 1996, 1997 and 1998 breeding seasons. Demersal benthic fish were by far the main prey, followed by molluscs (mainly octopods and bivalves) and polychaetes. *Harpagiferantarcticus* (1995 and 1998) and *Lepidonotothen nudifrons* (1996 and 1997) were the most frequent prey items, followed by *Gobionotothen gibberifrons* or *Trematomus newnesi. H. antarcticus,* followed by *L. nudifrons* or *T. newnesi,* was the most numerous prey item in all of the seasons and predominated in mass in 1995 and 1996, followed by *Notothenia coriiceps* and *L. nudifrons.* In 1997 *G. gibberifrons* and *N. coriiceps* were the species that most contributed to the diet, while *N. coriiceps* and *H. antarcticus* were dominant in 1998. Our results differ from those reported for the South Orkney Islands in previous studies. These differences could be due to the use of different diet-analysis methods and to shag-related and/or fishery-related changes in food availability. If it is assumed that fishing carried out in the area affected the structure and abundance of the fish populations, a comparison of our results with historical data may indicate a recovery of *G. gibberifrons* in inshore waters around the archipelago.

WG-EMM-00/9
Fish in the diet of the breeding Antarctic shag *Phalacrocorax bransfieldensis* at four colonies on the Danco Coast, Antarctic Peninsula.
R. Casaux, A. Baroni and E. Barrera-Oro (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 11 pp. (English, unpublished).

The diet of the breeding Antarctic shag *Phalacrocorax bransfieldensis* was investigated at four colonies on the Danco Coast, Antarctic Peninsula, by analysing 616 pellets (regurgitated casts) collected from December 1997 to February 1998. Overall, demersal benthic fish were the most frequent and important prey at all the colonies sampled, followed by octopods and gastropods. Among fish, *Notothenia coriiceps* was the main prey at all of the sampling sites, followed in similar importance by *Gobionotothen gibberifrons* at Cape Herschel, Primavera Island and

Midas Islands, and in less importance by *Harpagifer antarcticus* at Py Point. Between colonies there were marked differences in the size of fish consumed. The largest specimens were eaten by shags from Midas Islands, and the smallest by those from Py Point. This was mainly influenced by the number of specimens of the smallest fish species, *H. antarcticus*, consumed at this last colony. The differences in diet composition may be related to the different foraging areas used by the shags. Our results differ from those presented in the only two previous studies on the diet of these shags at the Antarctic Peninsula. The shags on the Danco Coast preyed much more intensively on *G. gibberifrons* than those at the South Shetland Islands. This finding indicates a low abundance of this fish species in inshore waters (<100 m depth) at the South Shetland Islands and supports the use of the Antarctic shag to monitor coastal fish populations.

WG-EMM-00/10
Second report on distribution, abundance and biological aspects of krill (*Euphausia superba*) north of the South Shetland Islands (Survey 0001 RV *Humboldt* – 23 to 28 January 2000 – XI Peruvian Antarctic Expedition). M. Gutiérrez, N. Herrera and J. Quiñones, X. Chalen and A. Antony (Peruvian Marine Institute (IMARPE), AP 22, Esq. Gamarra y Valle s/n. Callao, Peru), 13 pp. (English, unpublished), (abstract not available).

WG-EMM-00/11
Preliminary results on the diet of the snow petrel *Pagodroma nivea* at Laurie Island, Antarctica, during the 1997/98 breeding season. G. Soave, V. Ferretti, N. Coria and R. Casaux (Departamento Científico Zoología Vertebrados, Museo de Ciencias Naturales, Paseo del Bosque s/n, 1900 La Plata, Argentina), 7 pp. (English, unpublished).

The diet of the snow petrel *Pagodroma nivea* was investigated at Laurie Island, South Orkney Islands, (60°46'S, 44°42'W), Antarctica, over the period January–February 1998. Stomach contents and regurgitates of adults were sampled during the chick-rearing period. Fish, followed by the Antarctic krill *Euphausia superba*, were the main prey throughout the sampling period. Other crustaceans and cephalopods were scarcely represented. Among fish, Myctophids dominated in the diet, with *Electrona antarctica* being the main prey.

The information presented here should be considered as preliminary, and further studies on the composition of the diet of the snow petrel as well as on the distribution and abundance of its main prey are required to better understand the feeding behaviour of this bird.

WG-EMM-00/12
Final report of scientific observations of the commercial krill harvest aboard the Japanese stern trawler *Chiyo Maru No. 5*, 31 January to 1 March 2000. W. Rain (CCAMLR International Scientific Observer), 10 pp. (English, unpublished).

WG-EMM-00/13
Studies of seabirds and seals at Bouvetøya 1998/99. K. Isaksen, O. Huyser, S. Kirkman, R. Wanless and W. Wilson (Norwegian Polar Institute, Polarmiljøsenteret, N-9296 Tromsø, Norway), 11 pp. (English, unpublished).

Field studies were carried out at Bouvetøya from 9 December 1998 to 27 February 1999. The main objective for the 1998/99 expedition was to continue the CEMP monitoring work initiated in 1996/97. The species monitored were chinstrap penguin (*Pygoscelis antarctica)*, macaroni penguin *(Eudyptes chrysolophus)* and Antarctic fur seal *(Arctocephalus gazella*). In addition to the CEMP work, other work on seabirds and seals was carried out, including diving behaviour of penguins, and studies of diet and pup production of fur seals. The following CEMP parameters were studied in chinstrap and macaroni penguins: breeding population size (A3), age-specific annual survival and recruitment (A4), duration of foraging trips (A5), breeding success (A6), chick diet (A8) and breeding chronology (A9). For Antarctic fur seals, data on the duration of adult femaleforaging/attendance cycles (C 1) and pup growth (C2) were collected.

WG-EMM-00/14 Rev. 1
Utilising data from ecosystem monitoring for managing fisheries: development of statistical summaries of indices arising from the CCAMLR Ecosystem Monitoring Program. W. de la Mare and A.J. Constable. *CCAMLR Science*, Vol. 7: 101–117, 2000 (English).

A potential method is presented for combining data collected as part of the CCAMLR ecosystem monitoring program (CEMP) into a single index for each of predator, prey and environmental parameters. The paper is divided into four main parts. The first part develops the proposed method of forming summary indices, which is based on the usual theory of multivariate statistics and takes into account the covariance between parameters. The second part reports on a Monte Carlo simulation study that examines the robustness of the indices to missing data and the degree of correlation between parameters. These trials show that missing values were unlikely to be a problem for time series of parameters that are highly correlated (>0.6). Criteria for inclusion of parameters in the indices are discussed when parameters are moderately or poorly correlated. The third part uses further simulation tests to examine the power of the statistical procedure adopted by WG-EMM in 1996 for identifying anomalies in CEMP parameters. The power of the procedure to detect anomalies was found to fall to low levels once more than a few anomalous values have appeared in the data. An alternative procedure, using estimates of the mean and variance of baseline time series, was found to have consistently better statistical power regardless of the accumulation of anomalies. The last section outlines an approach to the further development of CEMP indices for application in CCAMLR.

WG-EMM-00/15
Notes on the commercial krill harvest of the Japanese stern trawler *Chiyo Maru No. 5* in Subarea 48.1. C. Jones (National Oceanic and Atmospheric Administration, National Marine Fisheries Service, US Antarctic Marine Living Resources Program, PO Box 271, La Jolla, Ca. 92038, USA), 10 pp. (English, unpublished).

The Japanese stern trawler *Chiyo Maru No. 5* conducted krill fishing operations in CCAMLR Subarea 48.1 during February 2000. Under an agreement by the Japanese and US governments, a CCAMLR international scientific observer was present on the vessel. This paper presents, in graphical form, much of the information collected and serves as a complement to the final report submitted by the scientific observer (WG-EMM-00/12). Fishing operations were conducted off the South Shetland Islands to the north of Elephant Island, and off the lower South Shetland Islands. Information on length frequency, maturity, and feeding intensity was summarised based on five regions off the South Shetland Islands where hauls were clustered. The biological information collected during this commercial fishing operation agrees well with the findings of the CCAMLR-2000 Survey in Subarea 48.1.

WG-EMM-00/16
A statistical assessment of the status and trends of Antarctic and sub-Antarctic seabirds (prepared for the SCAR Bird Biology Subcommittee and SC-CAMLR, working draft as of June 2000). E.J. Woehler, J. Cooper, J.P. Croxall, W.R. Fraser, G.L. Kooyman, G.D. Miller, D.C. Nel, D.L. Patterson, H.-U. Peter, C.A. Ribic, K. Salwicka, W.Z. Trivelpiece and H. Weimerskirch (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 50 pp. (English, unpublished).

WG-EMM-00/17
Haul data analysis from the Polish krill fishery in 1997–1999. E. Jackowski (Sea Fisheries Institute, Kollataja 1 Street, 81-332 Gdynia, Poland), 17 pp. (English, unpublished).

The analysis of fishing data from the ship's log of the Polish commercial vessel MT *Pollux* helped to describe catches and concentrations of krill between February and June from 1997 to 1999 in Area 48. Records from each haul were used for analysis, and, since the vessel carried out catches along with other Polish vessels, the results are of relevance to all Polish catches in this period and area. Each fishing season was different. In 1997 the

catches were taken in Subareas 48.1 and 48.3, in 1998 they were taken exclusively in Subarea 48.1, and in 1999 in Subareas 48.1 and 48.2. On average, the vessel made from 7 to 9.5 hauls daily, the average duration of which was 60 to 70 minutes. Differences in catch rates in various areas and years were observed. The highest catch rates (4–5 tonnes/hour) occurred near Elephant Island and King George Island, as well as near the South Orkney Islands and King George Island in 1998 and 1999 respectively. During the day, commercial krill concentrations occurred deeper, at depths of 10–140 m, while at night they were closer to the surface, at depths of 10–100 m. Catch rates were several times higher during the day than at night (4.35–9.33 tonnes/hour and 0.8–3.33 tonnes/hour respectively). In general, the night-time concentrations were shallower than daytime ones in the King George Island area, however in 1997 and 1998 the situation was reversed.

WG-EMM-00/18
Combined standardised indices of predator performance from Bird Island, summer 1977–2000. I.L. Boyd (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 4 pp. (English, unpublished).

WG-EMM-00/19
A description of the ecosystem status at South Georgia during winter 1999–summer 2000. K. Reid (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 5 pp. (English, unpublished), (abstract not available).

WG-EMM-00/20
Status of the South Georgia subarea (48.3) based on satellite monitoring of the sea-surface temperature, December 1999–January 2000. G. Vanyushin and A. Korobochka (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia), 7 pp. (English, unpublished).

Satellite monitoring (GOES-E) data on sea-surface temperature (SST) and real-time data from vessels reveal the hydrological situation off South Georgia (Subarea 48.3) in December 1999 and January 2000. Using the database of the SST maps for 1990/91 and the current standard weekly SST maps, we have developed mean monthly SST maps, maps of SST anomalies, and maps showing differences between the current SST maps (the 1999/2000 season) and those for the 1990/91 season.

Analysis of the SST distribution in Subarea 48.3 in January 2000 revealed unfavourable hydrological conditions for the formation and maintenance of large concentrations of krill *(Euphausia superba)* in shelf waters off South Georgia. This is primarily explained by the intensive advection of Weddell Sea waters. The SST maps for December 1999 and January 2000 illustrate this event. The transformed Weddell Sea waters spread in a northwestward direction as far as 50–51°S, and the associated krill transport passes the South Georgia shelf to the east as the conditions for forming large concentrations in these waters are unfavourable.

WG-EMM-00/22
Ecosystem management. I. Everson (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 26 pp. *CCAMLR Science,* submitted (English), (abstract not available).

WG-EMM-00/26
CEMP indices 2000: analysis of anomalies and trends. CCAMLR Secretariat, 45 pp. (English, unpublished).

