# 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 2002. It corresponds to the Twenty-first 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(iii) scientific papers not intended for publication, which are listed as 'unpublished'; and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-XXI/BG/11 (background document number 11 submitted at the Twenty-first Meeting of the Scientific Committee); or WG-EMM-02/8 (document number 8 submitted at the 2002 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Unpublished papers must not be cited without written permission of the author(s).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-XXI/BG/3**

**Beach debris survey – Main Bay, Bird Island, South Georgia, 2000/01.** J.L. Tanton and M.J. Jessopp (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 17 pp. (English, unpublished).

During the 11th year of standardised beach surveys of man-made debris at Bird Island, South Georgia, a total of 290 items were collected. This represents a 33.3% decrease on the total of 408 items recorded in 1999/2000 and the lowest levels of summer beach debris (147 items) since the 1994/95 season. The difference between the number of items collected in the summer and winter months is the lowest since reporting began, with only four more items collected in the summer than in the winter. Nylon line and associated fishing gear accounted for the majority of marine debris (51% of the total), but to a lesser extent than in previous years, whilst miscellaneous debris accounted for almost as great a proportion of all debris (45%). Marine debris remains a cause for concern, and the survey results for this period indicate that continued monitoring and CCAMLR effort is required to further decrease levels and ensure compliance with the correct waste disposal procedures for both domestic and fishing-related waste.

**SC-CAMLR-XXI/BG/4**

**Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Bird Island, South Georgia, during the 2001 winter and 2001/02 breeding season.** N.L. Warren (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 22 pp. (English, unpublished).

This paper reports the results of the survey of entanglements of Antarctic fur seals at Bird Island, South Georgia, for the 12th consecutive winter (2001) and 14th consecutive summer (2001/02). The overall number of entanglements showed an increase from recent years, with 20 entanglements reported over winter and 48 during the summer breeding period. The number of winter entanglements was the same as last year, however the summer entanglements were up 118%. Severe injuries accounted for 30% of entanglements over winter and 23% during the summer. As in previous years, most individuals observed entangled in debris were juveniles (95% of winter and 52% of summer observations); several pups were recorded entangled during the pup-rearing period, suggesting an increased presence of man-made debris in waters in the immediate vicinity of Bird Island. Of those entanglements where the animal could be sexed, males dominated the observations in winter but females dominated the summer observations; the reasons for this are discussed. Plastic packaging bands and synthetic strings accounted for the majority of entanglements in both winter and summer. Loops of synthetic string, as used in longline fishing, are now the most frequently recorded entangling material, whilst numbers of entanglements involving plastic packaging bands are comparable with those recorded before CCAMLR introduced measures to control their use. This highlights the need for continued monitoring and increased efforts to ensure correct disposal of debris with the potential to entangle wildlife at sea.

**SC-CAMLR-XXI/BG/5**

**Beach debris survey Signy Island, South Orkney Islands, 2001/02.** M. Dunn (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 12 pp. (English, unpublished).

During the 2001/02 austral summer the 12th annual beach debris survey was carried out at Signy Island, South Orkney Islands. Debris was cleared from three study beaches each month between December and March. The debris was counted, measured and classified by type, mass and size. A total of 39 items weighing 25.47 kg was collected. The number of items found was the

largest since 1999/2000 and the total mass of the waste recovered was the highest recorded since 1994/95 (an increase of 59% by number and 97% by mass since 2000/01). There was an increase in the number of plastic packaging bands (8) from the total recorded the previous season (1), a change in what has otherwise been a declining trend since 1993/94. Plastic waste was predominant, as in previous seasons, making up 71% of all items recorded, followed by wood (23%). Classifying the waste by source revealed that almost all had originated from ships or fishing vessels, with only one item having come from the Signy Research Station. However, with the exception of 1998/99, this has been the first season that the quantity of waste recorded at Signy Island has shown a reverse in what has otherwise been a declining trend since 1993/94. This increase clearly shows that 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 are aware of, and comply with, regulations prohibiting the disposal of debris at sea.

**SC-CAMLR-XXI/BG/6**

**Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Signy Island, South Orkney Islands, 2001/02.** M. Dunn (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 9 pp. (English, unpublished).

The results of the sixth annual survey of entanglement of Antarctic fur seals at Signy Island, South Orkney Islands, are reported for the 2001/02 summer season. There was a single sighting of a seal wearing a neck collar of man-made debris. Data are compared with results from a parallel study undertaken at Bird Island, South Georgia, in 2001/02. In contrast to Signy Island, these indicated that the number of entangled fur seals had increased by 118% compared to the previous year, this being the highest number recorded at Bird Island since 1992/93. The presence of the entangled seal at Signy Island, together with the considerable number of seals with neck collars at Bird Island, highlights the need for CCAMLR Members to continue their campaign to ensure that vessels are aware of, and comply with, regulations prohibiting the disposal of man-made debris at sea.

**SC-CAMLR-XXI/BG/7**

**Fishing gear, marine debris and oil associated with seabirds at Bird Island, South Georgia, 2001/02.** B. Phalan (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 21 pp. (English, unpublished).

This report describes and quantifies occurrences of fishing gear, marine debris and oil associated with seabirds at Bird Island, South Georgia, from 1 April 2001 to 31 March 2002. It is the ninth such annual report. Fewer hooks and other longline fishery discards were recorded in association with wandering albatrosses compared to last year, but the number of items (63) remains well above the mean since annual recording began. The number of items of fishing gear associated with grey-headed (12) and black-browed albatrosses (9) was the highest on record for both species, though small by comparison with wandering albatrosses. Northern and southern giant petrels were observed with ingested fishing line protruding from the bill. Fishing gear associated with white-chinned petrels (longline hooks) and snowy sheathbills (synthetic rope) was recorded for the first time in the study. More marine debris was found in association with wandering albatrosses (largely food wrappers and plastic bags) and grey-headed albatrosses (mostly small plastic fragments) than in any previous year. Small quantities of marine debris ingested by black-browed albatrosses, giant petrels, brown skuas and Antarctic prions were also recorded. One black-browed albatross was observed to have some oil on its plumage. The evidence of many seabird interactions with longline fishing is of particular concern, and suggests that

discarding of offal, complete with hooks and line, is still occurring on a large scale.

**SC-CAMLR-XXI/BG/13**
**Marine debris and its impact on marine living resources (status of data submitted).** CCAMLR Secretariat, 5 pp. (English, unpublished).

**SC-CAMLR-XXI/BG/21**
**IMAF assessment of new and exploratory fisheries by statistical area.** Ad Hoc Working Group on Incidental Mortality Arising from Fishing (WG-IMAF), 27 pp. (English, unpublished).

**SC-CAMLR-XXI/BG/22**
**Summary of population data, conservation status and foraging range of seabird species at risk from longline fisheries in the Convention Area.** Ad Hoc Working Group on Incidental Mortality Arising from Fishing (WG-IMAF), 9 pp. (English, unpublished).

**SC-CAMLR-XXI/BG/23**
**Incidental mortality of seabirds during unregulated longline fishing in the Convention Area.** Ad Hoc Working Group on Incidental Mortality Arising from Fishing (WG-IMAF), 10 pp. (English, unpublished).

**SC-CAMLR-XXI/BG/28**
**WG-FSA standard assessment methods.** Working Group on Fish Stock Assessment, 23 pp. (English, unpublished).

**SC-CAMLR-XXI/BG/29**
**Fish species profiles – mackerel icefish.** Convener of WG-FSA, 77 pp. (English, unpublished).

**SC-CAMLR-XXI/BG/30**
**Fish species profiles – toothfish.** Convener of WG-FSA, 115 pp. (English, unpublished).

**SC-CAMLR-XXI/BG/35**
**Beach survey of marine debris near the Artigas Antarctic Scientific Station on King George Island during 2001/02.** Delegation of Uruguay, 11 pp. (Spanish, unpublished).

Uruguay has developed a program of marine debris surveys which are conducted on the coastal areas near its facilities in the Antarctic Treaty Area, in Statistical Subarea 48.1 of the Convention Area, i.e. on the coastal strip accessible from the BCAA (Artigas Antarctic Scientific Station) on King George Island. The survey of selected beaches was carried out in accordance with the standard method established by the Commission.

The aim of the program is to cooperate with the Commission in analysing the effectiveness of conservation measures by monitoring indices which might affect Antarctic marine living resources, and therefore provide guidelines with respect to the harvesting and rational use of such resources so as to comply with the provisions of the Convention and the measures agreed upon accordingly.

## Working Group on Ecosystem Monitoring and Management

**WG-EMM-02/4**
**Does fish prey size affect the foraging patterns and breeding output of the Antarctic shag *Phalacrocorax bransfieldensis*?** R. Casaux and A. Baroni (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina, pipocasaux@infovia.com.ar), 14 pp. (English, unpublished).

Concurrent information on diet composition, foraging patterns and breeding output of the Antarctic shag (*Phalacrocorax bransfieldensis*) was obtained at three colonies on the Danco Coast (Py Point, Midas Island and Primavera Island), Antarctic Peninsula, during the 1997/98 breeding season. Overall, demersal-benthic fish were the most frequent and important prey at all the colonies sampled, followed by octopods and gastropods. Between colonies there were marked differences in the size of the fish consumed, the smaller specimens being eaten by shags from Py Point. These differences were mainly influenced by the number of specimens of the smallest fish species, *Harpagifer*

*antarcticus*, consumed at that colony. Differences in the composition of diet might be related to the different foraging areas used by the shags. Compared to Midas Island and Primavera Island, the shags from Py Point took longer foraging trips and spent significantly more time in foraging activities. Although at the beginning of the study the number of chicks per nest was similar in the three colonies, the breeding output at Py Point was markedly lower. The most likely explanation for the higher foraging effort and the lower breeding output of shags at Py Point might be the difference in fish prey consumption between these and shags from Midas Island and Primavera Island. Current results suggest that the decline in the inshore populations of *Gobionotothen gibberifrons* and *Notothenia rossii* observed in the last 18 years around the South Shetland Islands may be one of the reasons for the steady decrease in the number of breeding Antarctic shags observed over the last 12 years at colonies monitored in that archipelago.