The CCAMLR Ecosystem Monitoring Program uses indices derived from data on indicator species and the environment collected using standard methods within the three Integrated Study Regions of the Convention Area. Standardised index values are recalculated each year as new data become available, and trends and anomalies in theses data are presented.

WG-EMM-00/27
Development of environmental indices F1, F3 and F4. S. Olmastroni, S. Corsolini, K. Kerry, J. Clarke and D. Ramm (Università degli Studi di Siena, Italy), 12 pp. (English, unpublished).

The development of CEMP indices derived from visual data (indices F1, F3 and F4), automatic weather stations and satellite imagery is explored with reference to the CEMP sites at Edmonson Point (Terra Nova Bay, Ross Sea, Subarea 88.1) and Béchervaise Island (Mawson, Eastern Antarctica, Division 58.4.2). Possible links between the extent of sea-ice adjacent to CEMP sites, weather conditions at or near CEMP sites, and the dynamics of penguins during the breeding season are discussed.

WG-EMM-00/28
Update on the CCAMLR website. CCAMLR Secretariat, 11 pp. (English, unpublished).

WG-EMM-00/29
History of development and completion of tasks put forward by WG-EMM (1995–1999). CCAMLR Secretariat, 9 pp. (English, unpublished).

WG-EMM-00/30
A proposal to subdivide CCAMLR Statistical Division 58.4.1 using environmental data. S. Nicol and T. Pauly (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 18 pp. (English, unpublished).

A precautionary catch limit for krill was established for CCAMLR Division 58.4.1 in 1996 based on the results of an acoustic survey (BROKE) of the southernmost 873 000 km^2 of this area (CCAMLR, 1996). Detailed subsequent analysis of the results of this survey has indicated that Division 58.4.1 is not meridionally homogeneous in its oceanographic or biological characteristics. Based on environmental data, Division 58.4.1 can be divided into two approximately equal-sized subdivisions: 80–115°E and 115–150°E. Krill is more abundant in the western subdivision and its biomass is more latitudinally extensive in this area. This observed pattern appears to be historically stable. Because of the unequal distribution of krill in this division, and because of its extremely large size (4.68 million km^2), we propose the formal subdivision of Division 58.4.1 into two parts, based on the analysis of the scientific data collected during BROKE. The revised krill biomass estimates for these areas are: 3.04 million tonnes for the western portion and 1.79 for the eastern one. We suggest the calculation of new precautionary catch limits for the two subdivisions of Division 58.4.1 based on the revised krill biomass estimates.

WG-EMM-00/31
Evaluating the ecosystem impact of harvesting krill in the Southern Ocean: an ECOPATH with ECOSIM feasibility study. Prof. T. Pitcher (Fisheries Centre, University of British Columbia, Vancouver, V6T 1Z4, Canada), 5 pp. (English, unpublished).

WG-EMM-00/32
Béchervaise Island, MacRobertson Land, Antarctica – CCAMLR Ecosystem Monitoring Program (CEMP) Monitoring Site: description, maps and colony photographs. K. Kerry, L. Meyer, W. Papps, J. Clarke and L. Irvine (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 15 pp. (English, unpublished).

WG-EMM-00/33
Krill distribution pattern due to water structure and dynamics near the South Sandwich Islands in January–February 2000 (Krill Synoptic Survey 2000). V.A. Sushin, P.P. Chernyshkov, V. Shnar, F.F. Litvinov and K. Shulgovskiy (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 15 pp. (English, unpublished).

Hydroacoustic, biological and oceanographic surveys were carried out in Subarea 48.4 near the South Sandwich Islands. The main water masses were defined (Antarctic Circumpolar Current (ACC), Weddell Sea and the Secondary Frontal Zone of the Weddell Gyre) and their boundaries determined. Maps of geostrophic water circulation were made and analysis of environmental parameters and krill distribution was carried out. Three krill groups, differing from each other according to length frequency, maturity stages and waters inhabited, were determined. The

distribution of the first group (juveniles 25–29 mm) corresponds well to Weddell Current meanders to the west of the archipelago, and the distribution of the second group (41–47 mm) corresponds well to the Frontal Zone of the Weddell Gyre (FZWG). Small eddies on the FZWG boundary contain concentrations of krill of the third group (50–56 mm), transported there by ACC waters. These swarms are transported southwards from the east of the archipelago and may be mixed with krill of the first group. It is very probable that krill concentrated in stable eddies to the east of the archipelago may be kept there for a rather long time, allowing maturation and spawning to take place. Newly hatched larvae may drift further, providing krill recruitment for parts of its distribution range situated downstream.

WG-EMM-00/34
Interannual variations of water thermochaline structure on South Georgia Island, South Orkney Islands and Shetland Islands shelves.
P.P. Chernyshkov, V. Shnar, O. Berezhinsky and I. Polischuk (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 7 pp. (English, unpublished).

Based on the analysis of major water mass boundaries and their thermochaline characteristics, T,S summary diagrams have been made for hydrological stations carried out around the South Orkney and Shetland Islands each January–February since 1970. Three types of years are noted for the South Orkney Islands area. The first type was characterised by the presence of an intermediate cold layer. In some years of this type (1971, 1972, 1978, 1982) the layer had a positive temperature, while in other years (1980, 1981) it was negative. The second year type (1979, 1984, 1987) was characterised by a rather narrow range of water temperature from the surface to the bottom and higher salinity. The third type (1970, 1976, 1984, 1989) was characterised by a higher degree of principal water masses mixing within the area and a lack of distinct boundaries between these water masses. Two year types were observed for the South Orkney Islands area. The presence of a layer, warmed up over summer, and a cold intermediate layer was characteristic of the first year type. Lack of surface water of summer modification was characteristic of the second year type (1970, 1979, 1981, 1985, 1989).

As water structure within those areas was considered to be the result of hydrodynamic processes and it represents an indirect index of hydrodynamic situation observed, the results of generalisation undertaken could be used when analysing the distribution and density of krill aggregations over the period under examination.

WG-EMM-00/35
Interannual hydroclimate fluctuations in the Atlantic part of the Antarctic from 1970 to 2000.
G. Chernega, I. Polischuk and P.P. Chernyshkov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 10 pp. (English, unpublished).

Observations made in late in 1999 and early in 2000 showed a significant shift of the Falkland/Malvinas Current core towards the shelf and an abnormally large number of icebergs on the South Georgia Island shelf. We examined historical hydrometeorological data on areas of the Southwest Atlantic covering the period 1970 to 2000. Analysis of average monthly atmospheric pressure using the principal component method, as well as analysis of interannual variations in atmospheric circulation indices showed unusual developments in atmospheric processes since 1996. An anomalous increase in meridional air transport (southern component) was recorded in 1996–1998, but this was not typical for the whole period under investigation. Thus, the Antarctic Circumpolar Current regime may have changed, leading to variations in hydrodynamic conditions of krill habitat within insular areas. The small number of krill aggregations near South Georgia Island in January–February 2000 may serve as an indirect confirmation of such changes.

WG-EMM-00/36
Some changes observed in Antarctic seabird distribution and behaviour.
F.F. Litvinov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 5 pp. (English, unpublished).

This paper presents an analysis of data on seabird distribution and abundance

collected from November 1999 to April 2000 on the route Kaliningrad (Baltic Sea)–Falkland Islands–South Georgia Island–South Sandwich Islands–South Georgia Island–Montevideo–Kaliningrad. This analysis shows a significant shift of the southern boundary of the range of the great shearwater *Puffinus gravis* up to South Sandwich Islands (about 7°). This may be explained by changes in abundance or a southward shift of the Southern Polar Front. Unusual behaviour was noted in the black-browed albatross *Diomedea(Thalassarche) melanophrys*, which was observed diving for fish and swimming underwater at a depth of 1.5 m for 15 seconds. The abundance of black-browed albatross near the South Sandwich archipelago was very low. This phenomenon may be explained by black-browed albatrosses avoiding the area of the cold Weddell Sea waters penetrating north along the archipelago.

WG-EMM-00/37

A multiple-frequency method for identifying and assessing the Antarctic krill stock in the Ross Sea (1989/90, 1997/98 and 1999/2000). M. Azzali, J. Kalinowski and G. Lanciani (National Research Council, Institute for Marine Fisheries Research, Largo Fiera 2, 60100 Ancona, Italy), 34 pp. (English, unpublished).

This paper describes the criteria, based on multiple-frequency analysis, used by Italian expeditions to the Ross Sea to discriminate *Euphausia superba* (krill) aggregations from aggregations of *Euphausia crystallorophias*, and from other scatterers. These criteria, based on the experimental data acquired from expeditions conducted in 1989/90, 1997/98 and 1999/2000, are discussed and compared with other sources in the literature, and are used to estimate krill biomass in the area of the Ross Sea (22 000 n miles^2) investigated from 19 to 26 December 1997. Krill biomass estimated using the multiple-frequency method is 8.87% lower than that estimated using conventional methods (net samplings and/or echogram analysis).

WG-EMM-00/38

Summer distribution, abundance and structure of krill populations (*Euphausia superba* and *Euphausia crystallorophias*) sampled by plankton net in the western Ross Sea (January–February 2000). M. Azzali, A. Sala and G. Brancato (National Research Council, Institute for Marine Fisheries Research, Largo Fiera della pesca, 1, 60125 Ancona, Italy), 18 pp. (English, unpublished).

Net sample data from the 15th Italian Antarctic Oceanographic Cruise (January–February 2000) were analysed to obtain a general picture of the summer distribution pattern, abundance and demography of krill in the western Ross Sea (Antarctica). A midwater sampler-trawl (Hamburg plankton net) was used to collect zooplankton and fish larvae at 63 stations. The net was deployed normally as a standard double-oblique tow. Mean relative biomass of Antarctic krill, *Euphausia superba*, in the area north of the Continental Shelf was 9.4 g/1 000 m^3 (±18%) of filtered water with a mean density of 11.0 individuals/1 000 m^3 (±16%). The high abundance of *E. superba* (1 510 g/1 000 m^3) found in a single haul in the Mawson Bank area (73°S, 173°E) was remarkable. Ice krill, *Euphausiacrystallorophias*, replaced *E. superba* in dominance in the High Antarctic Zone (south of 74°), with a mean relative biomass of 3.0 g/1 000 m^3 (±26%) and mean density of 16.8 individuals/1 000 m^s (±10%). The data presented demonstrate that during the summer period the two species of euphausiid inhabit different areas of the Ross Sea. Lengths of *E. crystallorophias* and length, sex and reproductive stage of *E. superba* occurring in discrete aggregations were analysed. Results indicated that the composition of the aggregations in terms of the mean length, sex ratio and maturity stage was very variable. Catches of *E. superba* were characterised by the complete absence of larval stages and scarce occurrence of juveniles and were composed primarily of large adult stages. Analysis of the krill population structure showed that *E. superba* aged 3+ and 4+ were clearly predominant in mid-summer. The overall length-frequency distribution of *E. crystallorophias* is characterised by a first mode of juveniles (age class 1+) and a second mode consisting of sub-adults and adults (age groups 2+ and 3+).

WG-EMM-00/39
Comparative studies on the biological and acoustic properties of krill aggregations (*Euphausia superba* Dana) sampled during the 13th Italian Expedition to the Ross Sea (December 1997–January 1998). M. Azzali, J. Kalinowski, G. Lanciani and I. Leonori (National Research Council, Institute for Marine Fisheries Research, Largo Fiera 2, 60100 Ancona, Italy), 34 pp. *CCAMLR Science*, submitted (English).

During the 13th Italian Expedition to the Ross Sea in late spring and early summer (December–January 1997/98) 35 net sample hauls were made in order to biologically validate hydroacoustic recordings. Biological (krill length AT, sex and gonad maturity stage) and acoustic (differences in volume back-scattering strength (MVBS) of krill aggregations at 38, 120 and 200 kHz) parameters were examined for all hauls. The depth of the net and acoustic recordings made during the hauls were compared.

The surveyed area extended from 71° to 76°S and from 164°E to 177°W. The aims of the paper are: (i) to compare the species/length composition based on catch data and that obtained from acoustic data acquired during the net sampling; (ii) to present density distribution maps of *E. superba* and *Euphausia crystallorophias* based on acoustic data; and (iii) to analyse the population structure of *E. superba* on the basis of biological parameters calculated using catch data.

The analysis of the biologicalparameters seems to indicate statistically significant differences between the hauls, while within each haul the parameters are homogeneous. The maturity stage of krill in general increases with decreasing latitude (from 76° to 71°S).

The analysis of acoustic and catch data indicates that: (i) the acoustic discrimination between the two predominant species, based on the multifrequency method, is very close to that based on net samplings; (ii) the acoustic estimation of the krill mean length, based on the fluid sphere method, is quite close (around 9% less) to the mean catch values; and (iii) the numerical abundance of the krill, estimated by the fluid sphere method, is 20–100 times higher than that estimated from the catch.

The geographical biomass distribution of *E. superba* and *E. crystallorophias*, estimated acoustically, overlaps at this time of the year.

WG-EMM-00/40
Chick provisioning and chick survival to fledging. J. Clarke, K. Kerry, L. Irvine and B. Philips (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 16 pp. (English, unpublished).

This paper examines the foraging behaviour of Adélie penguin parents and the provisioning of their chicks during the guard and crèche stages of chick development. The differences, observed in three poor breeding seasons compared with six seasons where a higher fledging success was achieved, are highlighted. An automated monitoring system allowed continuous collection of data on foraging trip duration and meal mass (arrival weight minus departure weight) from birds of known breeding status and sex. It is concluded that chicks are most sensitive to decreased food availability during the guard stage and thus most susceptible to competition from a fishery.

WG-EMM-00/41
The length-frequency distribution of krill in the diets of predators at Admiralty Bay, King George Island, Antarctica in the austral summer of 1999/2000. W.Z. Trivelpiece, K. Salwicka, L. Shill and S. Trivelpiece (Antarctic Ecosystem Research Group, Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), 7 pp. (English, unpublished), (abstract not available).

WG-EMM-00/42
The use of predator-derived krill length-frequency distributions to calculate krill target strength. K. Reid and A.S. Brierley (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 12 pp. *CCAMLR Science*, submitted (English).

The relationship between krill abundance and predator performance is fundamental to an ecosystem-based approach to resource

management. We propose a method using krill sampled from the diet of predators to provide a length-frequency distribution of krill at times when it is possible to run automated ship-board acoustic systems but not to conduct scientific netting, i.e. during logistic/resupply operations. This will allow a robust estimate of krill abundance to be estimated from acoustic data. Changes in the length-frequency distribution of krill over a period of a few weeks produced a 10% difference in target strength, whereas simultaneous samples from predators and nets resulted only in a 1% difference, illustrating the need for simultaneous length-frequency data. By integrating data from land-based predators directly with automated on-board data collection systems it will be possible to gain important estimates of krill biomass at times of the season which are otherwise impossible to obtain from ship-board scientific surveys.

WG-EMM-00/43
Contribution to a discussion of the ecosystem approach to management of the krill fishery. R.P. Hewitt and E.H. Linen Low. Extract from *The fishery on Antarctic krill: defining an ecosystem approach to management*. In: *Reviews in Fishery Science*, 8 (3): 2000 (English).

WG-EMM-00/44
Variations in condition indices of mackerel icefish at South Georgia from 1972 to 1997. I. Everson and K.-H. Kock (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 31 pp. *CCAMLR Science*, submitted (English).

Mackerel icefish are widespread on the South Georgia shelf and have been subject to commercial fishing since the early 1970s. They are known to feed predominantly on krill. An index of condition which uses the ratio of the measured total mass to the estimated mass is shown to be a good indicator of local krill density. The index is likely to be little affected by the reproductive cycle unless there is high krill availability during the months around spawning time, and even then the effect is much less than the highest observed values. The condition index responds rapidly to changes in krill density and therefore can provide indications of short-term variations in krill availability. The condition index provides a useful proxy for krill density and is likely to be of considerable value in interpreting the results of ecosystem assessments, such as that in progress under the auspices of CCAMLR.

WG-EMM-00/45
Interannual variation to the gonad cycle of the mackerel icefish. I. Everson, K.-H. Kock and J. Ellison (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 19 pp. (English, unpublished).

Spawning by Antarctic fish is generally considered to be seasonal and restricted to a brief period during the autumn and winter. Arising from this, it has been assumed that the gonadal maturation cycle is also closely linked to the time of year. The gonadal maturation cycle of the mackerel icefish *Champsocephalus gunnari* was investigated using data collected during research surveys and from the commercial fishery. Spawning appears to occur at the same time each year, but the timing of gonadal development is subject to a considerable interannual variation. The implications of this variation are discussed with respect to feeding condition.

WG-EMM-00/46
A generalised algorithm for estimating energy and carbon budgets in marine predators. I.L. Boyd (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 26 pp. (English, unpublished), (abstract not available).

WG-EMM-00/47
Pinniped research at Cape Shirreff, Livingston Island, Antarctica, 1999/2000. M.E. Goebel. Extract from *US AMLR 1999/2000 Field Season Report*, 15 pp. (English).

WG-EMM-00/48
Aerobic dive limit: how often does it occur in nature? D.P. Costa, N.J. Gales and M.E. Goebel. In: P. Pongonis

(Ed.), *Proceedings of the Kooyman Symposium 2000*, 22 pp. (English).

Diving animals offer a unique opportunity to study the importance of physiological constraint in their everyday behaviours. An important component of the physiological capability of any diving animal is its aerobic dive limit (ADL). The ADL has only been measured in a few species. The goal of this study was to estimate the aerobic dive limit from measurements of body oxygen stores and at-sea metabolism. This calculated ADL (cADL) was then compared to measurements of diving behaviour of individual animals of three species of otariids, the Antarctic fur seal, *Arctocephalus gazella*, the Australian sea lion, *Neophoca cinerea*, and the New Zealand sea lion, *Phocarctos hookeri*.

Antarctic fur seals dove well within the cADL. In contrast, many individuals of both sea lion species exceeded the cADL, some by significant amounts. Australian sea lions typically dove 1.5 times longer than the cADL, while New Zealand sea lions on average dove 1.4 times longer than the cADL. The tendency to exceed the cADL was correlated with the dive pattern of individual animals. In both Antarctic fur seals and Australian sea lions, deeper diving females made longer dives that approached or exceeded the cADL ($P < 0.01$, $r^2 = 0.54$). Australian and New Zealand sea lions with longer bottom times also exceeded the cADL to a greater degree. The two sea lions forage on the benthos while the fur seals feed shallow in the water column. It appears that benthic foraging requires these animals to reach or exceed their aerobic dive limit.

WG-EMM-00/49

Some components of uncertainty in the CCAMLR 2000 acoustic survey of krill. D.A. Demer (Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), 30 pp. (English, unpublished).

Sources of uncertainty in the CCAMLR 2000 acoustic survey of krill abundance in FAO Statistical Area 48 were studied and quantified. The variance in system calibration was evaluated in relation to the effects of variant water temperature and salinity on sound speed, sound absorption and beam characteristics. Uncertainty in krill target strength (TS) was estimated using a distorted wave born approximation model of krill TS, fitted with measured distributions of animal lengths and orientations. The uncertainty in species delineation was also investigated using the same scattering model. The combined measurement and sampling variance was estimated from a simulation which assumed that the three frequency measurements provided independent estimates of the krill biomass. The overall variance (11.33%) was only slightly different from the sampling variance (11.38%). Thus, the measurement variance may be negligible relative to the sampling variance due to the large number of measurements averaged to derive the ultimate biomass estimate. Some potential sources of bias were also explored. The latter (i.e. stemming from uncertainties in target strength, species delineation, bubble attenuation, thresholding, area definition etc.) may be more significant components of measurement uncertainty. Further studies are warranted.

WG-EMM-00/50

Distribution of krill as a fraction of Antarctic zooplankton within the South Sandwich Islands area in summer 2000. S.M. Kasatkina and A.P. Malyshko (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 8 pp. *CCAMLR Science*, submitted (English).

This paper covers the results of an acoustic estimation of the distribution of krill and non-krill zooplankton in the South Sandwich Islands area; the results were obtained using multifrequency algorithms based on data from a survey by the Russian vessel *Atlantida* as part of the CCAMLR-2000 Survey. The distribution of acoustic characteristics for krill and non-krill components of Antarctic zooplankton has been compared. It has been shown that krill formed the bulk of zooplankton in Weddell Sea waters and the Frontal Zone of the Weddell Gyre, while non-krill zooplankton dominated in water masses of the Antarctic Circumpolar Current.

WG-EMM-00/51

Krill distribution as to water structure and dynamics on the South

Georgia shelf in January 2000 (AtlantNIRO-BAS Core Programme 1999/2000). V.A. Sushin, P.P. Chernyshkov, F.F. Litvinov, J.L. Watkins and A.S. Brierley (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 5 pp. (English, unpublished).

Research on water structure and dynamics, krill biomass, biology and distribution was carried out in two standard boxes on the shelf and slope northwest and northeast of South Georgia. Eight hydroacoustic transects with hydrographic stations were carried out in each box using RMT8+1 trawls.

Krill were distributed rather evenly throughout both boxes, but no dense concentrations were apparent.

In the western box, krill density was nearly 0.2 g/m^3 and in the eastern box it was 1.8–4.7 g/m^3. Juvenile krill of 30 to 36 mm length were observed in the shelf zone and larger specimens, including spawning and post-spawning females of 50 mm and larger, were distributed in the slope zone and deep oceanic waters.

According to these preliminary results, krill abundance on the South Georgia shelf in January 2000 was lower than usual and no concentrations suitable for commercial fishing were observed. Temperature and salinity measurements carried out on the standard hydrographic stations revealed oceanographic conditions similar to the long-term mean values. However, on this survey we did not observe any of the usual gyres or eddies which lead to the formation and maintenance of krill concentrations.

WG-EMM-00/52

Hydrography and acoustic biomass estimates of Antarctic krill (*Euphausia superba*) near the South Shetland Islands, Antarctica, during January 2000: preliminary results. D. Kang, Y. Lee, H.-C. Shin, W. Lee and S. Kim (Department of Earth and Marine Sciences, Hanyang University, Republic of Korea), 19 pp. (English, unpublished).

A hydroacoustic/oceanographic survey was conducted by the RV *Onnuri* from 9 to 19 January 2000 to estimate the abundance and distribution of Antarctic krill *(Euphausia superba)* in the vicinity of the South Shetland Islands. The acoustic data were obtained using a Simrad EK500 echosounder operating at 38, 120 and 200 kHz from eight transects within the South Shetland Islands mesoscale box (total transect length = 459 n miles, area = 11 313 n miles^2). Krill were collected with a Bongo net (mesh size: 0.333 mm, 0.505 mm) to determine their size composition and stage of development. In addition, a conductivity, temperature and depth recorder (CTD) and an on-station acoustic doppler current profiler (ADCP) were deployed to study the physical structure of the water column at 11 stations.

The hydrography varied between the offshore region and coastal area. Offshore stations showed the presence of 'Winter Water' in mid-layer and Circumpolar Deep Water at greater depths. Offshore water and coastal water modifications were also seen to the north and south of Elephant Island respectively. ADCP results indicate water flowing from the Bransfield Strait to the offshore region around the east of King George Island.

The length–weight relationship of krill sampled during the survey was $w = 0.0035^* (L)^{3.2108}$, where w was the mass (mg) and L was the total length (mm); the median length was 50 mm. The conversion factor for integrated backscattering area to areal krill biomass density at 120 kHz was 0.1556. The mean density of krill near the South Shetland Islands area was 12 g/m^2 with a coefficient of variation (CV) of 14.5%. The mean density and CV in the Bransfield Strait were 9 g/m^2 and 20.3%. Krill swarms of relatively high density occurred to the north of Smith Island, north and east of King George Island and north and south of Elephant Island.