**WG-EMM-02/5**

**CEMP indices 2002: analysis of anomalies and trends.** CCAMLR Secretariat, 53 pp. (English, unpublished).

The CCAMLR Ecosystem Monitoring Program (CEMP) uses indices derived from data on indicator species and the environment collected by 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 these data are presented.

**WG-EMM-02/6**

**Krill fishery information.** CCAMLR Secretariat, 47 pp. (English, unpublished).

The paper presents a compilation of information and work pertaining to the krill fisheries in CCAMLR waters, including:

- a report on catches for the last complete season (2000/01: December 2000 to November 2001) and an update on catches in the current 2001/02 season;
- measures of overlap between the krill fishery and krill predators;
- further development of the plan for the krill fishery in Area 48;
- evaluation of available methods for forecasting closure dates; and
- further development of the questionnaire on fishing strategies.

**WG-EMM-02/7**

**A review and preliminary analysis of CEMP data.** CCAMLR Secretariat, 13 pp. (English, unpublished).

A review of data in the CEMP database revealed minor inconsistencies that have now been amended. These inconsistencies had no effect on the CEMP indices, but need to be corrected. Other problems were detected, such as the use of old forms and standard methods, and difficulties with the increasing amount of automated data being collected and submitted. Members should ensure that they use the most current standard methods and CEMP forms found on the website (www.ccamlr.org). A review of the standard methods would ensure that everybody is satisfied with the existing methods, and new guidelines regarding automated collection could be formulated. A preliminary analysis of breeding population size and breeding chronology of the Adélie penguin (*Pygoscelis adeliae*) revealed a continual decline of the breeding population at Anvers Island. As the breeding success at this site has not declined, local redistribution could be the cause. An examination of migration patterns in the Peninsula region would show the validity of this theory. Water currents around the continent may have an important effect on the timing of critical dates in the breeding biology, however this needs to be examined more closely. Further analyses could be performed with the CEMP data, since the flying seabird and seal data have not yet been examined.

**EMM-02/8**

**Database of CCAMLR working documents.** CCAMLR Secretariat, 6 pp. (English, unpublished).

**WG-EMM-02/9**

**The diet of the Antarctic fur seal (*Arctocephalus gazella*) on the Danco Coast,**

**Antarctic Peninsula.** R. Casaux, A. Baroni and A. Ramón (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina, pipocasaux@infovia.com.ar), 15 pp. (English, unpublished).

The diet of non-breeding male Antarctic fur seals (*Arctocephalus gazella*) on the Danco Coast, Antarctic Peninsula, was investigated by analysing 31 and 149 scats collected from January to March 1998 and 2000 respectively. Overall, fish and krill, followed by penguins and squids, were the most frequent prey and constituted the bulk of the diet. The importance of the remaining taxa represented in the samples (octopods, gastropods, bivalves, isopods, polychaetes and porifera) was negligible. Of the fish species present, channichthyids constituted the bulk of the diet, with *Chionodraco rastrospinosus* and *Chaenodraco wilsoni*, followed by the nototheniid *Pleuragramma antarcticum*, being the main prey. The myctophid *Electrona antarctica* was the most frequent and numerous fish prey. The results are discussed and compared with those reported for the South Shetland Islands, the closest area on which similar information is available.

**WG-EMM-02/10**

**Geographical variation in the diet of the Antarctic fur seal (*Arctocephalus gazella*).** R. Casaux, A. Baroni, F. Arrighetti, A. Ramón and A. Carlini (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina, pipocasaux@infovia.com.ar), 15 pp. (English, unpublished).

The diet of non-breeding male Antarctic fur seals (*Arctocephalus gazella*) was investigated at different sites on the Antarctic Peninsula (Cierva Point and Hope Bay), South Shetland (Deception Island and Potter Peninsula) and South Orkney (Laurie Island) Islands, by analysing 438 scats collected from January to March 2000. The composition of the diet was diverse and both pelagic and benthic–demersal prey species were represented in the samples. Antarctic krill (*Euphausia superba*) was the most frequent (except at Cierva Point) and numerous prey species at all the study sites, being followed by fish, penguins and cephalopods. Antarctic krill also predominated by mass, followed by fish and penguins. Fish were the second most important prey by mass at the Antarctic Peninsula, whereas penguins occupied this position in the South Shetland and South Orkney Islands. Of the fish species, *Pleuragramma antarcticum* contributed most to the diet of Antarctic fur seals at the Antarctic Peninsula, whereas *Gymnoscopelus nicholsi* did so in the South Shetland and South Orkney Islands. The results are compared with previous studies, and the possibility of implementing monitoring studies on the distribution/abundance of myctophids and *P. antarcticum*, based on the analysis of the diet of Antarctic fur seals, is considered.

**WG-EMM-02/11**

**Diet of the Antarctic fur seal (*Arctocephalus gazella*) at Harmony Point, South Shetland Islands: evidence of opportunistic foraging on penguins?** R. Casaux, L. Bellizia and A. Baroni (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina, pipocasaux@infovia.com.ar), 18 pp. (English, unpublished).

The diet of non-breeding male Antarctic fur seals (*Arctocephalus gazella*) was investigated at Harmony Point, Nelson Island, South Shetland Islands, by analysing 523 scats collected from January to March 2001 and 2002. Diet composition was diverse, and both pelagic and benthic–demersal prey species were represented in the samples. Overall, Antarctic krill (*Euphausia superba*) and fish were the most frequent and numerous prey, followed by penguins (presumably *Pygoscelis antarctica*), cephalopods (mainly squid) and gastropods. Of the fish species, myctophids represented 86.5% and 65.8% of the fish mass in both seasons, with *Gymnoscopelus nicholsi* being the main prey. Interestingly, penguins were represented in 39.0% and 31.9% of the samples in 2001 and 2002 respectively and, as reflected by the reconstructed diet, were the main prey by mass (74.0% and 76.1%). The occurrence of penguins in the diet of *A. gazella*

at Harmony Point is discussed and analysed in relation to the foraging strategy used by seals and to the temporal availability of prey species.

**WG-EMM-02/12**
**History of development and completion of tasks put forward by WG-EMM (1995–2001).** Secretariat, 13 pp. (English, unpublished).

**WG-EMM-02/13**
**Incidence of Antarctic krill (*Euphausia superba*) mass infection near the coasts of South Georgia Island (Subarea 48.3).** M.S. Savich (Laboratory of Southern Ocean Bioresource, YugNIRO, 2 Sverdlov Street, Kerch 98300, Crimea, Ukraine, lkp@kerch.crimea.com), 4 pp. (English, unpublished).

On 30 July 2001, in the northeastern part of the South Georgia Island shelf (Subarea 48.3), young and mature Antarctic krill (*Euphausia superba*) individuals affected by a disease which has not been previously described were found for the first time. During winter and spring, male and female *E. superba* of all size groups (from 27 to 52 cm) were affected. From winter to spring the percentage of krill infected increased 2.3 times. Affected individuals occurred over the whole of the shelf area and on the continental slope of the northern part of South Georgia Island, where well defined currents provided for isolation of krill aggregations.

**WG-EMM-02/14**
**Spatial distribution of predator–prey interactions in the Scotia Sea: implications for measuring predator–fisheries overlap.** K. Reid, M. Sims, R.W. White and K.W. Gillon (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, k.reid@bas.ac.uk), 37 pp. *Deep-Sea Research* (CCAMLR-2000 Survey Special Issue), submitted (English).

The measurement of spatial overlap between predators and fisheries exploiting a common prey source is dependent on the measurement scale used and the use of inappropriate scales may provide misleading results. Previous assessments of the level of overlap between predators and fisheries for Antarctic krill (*Euphausia superba*) in the South Shetland Islands have used different measurement scales and arrives at contradictory conclusions. At-sea data from observations of krill predators during the CCAMLR-2000 krill survey were used to identify the areas of potential overlap with fisheries in the Scotia Sea and to determine the scale at which such overlap should be measured. The relationship between auto-correlation and sampling distance was used to identify the characteristic scales of the distribution of predators, krill and krill fisheries and an effort-corrected index of relative abundance as a function of distance from land was used to identify the characteristics of areas of high potential for overlap. Despite distinct differences in foraging ecology a group of krill-dependent species including chinstrap penguin *Pygoscelis antarctica*, (Antarctic) fur seal *Arctocephalus* sp. (*gazella*) and white-chinned petrel *Procellaria aequinoctialis* showed similar patterns of distribution; the relative abundances were highest at 60–120 and decreased sharply at distances greater than 150 km from land. There were more inter-specific differences in the characteristic scales which were of the order of 50–100 km. Antarctic krill had a characteristic scale of c. 200 km and the relationship with distance from land showed a log-linear decline. Krill fisheries operated at a scale of 150 km and almost all of this operation took place within 100 km of land. The requirement of land for breeding and the biological and oceanographic conditions that produce high concentrations of krill associated with those islands produce a system in which the demand for Antarctic krill from fisheries and predators is essentially co-extensive. The areas of greatest potential overlap are within 150–200 km of land and the extent of any such overlap in these areas should be assessed at scales of 70–100 km to accommodate the scales of operation of the predators involved.

**WG-EMM-02/15**

**Conflict or co-existence? Foraging distribution and competition for prey between Adélie and chinstrap penguins.** A.S. Lynnes, K. Reid, J.P. Croxall and P.N. Trathan (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, k.reid@bas.ac.uk). *Marine Biology*, in press (English).

Adélie (*Pygoscelis adeliae*) and chinstrap penguins (*P. antarctica*) are morphologically and ecologically very similar, have very similar diet and breed sympatrically in the Scotia Arc from the South Sandwich Islands to the Antarctic Peninsula. To investigate how these two species co-exist, their foraging distribution and diet were studied during the chick-rearing period at Signy Island, South Orkney Islands, during the breeding seasons of 2000 and 2001. Satellite-tracking data from 19 Adélie penguins and 24 chinstrap penguins were used to compare foraging distributions. In both years the diet of both species was exclusively Antarctic krill (*Euphausia superba*) of the same size range. In a year of low prey availability (2000), there was a statistically significant segregation of foraging areas between the two species, however, in a year of normal resource availability (2001) there was no such segregation. There was a significant difference in the foraging areas used by Adélie penguins between years but not for chinstrap penguins. Adélie penguins foraged significantly farther (mean 100 km) from the colony than chinstrap penguins (mean 58 km) in 2000 but not in 2001 (mean 58 km and 35 km respectively). In 2000, the breeding success of Adélie penguins was 51% lower than the long-term mean compared to 15% lower in chinstrap penguins. Both species achieved above-average breeding success in 2001. The changes in foraging distribution and breeding success suggest that in years of low resource availability, chinstrap penguins may be able to competitively exclude Adélie penguins from potential inshore foraging areas. Current trends in climatic change and possible effects on ice distribution and krill abundance suggest that conditions could become less favourable for Adélie penguins than chinstrap penguins in areas where both species occur.