WG-EMM-00/53

Collection of informative manuscripts regarding SO-GLOBEC activities on Antarctic krill. S. Kim and E. Hofmann (Department of Marine Biology, Pukyong National University, Pusan, Republic of Korea), 21 pp. (English, unpublished).

WG-EMM-00/54

Some notes on by-catch of fish and salps caught by the fishery vessel *Niitaka Maru* in the vicinity of the

South Shetland Islands (January to February 1999). T. Iwami, S. Kawaguchi and M. Naganobu (Laboratory of Biology, Tokyo Kasei Gakuin University, 2600 Aihara, Machida, Tokyo 194-0292, Japan), 3 pp. (English, unpublished).

Scientific observations of fish and salp by-catch taken during commercial krill fishing by the FV *Niitaka Maru* in the vicinity of the South Shetland Islands were made from 3 January to 4 February 1999. Of 74 net hauls examined, only five specimens of juvenile fish, belonging to three notothenioid species (*Notothenia coriiceps, Chaenocephalus aceratus* and *Chaenodraco wilsoni*), were found in four trawl catches. On the other hand, salps were taken as by-catch in 69 hauls, comprising 20 to 3 560 individuals/tonne of krill. By-catch fish fed on *Thysanoessa macrura; Euphausia superba* was not found in their stomachs. The abundance of salps in krill catches could have been dependent on the density of krill concentration. The large by-catch of salps (>2 500 individuals/tonne of krill) occurred in hauls with the low krill catch rates (<5 tonnes/h). A relationship between the abundance of salps and fishing time could not be established.

Scientific observations of the abundance of by-catch organisms (3 910 tonnes) were made during the austral summer months of 1999 (from 3 January to 4 February) on board FV *Niitaka Maru* in the offshore areas to the north of the South Shetland Islands. Trawling was carried out in the upper 100 m water layer using a commercial midwater trawl. To determine the abundance of by-catch organisms, a random sample of 50 kg of krill was taken from 74 hauls.

WG-EMM-00/55

Notes on the eighth Antarctic survey by the RV *Kaiyo Maru*, Japan, in 1999/2000. M. Naganobu, S. Kawaguchi, T. Kameda, Y. Takao and N. Iguchi (National Research Institute of Far Sea Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan), 8 pp. (English, unpublished).

The Antarctic research cruise by the RV *Kaiyo Maru,* Japan, was conducted in the Scotia Sea (Area 48) during November 1999 and February 2000. The objectives were to examine, for the CCAMLR krill synoptic survey, seasonal krill flux through krill fishing grounds, as well as to carry out oceanographic transects in the Southern Ocean and conduct laboratory experiments on krill.

WG-EMM-00/56

Scales of interannual variability in Antarctic krill biomass at South Georgia. A.W. Murray, A.S. Brierley and J.L. Watkins (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 17 pp. (English, unpublished).

Acoustic surveys of Antarctic krill have been conducted at South Georgia along standard transects within two 100 x 80 km survey boxes for four consecutive austral summers since 1995/96. Mean krill abundance varied substantially between boxes and years. Here we use analysis of variance of mean krill densities from individual survey transects to investigate the relative importance and scale of temporal and spatial variability of observed changes in overall mean krill abundance. We did not detect any significant effect of spatial position between transect means averaged over the four years. However, all other sources of variation and interactions were significant. Estimated components of variance showed that the interannual variability was very similar in magnitude between boxes and between transects, indicating that krill distribution patterns are extremely patchy in both space and time across spatial scales between 5–10 km and 100–200 km. Separate analyses for each box revealed that there was no statistically significant interannual variation in the survey box to the northwest of the island.

WG-EMM-00/57

CPUEs and body lengths of Antarctic krill during the 1998/99 season in Area 48. S. Kawaguchi (National Research Institute of Far Sea Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan), 18 pp. (English, unpublished).

Fishing operations were mainly distributed around the South Shetland Islands from mid-December to early April. From mid-April to the end of the fishing season, the main fishing ground gradually moved to

the area around the South Orkney Islands. The length frequency showed similar patterns between Subareas 48.1 and 48.2, with most lengths being between 40 to 50 mm (age 3+ and 4+). However, length classes larger than 50 mm were also observed as small amounts in Subarea 48.2. CPUEs were highly variable between early March and late April, when the vessels mainly operated around Elephant Island and/or the South Orkney Islands. Relatively stable CPUE1 (catch/haul) compared to CPUE2 (catch per hauling time) may be due to the fishing tactics which aim to avoid the squashing of krill in the net to keep a high quality of krill products.

WG-EMM-00/58
Analysis of krill trawling positions in the area north of the South Shetland Islands (Antarctic Peninsula area) from 1980/81 to 1998/99. S. Kawaguchi (National Research Institute of Far Sea Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan), 12 pp. *CCAMLR Science*, submitted (English).

Positions of commercial krill operations from the 1980/81 to the 1998/99 seasons in the area to the north of the South Shetland Islands were analysed using the Generalised Linear Model (GLM). Fishing season, timing and longitude were significant factors affecting the variability of latitudes where operations were undertaken. Operations tended to take place in the north in early 1980s, but from the mid-1980 onwards they tended to be carried out in the south, with the exception of the 1994/95 and the 1995/96 seasons. Predicted latitudes of operation significantly correlated with salp densities in the Elephant Island area (Spearman's rank correlation, $p < 0.05$), but not with krill densities. This may be due to the intention of fishing vessels to reduce the salp in the products.

WG-EMM-00/59
Krill length distribution in fur seal diet at Cape Shirreff, Livingston Island, 1999/2000. M.E. Goebel (Antarctic Ecosystem Research Group, Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), 9 pp. (English, unpublished), (abstract not available).

WG-EMM-00/60
The ecosystem approach to managing fisheries: achieving conservation objectives for predators of fished species. A.J. Constable (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 15 pp. *CCAMLR Science*, submitted (English), (abstract not available).

WG-EMM-00/61
Towards an ecosystem status assessment for South Georgia. British Antarctic Survey's 'Variability of Southern Ocean Ecosystems' Project Team (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 7 pp. (English, unpublished).

We present the beginnings of a compilation of a suite of physical and biological oceanographic data, and concomitant data on abundance and condition of some key zooplankton species and vertebrate higher predator species, collected at sea off South Georgia and from Bird Island between 1996 and 1999. We plan to use these data, some of which arise from the British Antarctic Survey's Core Programme, to develop multivariate indices of 'ecosystem status'. We expect that such indices will lead to an improved understanding of some cause-and-effect mechanisms that underlie the pronounced interannual variability that we observe regularly in many components of the South Georgia marine ecosystem. The indices may also contribute to CCAMLR's WG-EMM, the terms of reference of which include provision of advice on ecosystem assessment that combines information from dependant and harvested species, and from the environment, to provide holistic advice on ecosystem management.

WG-EMM-00/62
Seabird research at Cape Shirreff, Livingston Island, Antarctica, 1999 to 2000. T.M. Carten, W.Z. Trivelpiece, M.R. Taft and R.S. Holt (Antarctic Ecosystem Research Group, Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), 6 pp. (English, unpublished), (abstract not available).

WG-EMM-00/63
Report to CCAMLR WG-EMM, July 2000: Excerpts from the Report of the Meeting of the SCAR Group of Specialists on Seals. National Institute of Polar Research, Tokyo, Japan, 11 pp. (English, unpublished).

WG-EMM-00/64
Report to WG-EMM on implications of meeting schedules. Chairman of the Scientific Committee, 7 pp. (English, unpublished).

Working Group on Fish Stock Assessment

WG-FSA-00/7
United Kingdom genetic research relevant to Southern Ocean seabirds vulnerable to fisheries interactions. J.P. Croxall (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 1 p. (English, unpublished).

WG-FSA-00/8
United Kingdom research under way on Southern Ocean seabirds vulnerable to fisheries interactions. J.P. Croxall (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 5 pp. (English, unpublished).

WG-FSA-00/9
France research under way on Southern Ocean seabirds vulnerable to fisheries interactions. H. Weimerskirch (Centre d'Etudes Biologiques de Chizé, Centre National de la Recherche Scientifique, 79360 Beauvoir-Sur-Niort, France), 5 pp. (English, unpublished).

WG-FSA-00/10
Research under way on New Zealand seabirds vulnerable to fisheries interactions. J. Molloy (Biodiversity Recovery Unit, Department of Conservation, PO Box 10-420, Wellington, New Zealand), 4 pp. (English, unpublished).

WG-FSA-00/11
Documentation for the CCAMLR survey database and length-density analysis. CCAMLR Secretariat, 14 pp. (English, unpublished).

WG-FSA-00/12
Update on the CCAMLR Website. CCAMLR Secretariat, 10 pp. (English, unpublished).

WG-FSA-00/13
Longline fishing at Tristan da Cunha: impacts on seabirds. N. Glass, I. Lavarello, J.P. Glass and P.G. Ryan. *Atlantic Seabirds*, 2 (2): 2000, 8 pp. (in press), (English).

Tristan da Cunha and Gough Islands in the central South Atlantic Ocean support globally important seabird populations. Two longline fisheries occur within Tristan's Exclusive Economic Zone: a pelagic fishery for tunas and a demersal fishery for bluefish and alfoncino. Fishery observers have accompanied all three licensed demersal cruises. Despite attracting considerable numbers of birds and setting lines during the day, only one bird (a great shearwater *Puffinus gravis*) was killed (mortality rate 0.001 birds per 1 000 hooks). By comparison, the pelagic fishery for tuna, which exceeds demersal fishing effort, probably has a much greater impact. Observations aboard one vessel in mid-winter suggest a by-catch rate of >1 bird killed per 1 000 hooks; this could be even higher in summer when more birds are breeding at the islands. Stricter regulations are required for pelagic vessels, including routine placing of observers on board. The gravest threat posed by longline fishing to Tristan's seabirds comes from vessels fishing illegally in Tristan waters, as well as vessels in international waters that do not use basic mitigation measures. There is a pressing need for better policing of Tristan's waters.

WG-FSA-00/14
What do we know about fish stocks in the southern Scotia Arc region? A review and prospects for future research. K.-H. Kock and C. Jones (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany), 48 pp. (English, unpublished).

Up to the end of the 1960s, research on finfish in the southern Scotia Arc region had been restricted to taxonomic studies. Commercial exploitation, primarily of mackerel icefish, *Champsocephalus gunnari*, and marbled notothenia, *Notothenia rossii*, started around the South Orkney Islands (60–62°S/43–47°W) in 1977/78 and close to Elephant Island and the lower South Shetland Islands(60–62°S/54–62°W) in 1978/79. The fishery was profitable for a few seasons only, and was closed in 1989/90.

Stocks of finfish suffered substantial declines while the fishery was open. Most fish stocks, with the exception of *C. gunnari* and *N. rossii*, had recovered from exploitation by the end of the 1980s/ beginning of the 1990s. Since the early 1990s, the slight change in abundance of most species appeared to have been caused primarily by fluctuations in year-class strength and the environment. However stocks of *C. gunnari*, which had formed the backbone of the fishery, remained only small proportions of their initial sizes.

Most information on biological parameters of finfish stocks comes from Soviet, Polish, German and recent American research in the area. Two elements of the fish fauna overlapped in the southern Scotia Arc region: peri-Antarctic or lesser Antarctic species and high-Antarctic species. Peri-Antarctic species dominated in terms of weight and numbers. High-Antarctic species occurred regularly, albeit in small numbers, but played a negligible role in terms of biomass. Among the three subareas, the fish fauna around the South Orkney Islands was the least known. Basic biological parameters of fish species, such as vertical and horizontal distribution, reproduction, age and growth, food preferences and feeding (except in the South Orkney Islands) were comparatively well known, although some gaps in our knowledge still exist. Age and growth of most species were poorly understood. Major deficiencies were apparent in the understanding of the early life history of many species. Future work should focus on filling in the gaps in the biology of species, intensifying synecological work and better describing the relationships of fish species with each other, predator–prey relationships both with other fish species and seals and birds, food consumption of fish species and their interactions with the environment.