**WG-EMM-02/16**

**Krill population dynamics in the Scotia Sea: variability in growth and mortality within a single population.** K. Reid, E.J. Murphy, V. Loeb and R.P. Hewitt. *Journal of Marine Systems*, 36: 1–10 (2002). (English).

Understanding the demographics of Antarctic krill over large scales may be complicated by regional differences in the processes that govern population structure. The influence of regional differences in growth and mortality on population size structure was examined using data on the length–frequency distribution of krill in the Scotia Sea using samples from the South Shetland Islands and South Georgia collected annually from 1991 to 2000. A correction function, which took account of the higher growth rate at South Georgia, produced a consistent similarity in the position of the modal size classes that was not present in the raw data. Optimising the mortality rate, to minimise the differences in the growth corrected length–frequency distribution, suggested a higher mortality rate at South Georgia that the South Shetlands. The intra-specific variations in growth and mortality rates are consistent with published values and with other Euphausiids species. Having accounted for the demographic plasticity, it is apparent that strong recruitment of the smallest size class of krill is represented in both populations simultaneously. It appears that first-year krill are advected into different regions of the Scotia Sea where the resultant population size structure is determined by regional differences in growth and mortality. The majority of the commercial harvest of krill in the Antarctic occurs in a relatively small number of regional fisheries within the Scotia Sea and is managed using population models based on a single set of demographic parameters. Where substantial differences in these

parameters exist between fishing areas, the calculation of catch limits should take these differences into account.

**WG-EMM-02/17**

**Current temperature conditions off South Georgia during recent years (satellite data on Subarea 48.3).** G.P. Vanyushin (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia, sst.ocean@g23.relcom.ru), 9 pp. (English, unpublished).

Satellite monitoring of sea-surface temperatures (SST) off South Georgia (Subarea 48.3), including analysis of real-time data from vessels and buoy stations, provides continuous information on the temperature conditions of the area. Weekly SST maps constructed from GOES-E and Meteosat-7 daily satellite data are used to develop maps of mean monthly SST and SST anomalies. For quantitative monthly analysis of variations in temperature distribution and SST anomalies in South Georgia waters from December 1989 to March 1991 and November 1999 to April 2002, we have selected Cells 1 and 2 (2° x 2° resolution, centred at 54°S 41°W and 53°S 37°W respectively). Temperature values of monthly trends of mean SST and SST anomalies in Cells 1 and 2 are calculated with an accuracy of 0.01°C.

**WG-EMM-02/18**

**The US commercial krill fishery in Area 48: development, fishing patterns and decision making.** C.D. Jones and M. Hull (National Marine Fisheries Service, Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA, cdjones@ucsd.edu) 16 pp. *CCAMLR Science*, submitted (English).

A US-flagged commercial factory trawler, the *Top Ocean*, began fishing operations for krill (*Euphausia superba*) in Area 48 in July 2000. This fishery has continued and expanded each year since the initial fishing trials. This paper presents information on the development, yields and decision-making processes involved in harvesting krill by the US fishery. Because the captain of the *Top Ocean* had no prior experience fishing for krill, anecdotal and historical information served as the initial basis for decision making. Initial fishing trials in 2000 were conducted in Bransfield Strait and north of South Georgia; in 2001, all fishing was conducted off the South Shetland Islands and Bransfield Strait. In 2002, fishing operations were carried out off the Antarctic Peninsula, west of Elephant Island; and northwest of the South Orkney Islands. Information on set locations, effort, yield, catch rates and the decision-making processes involved in prosecuting the US commercial fishery for krill are summarised for each month and region fished. The decision-making processes involved during fishing operations were based on several factors, including krill abundance, weather, ice conditions, condition of krill in relation to the target product and ad hoc information from nearby fishing fleets. High concentrations of krill were found in Bransfield Strait in 2001 while fishing inside the ice edge. The success of the fishery has increased each year due to factors related to the experience of the *Top Ocean*. Increasing catch rates with time are likely to be related to the experience of the captain, as opposed to indices of krill abundance.

**WG-EMM-02/19**

**Combined standardised indices of predator performance at Bird Island, South Georgia, 1973–2002.** K. Reid (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 12 pp. (English, unpublished).

Long-term data on the reproductive performance of krill predators at Bird Island, South Georgia, where used to produce Combined Standardised Indices (CSI) that reflect processes operating over different time-scales. The output from all three CSIs indicated that in 2002 there were no indications of predators being unable to find sufficient food to provision themselves or their offspring.

**WG-EMM-02/20**

**Are krill recruitment indices from mesoscale surveys representative for larger areas?** V. Siegel, R.M. Ross and L.B. Quetin (Sea Fisheries Research Institute,

Palmaille 9, D-22767 Hamburg, Germany, siegel.ish@bfafisch.de), 13 pp. (English, unpublished).

The present contribution uses data from German surveys in the 1980s and the US LTER program which has continuously collected krill demography data since 1993 during the austral summer season in the upstream area of the Elephant Island mesoscale survey. The intention was to compare the recruitment indices derived from these two mesoscale surveys and analyse whether results from mesoscale surveys are representative for a wider region. Generally the proportional recruitment indices for one- (R1) and two-year-old (R2) krill differ substantially between years. However, results were in conformity with the results from other scientific surveys. Recruitment indices showed a significant correlation for age-one krill between scientific surveys from the northern Bellingshausen Sea, the Elephant Island area and South Georgia. The correlation becomes weaker for R2 recruitment indices. No correlation was detectable between the krill recruitment of Atlantic and Indian Ocean survey sites. Problems of single-year outliers from Elephant Island are discussed as well as the problem of 'undersized' length classes of the age-one group which occur in the samples of some years.

**WG-EMM-02/21**

**Seasonal and interannual variation in foraging range and habitat of macaroni penguins *Eudyptes chrysolophus* at South Georgia.** K.E. Barlow and J.P. Croxall. *Marine Ecology Progress Series*, 232: 291–304 (2002). (English).

In marine ecosystems, characterisation of the foraging areas and habitats of predators is a key factor in interpreting their ecological role. We studied the foraging areas of the macaroni penguin *Eudyptes chrysolophus* at Bird Island, South Georgia, throughout the breeding seasons of 1999–2001 using satellite tracking. We investigated differences in foraging ranges and characteristics between different stages of the breeding season, between sexes, between years and between individuals. During incubation, on foraging trips of 10–26 d, both sexes travelled long distances from Bird Island (male average = 572 km; female average = 376 km) in a northwesterly direction towards the Maurice Ewing bank; some individuals, particularly males, travelled to forage in the Polar Frontal Zone. In contrast, during the chick-rearing period, both sexes mainly foraged relatively close (average 62 km) to South Georgia over the continental shelf. Foraging trip characteristics differed between males and females during chick rearing: females travelled further on average and on more direct trips. During chick rearing, males and females on longer foraging trips covered greater distances and travelled further from Bird Island. There were no interannual differences in characteristics of foraging trips although sex differences in some parameters varied between years. The bearings of chick-rearing foraging trips were non-random and most were in a northwesterly direction. Variation, both intra- and inter-individual, in bearings of foraging trips was high. Travel speeds were slower during foraging trips in the chick-rearing period than during incubation, probably relating to the differences in distances travelled. The stage of the breeding season, associated constraints on the penguins at different stages, and sex were important in determining variation in foraging range and characteristics in macaroni penguins, but year and individual effects were relatively unimportant.

**WG-EMM-02/22**

**Are penguins and seals in competition for Antarctic krill at South Georgia?** K.E. Barlow, I.L. Boyd, J.P. Croxall, K. Reid, U.J. Staniland and A.S. Brierley. *Marine Biology*, 140: 205–213 (2002). (English).

The Antarctic fur seal (*Arctocephalus gazella*) and macaroni penguin (*Eudyptes chrysolophus*) are sympatric top predators that occur in the Southern Ocean around South Georgia where they are, respectively, the main mammal and bird consumers of Antarctic krill (*Euphausia superba*). In recent years the population of fur seals has increased whereas that of macaroni penguins has declined. Both species feed

on krill of similar size ranges, dive to similar depths and are restricted in their foraging range at least while provisioning their offspring. In this study we test the hypothesis that the increased fur seal population at South Georgia may have resulted in greater competition for the prey of macaroni penguins leading to the decline in their population. We used: (1) satellite-tracking data to investigate the spatial separation of the Bird Island populations of these two species whilst at sea during the breeding seasons of 1999 and 2000 and (2) diet data to assess potential changes in their trophic niches between 1989 and 2000. Foraging ranges of the two species showed considerable overlap in both years but the concentrations of foraging activity were significantly segregated spatially. The size of krill taken by both species was very similar, but over the last 12 years the prevalence of krill in their diets has diverged with nowadays less krill in the diet of macaroni penguins than in that of Antarctic fur seals. Despite a significant degree of segregation in spatial resource use by the study populations, it is likely that the South Georgia populations of Antarctic fur seal and macaroni penguin exploit the same krill population during their breeding season. For explaining the opposing population trends of the two species, the relative contributions of independent differential response to interannual variation in krill availability and of interspecies competition cannot be resolved with available evidence. The likely competitive advantage of Antarctic fur seals will be enhanced as their population continues to increase, particularly in years of krill scarcity.

**WG-EMM-02/23**

**Estimating food consumption of marine predators: Antarctic fur seals and macaroni penguins.** I.L. Boyd. *Journal of Applied Ecology*, 39: 103–119 (2002). (English).

1. Estimating food consumption is central to defining the ecological role of marine predators. This study developed an algorithm for synthesising information about physiology, metabolism, growth, diet, life history and the activity budgets of marine predators to estimate population energy requirements and food consumption.