WG-FSA-00/15
Preparation of identification keys for by-catch fish species. CCAMLR Secretariat, 5 pp. (English, unpublished).

WG-FSA-00/16
Restoration of retrospective data on *Dissostichus eleginoides* catches in Subarea 48.3. YugNIRO (Ukraine) and AtlantNIRO (Russia), 1 p. (English, unpublished).

WG-FSA-00/17
Brief report of the national scientific observer aboard the longliner *RK-1*. A.S. Petrenko (Ukraine), 2 pp. (English, unpublished).

WG-FSA-00/18
Summary of observations aboard trawlers operating in the Convention Area during the 1999/2000 season. CCAMLR Secretariat, 5 pp. (English, unpublished).

WG-FSA-00/19
Hydroacoustic observations of the vertical distribution of icefish (*Champsocephalus gunnari*) in the western part of the slope of South Georgia Island in December 1999–January 2000. V.L. Senioukov (PINRO, 6 Knipovich Street, Murmansk 183763, Russia), 16 pp. (English, unpublished).

The dynamics of daily vertical migrations of icefish (*Champsocephalus gunnari*) were studied and some quantitative estimates were obtained by analysing more than 150 echogram samples obtained using a 'Priboi-101' echosounder during the directed fishery for *C. gunnari* in Subarea 48.3 in December 1999–January 2000. Commercial concentrations of *C. gunnari* can be considered by the type of its vertical distribution as bottom-pelagic; the pelagic component of biomass is great both during the day and at night. Therefore, it can be concluded that assessments of *C. gunnari* stock based on the results of bottom trawl surveys may be underestimated.

WG-FSA-00/20
Biological features of icefish (*Champsocephalus gunnari*) from commercial catches in Subarea 48.3 during the period from 8 December 1999 to 31 January 2000. V.L. Seniookov (PINRO, 6 Knipovich Street, Murmansk 183763, Russia), 12 pp. (English, unpublished).

From 11 December 1999 to 31 January 2000 the Russian trawler *Zakhar Sorokin* carried out fishing for feeding concentrations of icefish (*Champsocephalusgunnari*) on the western shelf of South Georgia Island. *C. gunnari* 26 to 40 cm in length (average size 30.3 cm) made up the bulk of catches. Length-frequency distribution was characterised by bimodality, with frequency peaks at 27–29 and 33 cm for fish aged 3 and 4 years respectively. The by-catch of small *C. gunnari* (length of 24 cm or less) was on average 0.6% per haul.

The mean male-to-female ratio was 1:1.2. Gonad maturation was more rapid in females. Gonad maturation stages II and II–III dominated in December, while stages II–III and III dominated in January.

C. gunnari feeding intensity remained relatively high during the study period. Mean stomach fullness was 2.5. Antarctic krill (*Euphausia superba*), whose occurrence in stomachs was estimated at 86%, and *Themisto gaudichaudii* (27.8%), were the main prey items.

Mean prevalence and intensity respectively, of *C. gunnari* infestation by the leech *Trulliobdella capitus* was 11.9% and 1.3 and by parasitic copepods *Eubrachiella antarctica* – 37% and 3.

WG-FSA-00/21
UK groundfish survey in Subarea 48.3 (South Georgia and Shag Rocks), January 2000. I. Everson, D. Agnew, P. Bagley, M. Collins, T. Daw, R. Forster, T. Marlow, A. North, J. Szlakowski, E. van Wijk, S. Wilhelms and C. Yau (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 17 pp. (English, unpublished).

A survey was conducted by the UK around South Georgia and Shag Rocks, Subarea 48.3, from 11 January to 2 February 2000, using the FV *Argos Galicia*. The design followed similar surveys by the UK conducted throughout the late 1980s and 1990s. The swept-area estimates of the standing stock of *Champsocephalus gunnari* were about 24 800 tonnes. Estimates for other major species are given.

WG-FSA-00/22
Notes on the biology of the South Georgia ray, *Raja georgiana*. I. Everson, J. Kerr, C. Yau and A. Williams (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 13 pp. (English, unpublished).

Morphological information is given on specimens of *Raja georgiana* that were caught during a demersal trawl survey in Subarea 48.3 (South Georgia). It is concluded that, in spite of allometric growth, it is best for proportional measurements to be referenced to total length rather than disc width. Additional biological information is given: total mass = 0.00000646 x (total length)$^{3.06}$. Based on data from male fish, they are thought to mature at about 800 mm total length.

WG-FSA-00/23
Fishing for toothfish using pots: results of trials undertaken around South Georgia, March–May 2000. D. Agnew, T. Daw, M. Purves and G. Pilling (Renewable Resources Assessment Group, Imperial College, Royal School of Mines, Prince Consort Road, London, SW7 2BP, United Kingdom), 16 pp. *CCAMLR Science*, submitted (English).

During the period March to May 2000, the UK undertook trials of a pot fishing method to catch *Dissostichus eleginoides* around South Georgia (Subarea 48.3). This method has the potential to minimise, or eliminate, incidental bird mortality when compared to the standard longline method. This paper describes the trial and the results, and discusses the commercial viability of this fishing method for toothfish fisheries in the Convention Area. While the method successfully caught *D. eleginoides*, there was a large by-catch of crab species. The catch rate of toothfish was notably lower than that achieved in the longline fishery. Importantly, the use of pots elimi-

nated bird by-catch. To capitalise on this feature, the commercial viability of the method needs to be improved and the by-catch minimised. A number of potential changes are suggested to achieve these goals.

WG-FSA-00/24

Crab by-catch in the experimental toothfish pot fishery around South Georgia, 2000. T. Daw, D. Agnew, M. Purves, G. Pilling and C. Yau (Renewable Resources Assessment Group, Imperial College, Royal School of Mines, Prince Consort Road, London, SW7 2BP, United Kingdom), 19 pp. *CCAMLR Science*, submitted (English).

Trials of a method of fishing for toothfish using pots were undertaken by the FV *Argos Georgia* from March to May 2000. A significant by-catch of crabs was taken. *Paralomis spinosissima* occurred in shallow water, generally shallower than 800 m. *P. anamerae,* which has not been reported for this area previously, had an intermediate depth distribution from 400 to 800 m. *P. formosa* was present in shallow waters but reached much higher catch levels (and, presumably, densities) between 800 and 1 400 m. There were some differences in catch rates between areas, with the lowest catch rates being encountered between Shag Rocks and South Georgia, and the highest for *P. formosa* in deep water north of South Georgia. Few crabs (3% of *P. spinosissima* and 10.5% of *P. formosa*) were males above the legal size limit and could be retained. All other crabs were discarded. Mortality rates estimated from reimmersion experiments indicated that about 10% of apparently lively discarded crabs would die.

WG-FSA-00/25

Examination of the gut contents of Patagonian toothfish (*Dissostichus eleginoides*) from the toothfish pot fishery trials around South Georgia. G. Pilling, T. Daw, M. Purves, D. Agnew and J. Xavier (MRAG Ltd, 47 Prince's Gate, London, SW7 2QA, United Kingdom), 17 pp. (English, unpublished).

To apply the 'ecosystem approach' to fisheries management recommended by CCAMLR, an understanding of the trophic relationships of exploited species is vital. Toothfish *(Dissostichus eleginoides)* is an important target species for fisheries not only in the study area around South Georgia (Subarea 48.3), but also in other CCAMLR areas. To improve knowledge about the trophic relationships of this species, stomach analyses were performed on individuals caught during the toothfish pot fishery trials undertaken in the study area during the period from March to May 2000. Stomach contents of 3 640 individuals were identified. The proportion of individuals found with empty stomachs was greatly reduced in fish caught using pots rather than longlines, which increased sample sizes. This was hypothesised to result from fish caught in pots suffering reduced levels of trauma. The most common prey item for fish caught using pots was prawns. This prey category was localised in location and depth. However prawns were not common in the stomachs of fish caught from this location using longlines. The next most common prey category was fish, as found in previous studies of this species. This confirms that *D. eleginoides* is an opportunistic carnivore, whose feeding habits vary depending on the availability of food items as well as factors such as depth.

WG-FSA-00/26

Toothfish tagging program around South Georgia, 2000. G. Pilling, I. Everson, D. Agnew, T. Daw, R. Forster, A. North, and M. Purves (MRAG Ltd, 47 Prince's Gate, London, SW7 2QA, United Kingdom), 10 pp. (English, unpublished).

A tagging program for toothfish (*Dissostichus eleginoides*) was undertaken around South Georgia in early 2000. Details of the program are given. A total of 359 toothfish were tagged during a trawl survey on the Shag Rocks shelf and a further 135 were tagged on the continental slope around South Georgia and Shag Rocks. The program has been advertised widely amongst industrial fishermen operating in the region.

WG-FSA-00/27

Spawning activity of mackerel icefish at South Georgia. I. Everson, A. North and K.-H. Kock (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road,

Cambridge CB3 0ET, United Kingdom), 12 pp. *CCAMLR Science*, submitted (English).

Historical information on the distribution of spawning and larval mackerel icefish within Subarea 48.3 (South Georgia) is assessed. This is considered alongside other new data from commercial fisheries and research surveys. It is concluded that there is strong evidence for inshore spawning during April within and close to the bays on the north side of the island. Some spawning at much lower intensity almost certainly occurs over much of the shelf, although the intensity appears to be small in comparison with inshore spawning. There is some evidence for spawning at Shag Rocks, although the precise location is unknown and there are indications of a second limited spawning season in October, although the evidence is weak.

WG-FSA-00/28

A comparison between otoliths and scales for use in estimating the age of *Dissostichus eleginoides* from South Georgia. J. Ashford, C. Jones, S. Wischniowski, S. Bobko and I. Everson (Center for Quantitative Fisheries Ecology, Old Dominion University, Norfolk, Va. 23529, USA), 23 pp. *CCAMLR Science*, submitted (English).

Age composition is fundamental to understanding the population dynamics and productivity of a fish stock. With accurate age data, population age structure can be modelled, and growth, mortality and recruitment rates estimated. Stock assessment biologists can examine the effect of fishing mortality on population dynamics under different management scenarios using dynamic pool and age-structured stock assessment models.

However, inaccuracies in age data can lead to significant bias towards younger or older individuals, the masking of strong year classes and erroneous output from models, leading to inappropriate management strategies. The use of scales has been shown to result in large errors in age data for several long-lived commercial species; Patagonian toothfish *(Dissostichus eleginoides)* are considered to have a life span of 20+ years, but both scales and otoliths have been used to estimate age. In 1998, the CCAMLR Working Group on Fish Stock Assessment encouraged its members to undertake studies to determine which method would be the most effective.

In response to this request, we estimated age for *D. eleginoides* caught off South Georgia, using otoliths and scales independently. For scales, we made impressions on acetate slides, and developed criteria for estimating age; for otoliths, methods were as outlined in Ashford and Horn (1999). Using ANOVA, we compared data obtained from the two structures to test the hypothesis that otoliths and scales give the same age estimates, and compared precision of age estimation for both structures and between readers.

WG-FSA-00/29

Reducing seabird by-catch with an underwater longline setting funnel. P.G. Ryan and B. Watkins (Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7701, South Africa), 10 pp. (English, unpublished).