2. Two species of marine predators (Antarctic fur seal *Arctocephalus gazella* and macaroni penguin *Eudyptes chrysolophus*) that feed on krill in the Southern Ocean were used as examples to test the algorithm. A sensitivity analysis showed that estimates of prey consumed were most sensitive to uncertainty in some demographic variables, particularly the annual survival rate and total offspring production. Uncertainty in the measurement of metabolic rate led to a positive bias in the mean amount of food consumed. Uncertainty in most other variables had little influence on the estimated food consumed.

3. Assuming a diet mainly of krill *Euphausia superba*, annual food consumption by Antarctic fur seals and macaroni penguins at the island of South Georgia was 3.84 [coefficient of variation (CV) = 0.11] and 8.08 (CV = 0.23) million tonnes, respectively. This was equivalent to a total annual carbon consumption of 0.35 (CV = 0.11) and 0.72 (CV = 0.23) G tonnes $year^{-1}$. Carbon expired as $CO^2$ was 0.26 (CV = 0.06) and 0.65 (CV = 0.19) G tonnes $year^{-1}$ for fur seals and macaroni penguins, respectively. The *per capita* food consumption varied depending upon sex and age but, overall, this was 1.7 (CV = 0.22) tonnes $year^{-1}$ for Antarctic fur seals and 0.45 (CV = 0.22) tonnes $year^{-1}$ for macaroni penguins.

4. The algorithm showed that the seasonal demand for food peaked in both species in the second half of the breeding season and, for macaroni penguins, there was a second peak immediately after moult. Minimum food demand occurred in both species during the first half of the breeding season.

5. As both Antarctic fur seals and macaroni penguins compete for krill with a commercial fishery, these results provide an insight into the seasons and stages of the life cycle in which competition is likely to be greatest.

**WG-EMM-02/24**

**World Fisheries Congress.** J.P. Croxall (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, j.croxall@bas.ac.uk), 5 pp. (English, unpublished).

**WG-EMM-02/25**

**Detecting trends in the krill fishery.** S. Nicol and J. Foster (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 16 pp. (English, unpublished).

The development of the krill fishery can be monitored and predicted using a number of different sources of information. Information on current catches and scientific information on the krill stocks is of limited value in plotting trends in the fishery at its current level. Predictions by Members of their future plans are also of limited use because they ultimately depend on the underlying economics of the fishery. We have analysed predictions made by Members of their future activities and have found that they are generally less accurate than will be necessary to detect trends in the future. Economic information on the krill fishery has been difficult to access in the past but will be necessary to provide reliable predictions of future harvesting trends. Sources of such information are now available but the interpretation of economic and marketing information requires specialised skills which are not generally available in the Scientific Committee. Technological information may provide early warnings of developments that could later herald an expansion in krill fishing. Information on new products from the krill fishery, and new krill processing technology is widely available once patents have been lodged. We have examined patent databases to find information on products and processes involving krill and have found 376 recorded patents. These patents reveal some trends in the development of products using krill. Complete interpretation of technological and market data requires specialist skills which would have to be harnessed if full use is to be made of these sources of information. An expansion in krill fishing to relatively high levels may occur over a short (<5 year) time-scale and could result in an unacceptable concentration of fishing effort in small areas. This highlights the need for the development of smaller management units for the krill fishery, for the development of procedures to access information on economics and technological developments, and for better information on the potential rate of increase in krill catches.

**WG-EMM-02/26**

**Conserving seabirds competing with fisheries for food – observations from southern Africa and Marion Island.** R.J.M. Crawford, C.M. Duncombe Rae and D.C. Nel (Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Roggebaai 8012, South Africa), 11 pp. (English, unpublished).

The paper describes moves towards accounting for the food requirements of some of southern Africa's seabirds in management of pelagic fish stocks. It also considers moves towards establishing target populations for seabirds in South Africa, especially those of conservation concern. It describes anomalous breeding by several seabird species at Marion Island in 1997. This is assumed to have resulted from an environmental anomaly that may have been related to the strong ENSO of 1997/98.

**WG-EMM-02/27**

**Soviet krill fishery in the Atlantic sector of Antarctic from 1977 to 1992, part II. CPUE changes and fleet displacement.** F.F. Litvinov, P.S. Gasiukov, A.Z. Sundakov and O.A Berezhinsky (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 20 pp. (English, unpublished).

CPUE values of the Soviet krill fishery from 1977 to 1992 in Subareas 48.1, 48.2 and 48.3 are standardised by vessel type, regional fishery association, month, year and subarea. The causes which determine CPUE variability are revealed.

**WG-EMM-02/28 Rev. 1**
**Fishing patterns of Japanese krill trawlers.** S. Kawaguchi, T. Kameda and Y. Takeuchi (National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan), 98 pp. (English, unpublished).

**WG-EMM-02/29**
**The krill fishery observer manual – points to be revised.** S. Kawaguchi (National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan), 4 pp. (English, unpublished).