We tested the efficacy of a Mustad underwater setting funnel to reduce seabird by-catch in a demersal longline fishery for Patagonian toothfish (*Dissostichus eleginoides*). The funnel, which deploys the longline 1 to 2 m beneath the sea surface, was used on 52% of 1 714 sets (total effort 5.12 million hooks) over a two-year period. There was no evidence of lower catches or significantly higher bait loss on sets through the funnel. Overall bird by-catch rate was low (0.022 birds/thousand hooks), and was dominated by white-chinned petrels (*Procellaria aequinoctialis* – 88% of the 114 birds killed). The by-catch rate was three times lower when the funnel was used both by day and at night. Daytime catch rates with the funnel were less than those attained during night sets without the funnel. Underwater setting offers a significant reduction in seabird mortality and could increase fishing efficiency by allowing daytime setting. However, small numbers of albatrosses were caught during daytime sets with the funnel, and its use for daytime sets should be closely monitored.

WG-FSA-00/30

Seabird by-catch in the Patagonian toothfish longline fishery at the Prince Edward Islands: 1999–2000.

P.G. Ryan and B. Watkins (Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7701, South Africa), 12 pp. (English, unpublished).

This paper summarises seabird by-catch during the fourth year (July 1999–June 2000) of sanctioned longline fishing for Patagonian toothfish (*Dissostichus eleginoides*) in the Exclusive Economic Zone around South Africa's Prince Edward Islands. Data were obtained from fishery observers aboard vessels during all 11 sanctioned fishing trips. Fishing effort was 7.4 million hooks, a 45% increase on the number of hooks set in 1998/99. Observers reported 268 birds of six species killed. White-chinned petrels (*Procellaria aequinoctialis*) predominated (92.2%), followed by eastern yellow-nosed albatrosses (*Diomedea chlororhynchos* – 3.5%), grey petrels (*P. cinerea* – 1.8%), grey-headed albatrosses (*D. chrysostoma* – 1.5%) and giant petrels (*Macronectes* spp. – 1.1%). The average seabird by-catch rate by sanctioned vessels was 0.036 birds/thousand hooks, more than double that reported in 1998/99, but still considerably less than that reported in either 1996/97 or 1997/98. The absolute number of birds killed increased more than threefold compared to 1998/99 due to the marked increase in fishing effort.

Variance in bird by-catch rates among trips ranged from 0 to 0.142 birds killed/thousand hooks. Birds were killed on 7.7% of sets, with most (68%) birds killed on only 49 sets that had multiple casualties (2.8% of sets). As in previous years, much of the variance could be explained in terms of fishing season (higher by-catch rate in summer), time of setting (higher during the day), and distance from the Prince Edward Islands (higher within 200 km of the islands).

WG-FSA-00/31

The possibility of using acoustic methods to improve the quality of *Champsocephalus gunnari* biomass estimates in Subarea 48.3. S.M. Kasatkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 12 pp. *CCAMLR Science*, submitted (English).

An attempt has been made to study icefish (*Champsocephalus gunnari*) using acoustic and biological data collected by the Russian RV *Atlantida* in the South Georgia Island area (January–February 2000). Estimation of possible target strength (TS) values was made by comparing the TS of other fish species having similar body structure and morphological characteristics, as well as by taking into account its chemical and physical properties. *C. gunnari* length frequencies obtained from midwater trawl catches are proven to be comparable with those estimated using TS *in situ* measurements for fish recorded within the pelagic zone. Analysis of acoustic measurements and the results of commercial fleet operation, demonstrate the daytime availability of *C. gunnari* concentrations within the pelagic zone; these concentrations would be out of range for bottom trawl surveys. It has been suggested that one way of improving *C. gunnari* stock assessments could be to use an acoustic method to evaluate biomass distributed within the pelagic zone. The latter raises the problem of carrying out acoustic trawl surveys to estimate *C. gunnari* biomass and the distribution of pelagic and near-bottom concentrations.

WG-FSA-00/32

Length-age composition of icefish (*Champsocephalus gunnari*, perciformes, notothenioidei, Channichthyidae) from different locations in the South Georgia Island subarea. Zh.A. Frolkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 23 pp. *CCAMLR Science*, submitted (English).

Biostatistic data obtained by Soviet research and commercial vessels from 1970 to 1991 have been used to study the length-age composition of *Champsocephalus gunnari* from different locations in the South Georgia Island subarea. An analysis of the spatial distribution of *C. gunnari* length-age groups over the eastern, northern, western and southern island shelf, as well as near Shag Rocks showed the similarity of *C. gunnari* length-age composition during the early years of life for fish inhabiting areas to the south of the island and near Shag Rocks, and also revealed a difference between those two groups and the eastern group. The larger number of 'mature' fish in the west is related to migration from the eastern area of maturing individuals as they

grow. It has been found that a part of the western group of fish (aged 2–3 years) had been migrating towards the Shag Rocks. It was found that in absolute numbers recruits prevail over remaining fish. It is a characteristic feature of the whole population irrespective of the absence or presence of a fishery. This is obviously a natural feature of the population under consideration. *C. gunnari* could rapidly attain its previously high abundance in the subarea thanks to this characteristic, together with the pelagic distribution of the species, earlier age of sexual maturity compared to notothenia, and also favourable oceanographic conditions.

WG-FSA-00/33
Standardised estimates of *D. eleginoides* catches per effort in Subarea 48.3 using information from the 1985/86–1990/91 seasons. P.S. Gasiukov and V. Bibik (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 11 pp. *CCAMLR Science*, submitted (English).

A brief description of haul-by-haul datasets from Ukrainian commercial vessels fishing for toothfish in Subarea 48.3 from 1986 to 1991 is presented. Fishing was mainly carried out in the summer months to the east of South Georgia and at Shag Rocks. The length-frequency modes were 95–100 cm, which exceeded modes for the most recent years of the fishery. The catch-per-effort estimates for 1986–1999 were standardised using the generalised additive model. Fishing efficiency in 1986–1995 was broadly similar, while in 1996–1999 it decreased sharply. It is shown that the significance of factors such as month and depth is low; a modified model that does not consider these factors provides more accurate estimates.

WG-FSA-00/34
Global status of albatrosses and Macronectes and Procellaria petrels. Source: BirdLife International. 2000. *Threatened Birds of the World*. BirdLife International/Lynx-Edicions, Barcelona. 1 p. (English).

WG-FSA-00/35
Fishery dependent research. (Extract from the Report of New Zealand on Member's Activities in the Convention Area in 1999/2000), 3 pp. (English, unpublished).

WG-FSA-00/36
Fish Heaven: a Monte Carlo, spatially explicit, single-species fishery model for the testing of parameter estimation methods. I. Ball and A.J. Constable (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 59 pp. (English).

Fish Heaven is a simple, spatially explicit age-structured fish model, containing the basic features of standard fish modelling with a number of optional extras. It was designed within an object-oriented framework to allow for possible extensions in a number of directions. In particular, it was designed to test the efficacy of different statistical sampling regimes given various plausible spatial structures of fish stocks.

The model assumes a simple age and space structured population governed by the normal life history parameters and subject to both environmental stochasticity (if desired) as well as demographic stochasticity. It is a spatially explicit model in which fish will tend to distribute themselves according to their density and the underlying habitat quality variable. On top of this, fishing occurs. This includes a wide range of fishing options. The software has been constructed to allow for the inclusion of more complex fishing management practices.

The manual for the software, *Fish Heaven Version 1.0.0*, forms the body of the paper. Although Version 1.0.0 of the software is complete, it is still considered to be under development. Currently the software is designed to allow environmental simulations with fishing while taking into account various statistics about the status of the system. Analysis of the output must be done using separate software, such as a statistical package, reading in the output files of Fish Heaven. A number of extensions are planned for the software and these are described in the relevant sections of the manual as 'further improvements'.

The manual and software are both contained in the file *FishHeav.zip*. These are available on a CD produced by the Australian Antarctic Division, additional copies of which are available. The manual contains colour pictures, although black and

white copies of the manual still contain all of the necessary information. The copy of the manual in *FishHeav.zip is* a *pdf* file and includes all the coloured pictures.

The executable file has been compiled for Windows NT but should run on any 32 bit Windows operating system. It requires no additional libraries to run and takes up less than 1.4 M of disk space. When running, the size of the spatial grid is the limiting factor on memory requirements, but is not overly restrictive.

WG-FSA-00/37
A summary of observations on board longline vessels operating within the CCAMLR Convention Area. CCAMLR Secretariat, 8 pp. (English, unpublished).

WG-FSA-00/38
A summary of observations on compliance with Conservation Measures 29/XVI and 63/XV. CCAMLR Secretariat, 11 pp. (English, unpublished).

WG-FSA-00/39
Integration of CPUE data into assessments using the generalised yield model. G. Kirkwood and A.J. Constable (Renewable Resources Assessment Group, T.H. Huxley School of Environment, Earth Sciences and Engineering, Imperial College, RSM Building, Prince Consort Road, London, SW7 2BP, United Kingdom), 10 pp. *CCAMLR Science*, submitted (English).

For the last three years WG-FSA has accorded high priority to the development of a method to integrate different indicators of stock status into assessments using the generalised yield model (GYM). In this paper we propose a method, based on using the sampling/importance-resampling algorithm, for incorporating information on trends in standardised CPUEs into GYM assessments. The use of the method is illustrated using data for *Dissostichus eleginoides* in Subarea 48.3. As the method requires only very small adjustments to the computer program implementing the GYM assessments, we propose that this method be adopted for use during the 2000 meeting of WG-FSA.

WG-FSA-00/40
A survey of fish stocks in the Heard Island and McDonald Islands region in the 1999/2000 season and a comparison of the abundances of selected species with those obtained in previous surveys. R. Williams, A.J. Constable, T. Lamb and E. van Wijk (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 13 pp. (English, unpublished).

A random stratified trawl survey was conducted in May 2000 to assess the abundance of icefish, *Champsocephalus gunnari,* and juvenile pre-recruit toothfish, *Dissostichus eleginoides,* on the Heard Island Plateau and Shell Bank. Abundances and length-density plots of these species and two principal by-catch species, *Lepidonotothen squamifrons* and *Channichthys rhinoceratus,* are given for each stratum. A total of seven surveys have been conducted in the Heard Island and McDonald Islands region since 1990; results from each survey are presented so that interannual comparisons can be made. Abundances of *D. eleginoides, L. squamifrons* and *C. rhinoceratus* in each stratum are relatively steady, varying by a factor of 2–3 between years, however *C. gunnari* abundance can vary by a factor of about 20 between years. This is the result of occasional strong year classes entering the fishery and dominating the population for about two years before disappearing, as has been documented in other locations.

WG-FSA-00/41
A revision of yield and catch controls for managing the mackerel icefish (*Champsocephalus gunnari*) fishery in the vicinity of Heard Island and McDonald Islands. A.J. Constable, R. Williams, T. Lamb and E. van Wijk (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 10 pp. (English, unpublished).

A recent 2000 survey of mackerel icefish (*Champsocephalus gunnari*) in the vicinity of Heard Island enabled a revised estimate of yield for the coming two seasons. While the biomass of *C. gunnari* appears lower

than in previous years, it is dominated by a strong age-2 year class. Estimates of yield for the Heard Island Plateau population using the short-term assessment are 1 150 tonnes for the 2000/ 01 and 1 000 tonnes for the 2001/02 fishing seasons. The results of the 2000 survey confirm the need to retain a closure to fishing on Shell Bank. The paper reviews current catch controls and suggests that some consideration needs to be given to the implementation of closed periods during the year to provide safeguards to predators as well as to ensure that spawning aggregations are not disrupted. Also, some consideration may need to be given at CCAMLR in 2001 to altering the minimum size regulations to account for the possibility of unassessed cohorts entering the fishery prior to assessments occurring.

WG-FSA-00/42
Update to recruitment series for Patagonian toothfish in the Heard Island region. A.J. Constable, R. Williams, T. Lamb and E. van Wijk (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 6 pp. (English, unpublished).

The recent fish survey in the vicinity of Heard Island in 2000 has provided estimates of recruitment for at least one new cohort (1996) and another estimate of the 1995 cohort. The older cohorts are likely to be distributed more widely than the shallow part of the Heard Plateau, consistent with observations from 1999. A reanalysis of all survey data from the region has shown that toothfish smaller than 450 mm are likely to be found predominantly in the shallow part of the Heard Plateau. Surveys aimed at providing a time series of recruitments could focus on this area. However, if estimates of mortality are to be obtained for this species then surveys over the deeper strata of the plateau will be required.

WG-FSA-00/43
An exact-time-of-release-and-recapture stock assessment model applied to Macquarie Island Patagonian toothfish (*Dissostichus eleginoides*). G. Tuck, W. de la Mare, W. Hearn, R. Williams, A.D.M. Smith, X. He and A.J. Constable (CSIRO Division of Marine Research, GPO Box 1538, Hobart 7001, Tasmania, Australia), 38 pp. (English, unpublished).

This paper presents an assessment of the harvested population of Patagonian toothfish (*Dissostichus eleginoides*) at Macquarie Island based on data from a tag-recapture experiment initiated during the 1995/96 fishing season. Population models that include dynamics of tagged and untagged fish, daily releases, catches, recaptures, natural mortality and annual net recruitment are used to assess the population of one of the main fishing regions of Macquarie Island: Aurora Trough. The pre-tagging abundance is estimated by incorporating a Petersen approach in a novel semi-parametric model using maximum likelihood methods. The model (the 'base-case model') assumes the recaptures are Poisson distributed, and the recapture expectations are conditional on catch numbers and previous recaptures. A second model (the 'selectivity model') attempts to account for apparent decreasing fish availability with length. It assumes a maximum age or length above which a fish is no longer available to the gear. Each released fish is assigned a length of time in the available population according to its estimatedrelease age. Once this time has elapsed, the fish is removed from the analysis.

The base-case model estimated that pre-tagging abundance was between 1.0 and 1.5 million fish, depending on assumed mixing levels between tagged and untagged fish. Estimates of net recruitment were occasionally negative, suggesting that emigration may have exceeded immigration. The estimated percentage of the pre-tagging available abundance remaining in Aurora Trough was about 35% in the base-case model. In general, the selectivity model estimated a lower available abundance, and a lower percentage remaining, than the base-case model. The substantial decline in available abundance predicted by both models provides some evidence of large-scale emigration, and could not be due to fishing alone.

WG-FSA-00/44
Stock structure and growth in Patagonian toothfish (*Dissostichus eleginoides*) in the Southern Ocean.

J. Ashford, C. Jones and I. Everson (Center for Quantitative Fisheries Ecology, Old Dominion University, Norfolk, Va. 23529, USA), 26 pp. (English, unpublished).

Most models used in stock assessment treat a stock as a grouping of individuals with the same vital rates and risk of mortality. Detailed knowledge of structure and movement within and between populations is therefore critical in delimiting the domain and understanding the limitations of a model when applied to a particular stock.

Discrepancies in physiological parameters like growth between groups in different locations may be used to infer stock boundaries. In this study, length-at-age data were sampled from the fishable populations of *Dissostichus eleginoides* taken off South Georgia (by longline), Kerguelen (by trawl and longline), Heard Island (by trawl) and the Falkland/Malvinas Islands (by longline). Growth was modelled using the von Bertalanffy function. Normal likelihood methods were used to estimate parameters and examine differences: (i) between populations captured by trawl and longline at Kerguelen; (ii) between sexes for each subarea sampled; and (iii) between locations.

WG-FSA-00/45

The state of the *Champsocephalus gunnari* stock in Subarea 48.3 and methods of its assessment. K. Shust, V.L. Senioukov, P.S. Gasiukov and A. Kozlov (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia), 9 pp. (English, unpublished).

The mackerel icefish *(Champsocephalus gunnari)* fishery in the South Georgia Island subarea (48.3) is usually quite productive, as evidenced by the month and a half when two fishing vessels (Russia and Chile) caught more than 4 000 tonnes. However subsequent bottom trawl surveys by Russia and the UK (December 1999–February 2000) clearly show the need to revise methods used to assess *C. gunnari* (which is a near-bottom and pelagic fish species) biomass based on the results of bottom trawl surveys.

The unreliability of bottom trawl surveys conducted by research and small-tonnage fishery vessels and used for *C. gunnari* stock assessment has been raised repeatedly at the meetings of the Working Group on Fish Stock Assessment (WG-FSA), both during the period of the *C. gunnari* fishery in the 1980s and after it ceased in the 1990s.

In all cases, a comparison of stock assessment results based on bottom trawl surveys (1984–1997) with the total catch, catch per unit effort (CPUE), and calculations using virtual population analysis (VPA) showed a clear underestimation of the stock.

Now, once again having available good fishery and scientific data for comparison, it is possible to define the reasons for underestimating *C. gunnari* biomass based on bottom trawling:

- the vertical opening of bottom trawls used by research vessels is no greater than 15 m, while the vertical extent of even near-bottom *C. gunnari* concentrations reaches 40 to 50 m;
- the use of trawls with a mesh less than 80 mm can result in a high number of small fish being caught;
- the catchability of a 'slower' small-mesh bottom trawl is not 1.0;
- as a rule, surveys conducted over one month do not include a sufficient number of hauls and the results do not reflect the real irregular distribution of *C. gunnari* concentrations;
- high catches in some locations are considered to be statistically insignificant and are not taken into account (Soviet and UK surveys in 1990).

As a result, for more than 10 years bottom surveys have distorted the real status of near-bottom and pelagic Nototheniidae stocks not only in the South Georgia subarea (48.3), but in subareas of the South Orkney (48.2) and South Shetland (48.1) Islands. Based on the unreliable results obtained, either very low catch limits have been set or the fishery has been closed.

Results of a successful fishery and surveys of 1999/2000 dictate the necessity to revise assessment methods based solely on bottom trawling. Complex investigations, including the regulated fishery and trawl-acoustic surveys by midwater trawl, are needed to catch *C. gunnari* concentrations both in pelagic waters and in the near-bottom layer.

WG-FSA-00/46
Results of *D. eleginoides* stock assessment for Subarea 48.3 using a dynamic age-structured production model. P.S. Gasiukov and R. Dorovskikh (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 10 pp. (English, unpublished).

Fishing for *Dissostichus eleginoides* has been carried out in Subarea 48.3 since the early 1980s. Assessment of this commercial species stock is nevertheless an open question, although attempts at solving the problem have been made (Gasiukov et al., 1991). At present, the CCAMLR Working Group on Fish Stock Assessment (WG-FSA) is elaborating recommendations for stock management, based on estimates of the species' long-term potential yield obtained using the GYM (de la Mare and Constable, 1997, 1998; SC-CAMLR, 1998). It is obvious that such an approach does not take into account the current status of the *D. eleginoides* stock, and thus may produce unreliable estimates.

We have conducted a *D. eleginoides* stock assessment based on a dynamic age-structured production model (Geromont, 1997; Geromont and Butterworth, 1998). Examples of the application of this model in practice appear in the literature (Punt, 1994; Punt et al., 1995). The model is an interim solution between production and age-structured models, and may be run successfully using the input data and parameters required for the *D. eleginoides* GYM (WG-FSA-99).

WG-FSA-00/47
Brief information on the results of the bottom trawling survey of the RV *Atlantida* in February 2000 in the South Georgia subarea (48.3). P.P. Chernyshkov, P. Bukatin and V. Khvichya (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 12 pp. (English, unpublished).

WG-FSA-00/48 Rev. 1
IUCN/CITES criteria for critically endangered, endangered and vulnerable species. CCAMLR Secretariat, 1 p. (English, unpublished).

WG-FSA-00/49
Australian research under way on seabirds vulnerable to fisheries interactions. B. Baker and R. Gales (Environment Australia, PO Box 8, Canberra, ACT 2601, Australia), 7 pp. (English, unpublished).

WG-FSA-00/50
Information received from Norway on research related to the development of artificial bait and setting devices for longlines. CCAMLR Secretariat, 3 pp. (English, unpublished).

WG-FSA-00/51
Distribution, biological characteristics and biomass of mackerel icefish based on the results of the trawl survey carried out by the RV *Atlantida* in February 2000. Zh.A. Frolkina and P.S. Gasiukov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 17 pp. (English, unpublished).

The results of the mackerel icefish *(Champsocephalus gunnari)* trawl survey carried out by the Russian RV *Atlantida* in February 2000 in Subarea 48.3 are presented. During that period *C. gunnari* were feeding. In all parts of the subarea (except the northwest) *C. gunnari* of 22–28 cm in length and 2 to 3 years old predominated. Fish biomass distributed near the bottom estimated with different methods amounted to 47 000 to 87 000 tonnes. The estimation also took into account the catchability coefficient. Objective data are submitted to prove that part of the *C. gunnari* stock may stay in the pelagic layer during the feeding period. Therefore, the bottom survey only estimates the population proportion distributed near the bottom at a given time. It is proposed to review the survey method. Conducting regular trawl acoustic surveys in the area may improve the abundance estimates of this important commercial species and will answer some questions which are currently unresolved.

WG-FSA-00/52
A method for estimating recruitment and mortality from time series of length-density data. A.J. Constable and I. Ball (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 6 pp. *CCAMLR Science*, submitted (English).

Estimates of natural mortality are currently unavailable for Patagonian toothfish. Such estimates are needed for estimating recruitments and for use in assessing yield. This paper proposes a method for jointly estimating natural mortality and cohort strength at age 4 using a negative log-likelihood function based on one or more cohorts whose abundance has been estimated in two or more years. A worked example is appended.

WG-FSA-00/53
Population genetics of Patagonian toothfish (*Dissostichus eleginoides*) and fillet identification of Patagonian toothfish and Antarctic toothfish (*D. mawsoni*). P.J. Smith and P. Gaffney (National Institute of Water and Atmospheric Research Ltd, PO Box 14 901, Wellington, New Zealand), 13 pp. (English, unpublished).

Molecular methods have been used to determine the genetic relationships among populations of the Patagonian toothfish (*Dissostichus eleginoides*) in the Southern Ocean. Eight microsatellite loci were tested in samples from the Atlantic, Indian and Pacific Ocean sectors of the Southern Ocean. Some loci were characterised by a large number of alleles, but no alleles were restricted to specific ocean basins. However there was a significant allelic heterogeneity in the total data, indicative of population differentiation, and a high level of genetic subdivision was measured using F_{ST} and R_{ST}. Seven polymorphic allozyme loci revealed no significant heterogeneity among Pacific and Indian Ocean sector samples. The microsatellite DNA heterogeneity suggests that there is restricted gene flow through the Southern Ocean, and that the different fishing grounds may support independent stocks.

Three regions of the mitochondrial (mt) DNA show a distinct genetic break between South American shelf and Southern Ocean populations. The Antarctic convergence appears to act as a barrier to gene flow between the South American shelf and the Scotia Arc. The mtDNA control region further revealed two distinct groups in the Southern Ocean: (i) FAO Areas 81 and 88 (Ross Dependency and Macquarie Island); and (ii) FAO Areas 58 (Heard, McDonald, Kerguelen and Prince Edward Islands) and 41 (South Georgia Island).

Fillets of *D. eleginoides* and Antarctic toothfish (*D. mawsoni*) are readily distinguished by isoelectric focusing of muscle proteins. The protein profiles distinguish toothfish from other fillets marketed under common trade names, such as bass and hake. Three regions of mtDNA also provide diagnostic species markers.

WG-FSA-00/54
New information on size at maturity of *Dissostichus mawsoni* in Subarea 88.1. G. Patchell (Sealord Group Ltd, PO Box 11, Nelson, New Zealand), 7 pp. (English, unpublished), (abstract not available).

WG-FSA-00/55
The Ross Sea Antarctic toothfish (*Dissostichus mawsoni*) fishery from 1997/98 to 1999/2000. S. Hanchet and P. Horn (National Institute of Water and Atmospheric Research Ltd, PO Box 14 901, Wellington, New Zealand), 31 pp. (English, unpublished).

An exploratory fishery for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea has been in operation for three seasons, conducted by independently observed New Zealand commercial fishing vessels. The report presents an analysis of data collected in the toothfish fishery from 1997/98 to 1999/2000.

D. mawsoni were recorded at depths from 300 to 1 500 m, but were most abundant from about 600 to 1 300 m. The main by-catch species were rat tails, which averaged about 10% (range 6–17%) of the annual catch, and skates, which averaged about 8% (range 5–11%) of the annual catch.

Biological data on *D. mawsoni* collected by observers were analysed. Length–weight parameters were similar for males and females, and the combined values were $a = 0.0000047$ and $b = 3.199$. As in previous years, there appeared to be inconsistencies in staging the maturity of fish. Because of this, and the trend for an increase in the proportion with developing ovaries with size of fish, it is recommended that the macroscopic data not be used and the current length at maturity be retained.

Length-frequency data were adjusted proportionally to the catch by vessel, and then combined by year. No progressions of any particularly strong or weak year classes were apparent throughout the series. New growth parameters have been estimated using all available data, but they differ only slightly from those calculated previously. Values for both sexes combined are L_∞ = 180.2 cm, k = 0.095, t_0 = 0.04. However, parameters are also presented for each sex separately, and it is recommended that these values be used in stock assessments. The best estimates of M based on the minimum age of the oldest 1% of fish in the longline catch were 0.18 and 0.19. Because of the uncertainty of these estimates, however, it is recommended that a range of 0.15 to 0.22 be used for M. Fish of both sexes appear to be fully selected in the longline fishery at about age 9, with 50% selectivity at about age 7. However, there is a clear indication that age at full selectivity has been increasing steadily over the three years of fishing, almost certainly owing to changes in fishing practices.

WG-FSA-00/56
Summary of seabird and marine mammal observations during observed toothfish (*Dissostichus* spp.) longline fishing operations in CCAMLR Subarea 88.1, 1998–2000. S. Baird (National Institute of Water and Atmospheric Research Ltd, PO Box 14 901, Wellington, New Zealand), 27 pp. (English, unpublished).

Scientific observers collected data on the abundance of seabird and marine mammal species near the vessels during six toothfish (*Dissostichus* spp.) longline trips in the CCAMLR Subarea 88.1 over the summers of 1998–2000. Most of the fishing effort was carried out north of or close to the continental slope. This area appeared to have the highest diversity of seabird species. Seabirds were not always seen in attendance at the setting operation and more seabirds were present during hauling operations. Seabird numbers increased over the duration of fishing effort in an area. Seabirds appeared to be generally uninterested in the line setting and hauling operations, and were more likely to be well astern of the vessel. There were no observations of seabirds diving on the baited hooks during the set. Lost bait or by-catch fish species, mainly rattails, were taken by some species, but away from the vessel activity. A total of 15 seabird species was counted. The most commonly seen seabirds were Antarctic petrels, Wilson's storm petrels and snow petrels. These seabirds were often observed in association with each other. Some seabird species were limited to preferred habitats such as pack-ice, open water, or the iceberg zone. Four marine mammal species were observed close to the vessel, but there were few observations. No seabirds or marine mammals were observed caught during these operations.

WG-FSA-00/57
Fishes collected during the 1999/2000 exploratory fishery by New Zealand in CCAMLR Subarea 88.1 and registered in the National Fish Collection at the Museum of New Zealand Te Papa Tongarewa. Delegation of New Zealand, 2 pp. (English, unpublished).

WG-FSA-00/58
Factors affecting the sink rate of autoline longline fishing gear. R. Blackwell, B. Bull, S. Hanchet and N.W. Smith. *New Zealand Fisheries Assessment Report 2000/xx,* 14 pp. (English).

In most CCAMLR statistical reporting areas, longline fishing is restricted to night time, to mitigate against accidental seabird by-catch. As there are no periods of darkness in the Ross Sea (CCAMLR Statistical Subarea 88. 1) during the Austral summer when this fishery operates, an alternative protocol has been developed. This requires longline fishing gear to achieve a minimum sink rate of 0.3 m/s, to a minimum depth of 15 m (SR15), as determined by time depth recorders (TDRs). Although this protocol has been followed by vessels fishing during 1998/99 and 1999/2000, these TDRs may malfunction and become lost. Two observers are carried on each vessel, one from New Zealand and the other from another CCAMLR nation. As the sets monitored by the TDRs represent only the sets that were observed by MFish staff, the TDR data cannot be applied to all of the sets for each vessel. This project aimed to determine

whether the sink rate of the gear could be predicted using a combination of weighting schedule, vessel speed and other parameters.

Although the autoline fishing gear is designed to sink without additional weights, the minimum target sink rate can only be achieved by the use of additional weights on the backbone. This report reviews available sink rate data from experimental trials, certification trials and from fisheries observer information collected during the operation of the exploratory fishery using a linear regression approach to examine the influence of gear and environmental parameters.

The ability to achieve the minimum sink rate was related to the weight added to the fishing gear, the setting speed of the vessel and the swell height. More weight or a lower speed was required when the gear was set in a heavy swell. Although some variability remained in the data after the model was fitted, this was associated with differences between fishing vessels and the TDRs used in the analysis. These variables were confounded by the unbalanced nature of the available data, as the vessel that carried out the initial experimental sets did not complete any subsequent exploratory fishing in the Ross Sea. The data were pooled across all vessels, and the relationship between available parameters and sink rate SR15 was explored using a multiple linear regression model, that explained 78% of variability in the data. Within this model, added weight explained 72% of data variability, whilst a further 4% and 2% were explained by swell height and setting speed respectively. Based on this initial model, the range of values were identified where the target sink rate may be achieved with 90% and 95% confidence, and thus potentially avoid the need for the use of TDRs.

WG-FSA-00/59

Examination of the skate by-catch from around South Georgia from one vessel in the 2000 longline toothfish season. M. Endicott, D. Agnew and C.P. Nolan (MRAG Ltd, 47 Prince's Gate, London, SW7 2QA, United Kingdom), 16 pp. (English, unpublished).

Two previously recorded species, *Raja georgiana* and *Bathyraja meridionalis*, were recorded as by-catch on one vessel in the South Georgia toothfish fishery in 2000. One further species could not be identified and was referred to as R. species 1. *R. georgiana* occurred in shallow water, the other two in deep water. The average catch rate was 0.23 rajids/thousand hooks. Distribution and length at maturity are described, as are the results of initial investigations of age determination using both vertebrae and thorns.

WG-FSA-00/60

Interactions between killer whales (*Orcinus orca*) and sperm whales (*Physeter macrocephalus*) with a longline fishing vessel. C.P. Nolan, G.M. Liddle and J. Elliot. *MarineMammal Science*, 16 (3): 658–664, July 2000. (English).

This communication presents observations of possible aggressive interactions between sperm whales and killer whales in association with a fishing vessel longlining for Patagonian toothfish *(Dissostichus eleginoides)* in the Falkland Islands' fisheries conservation zone in 1995. Sperm whales are commonly seen from longliners in the northern and southeastern parts of the Falkland Islands' two-hundred-mile fisheries conservation zone (FIFD internal reports). It is less common, although not unusual, for killer whales also to be reported in association with fishing vessels in the northern area.

There are no confirmed records of sperm whales from the Falkland Islands. Records from the Christian Salvesen Ltd.'s whaling station at New Island (51°42'S, 61°17'W), which operated between 1908 and 1915, do not contain a single entry for sperm whales (Christian Salvesen Ltd., 1982). Past records of killer whales from the Falkland Islands tend to be anecdotal nearshore sightings or occasional reports from fisheries observers and seafarers. Little is known of their offshore habits and behaviour, although anecdotal comment and behaviour reported from the longline fishery for Patagonian toothfish off South Georgia (Ashford, 1993; Ashford et al., 1996) and in other longline fisheries elsewhere (Northridge, 1984, 1991; Yano and Dahlheim, 1995) suggest a complex of interspecific cetacean interactions with fishing vessels.

WG-FSA-00/61
Review and evaluation of three mitigation measures – bird-scaring line, underwater setting and line shooter – to reduce seabird by-catch in the Norwegian longline fishery. S. Løkkeborg (Institute of Marine Research, Fish Capture Division, PO Box 1870, Nordnes, N-5817 Bergen, Norway). ICES CM 2000/J: 10, 11 pp. (English).

Seabirds scavenge baits from the hooks of commercial longlines, resulting in incidental seabird mortality and bait loss. As interactions between seabirds and longline fishing may cause decline in seabird populations and reduced gear efficiency, the potential for solving this problem by means of various mitigation measures has been tested. Four fishing experiments were conducted in commercial longlining in the north Atlantic to investigate the effectiveness of a bird-scaring line, underwater setting and a line shooter in reducing seabird by-catch during longline setting. The results are reviewed and the performance of the mitigation measures is evaluated. Accidental catches of birds were reduced by all three methods, most clearly by the bird-scaring line that had an efficiency of 98–100%. The experiments also produced a reduction in bait loss and raised the catch rates of target species, which are important incentives for fishermen to employ mitigation measures.

WG-FSA-00/62
Feasibility of video monitoring seabird interactions on small domestic tuna longliners. *Conservation Advisory Science Notes*: 303. Department of Conservation, Te Papa Atawhai, New Zealand, 4 pp. (English).

WG-FSA-00/63
Preliminary information on inshore demersal fish from the Danco Coast, Antarctic Peninsula, in the 1999/2000 summer season. R. Casaux, E. Barrera-Oro, A. Baroni and A. Ramón (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 17 pp. (English, unpublished).

A total of 1 103 inshore notothenioid fish were caught by means of trammel nets at four sites surrounding Cierva Point (Moss Island 1; Moss Island 2; Sterneck Island and Leopardo Island), Danco Coast, West Antarctic Peninsula, in the summer season of 2000. The families Nototheniidae, Channichthyidae and Bathydraconidae were represented, with *Notothenia coriiceps* being the dominant species. *Gobionotothen gibberifrons* and *Trematomus newnesi* followed in importance. In general, the ichthyofauna agreed in terms of number and mass, with that of the South Shetland Islands area, except for a markedly higher occurrence of *G. gibberifrons* on the Danco Coast. This supports the hypothesis that the commercial fishery around the South Shetland Islands at the end of the 1970s was responsible for the decrease in the inshore population of *G. gibberifrons* in that area during the last 17 years. Information is provided on the reproduction and diet of the fish species caught. The diet analysis showed general agreement regarding the feeding types and feeding behaviour of these fish species in other areas.

WG-FSA-00/64
Performance assessment and performance improvement of two underwater line setting devices for avoidance of seabird interactions in pelagic longline fisheries. N. Brothers, D. Chaffey and T. Reid (Marine Conservation Unit, Resource Management and Conservation, Department of Primary Industry, Water and Environment, PO Box 44A, Hobart 7000, Tasmania, Australia), 32 pp. Published by the Australian Fisheries Management Authority (AFMA) through the AFMA Research Fund and Environment Australia, (English).

Two underwater setting devices, the chute and the capsule were trialled at sea. These trials were undertaken in waters off Tasmania in the presence of significant numbers of seabirds known to be vulnerable to longline fishing. Both devices adequately demonstrated their capacity to minimise seabird interactions during line setting in pelagic longline fishing. Both showed dramatically lower rates of baits taken in comparison to baited hooks set in the standard, manual way. Most, or all, bait that were taken were the direct result of tangles on board the vessel.

The chute was developed to a stage where it is now ready for more widespread testing in the industry. When in use, over

98% of baits were successfully set, irrespective of bait type, and there were no tangles.

The capsule remains in need of further development. There continues to be problems with tangling, though this was reduced so that almost 99% of hooks are set successfully. This needs further development. Excluding those occasions when tangles occurred, the capsule was capable of setting hooks at sufficient depth to avoid interactions with seabirds.

AUTHOR INDEX