**WG-EMM-02/30**
**Results of an acoustic investigation of Antarctic krill (*Euphausia superba*) biomass density in the Elephant Island area in January–February 2001.** M.A. Thomasson, J.H. Emery, J. Rademan, R.P. Hewitt and B.I. Bergström (Kristineberg Marine Research Station, Kristineberg 2130, S-450 34 Fiskebäckskil, Sweden), 15 pp. (English, unpublished).

Results from an acoustic krill survey in the Elephant Island Area carried out from 27 January to 4 February 2001 are presented. Data were collected with a Simrad EK60 scientific echosounder installed on the RV *Polarstern*. The collected acoustic data were post-stratified in three strata based on demographic results obtained by net sampling. Data files from the 38 kHz and 120 kHz recordings were prepared and processed according to protocols used for the CCAMLR 2000 Krill Synoptic Survey of Area 48.

An average biomass density of 15.32 g/m$^2$ and a standing stock ($B_0$) of 1.7 million tonnes were estimated for the entire area. The highest density was found in the southernmost stratum and lowest density in the northernmost stratum.

The estimated average agrees well with estimates made by the US AMLR Program from two surveys (15.6 g/m$^2$ and 12.8 g/m$^2$ respectively) performed during the same field season in partly the same area, and with the estimate based on RMT-8 net sampling, carried out during the *Polarstern* expedition (13.04 g/m$^2$). The biomass density presented here is also higher than the long-term running mean from net samples for the Elephant Island area (13.9 g/m$^2$, 1977–2001).

**WG-EMM-02/31**
**Design of the Italian acoustic survey in the Ross Sea for the austral summer 2003/04.** M. Azzali, A. Sala and S. Manoukian (National Research Council, Institute for Marine Fisheries Research, Largo Fiera della Pesca, 1, 60125 Ancona, Italy), 12 pp. (English, unpublished).

In accordance with SC-CAMLR-XIX, Annex 4, paragraph 2.78, this paper presents the next Italian survey that will be carried out in the Ross Sea during the austral summer 2003/04.

The research consists of three core activities: (i) acoustic sampling of krill (*Euphausia superba* and *E. crystallorophias*) populations and concurrent censuses of their top predators for estimating krill distribution and abundance, and the effects of predators on altering them; (ii) net sampling for describing krill demography, energetic/physiology and genetics; (iii) CTD and XBT sampling for identifying the characteristics of the water masses which influence krill ecological behaviour. All these activities will be undertaken synoptically along a cruise track (about 2 500 n miles) that gives a uniform density of acoustic, net and CTD samplings across the whole area (90 000 n miles$^2$).

The primary objective of this research is to improve those measurements required for the conservation of krill biology in the Ross Sea and the adjacent area of the Pacific Ocean. The second main objective is to use krill as a model organism for studying interactions between the environment and organism variability. The third main objective is to investigate the relationships between krill (*E. superba*) and its main competitive or predator species.

**WG-EMM-02/32**
**Krill of the Ross Sea: distribution, abundance and demography of *Euphausia superba* and *Euphausia crystallorophias* during the Italian Antarctic expedition (January–February 2000).**

A. Sala, M. Azzali and A. Russo. *Scientia Marina*, 66 (2): 123–133 (2002). (English).

Net samples data from the 15th Italian Antarctic Oceanographic Cruise (Jan–Feb 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. Mean relative biomass of Antarctic krill *Euphausia superba*, in the area north of Continental Shelf, was 9.3 g/1 000 $m^3$ of filtered water with a mean density of 10.9 individuals per 1 000 $m^3$. Ice krill *Euphausia crystallorophias* replaced the Antarctic krill in dominance in the High Antarctic Zone (south of 74°), with a mean relative biomass of 3.0 g/1 000 $m^3$ and mean density of 19.1 ind/1 000 $m^3$. The present data have demonstrated that in the Ross Sea during the summer period, the two species of euphausiid inhabited different areas. Oceanographic data indicate that both euphausiid species were found in surface waters, *Euphausia crystallorophias* in proper Ross Sea water, and *Euphausia superba* in Antarctic Surface Water. The catch data of *Euphausia superba* were characterised by the complete absence of larval stages, scarce occurrence of juveniles and composed primarily of large adult stages, whereas the overall length frequency distribution of *Euphausia crystallorophias* was characterised by a first mode of juvenile individuals and a second mode consisting of sub-adults and adults.

**WG-EMM-02/33**

**Spatial and temporal variability in foraging patterns of krill predators at Signy Island and South Georgia.** P.N. Trathan, J.L. Tanton, A.S. Lynnes, M.J. Jessopp, H. Peat, K. Reid and J.P. Croxall (British Antarctic Survey, Biological Sciences Division, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 33 pp. (English, unpublished).

While constrained by the requirement to feed their young, land-based marine predators act as central-placed foragers with movements between their breeding colony and their food resource. In a system where the distribution and abundance of prey is highly variable, foraging behaviour must be highly adaptable. In this paper we consider the behaviour of seal and seabird krill-dependent predators foraging to provision their young and to feed themselves. We examine data from a variety of species to determine whether foraging is more intense close to the colony, or whether it is more widely distributed within the wider potential foraging range.

During the breeding season, parents are able to forage for increasingly long periods and over much greater areas as their offspring develop. Their potential foraging range increases as the breeding season advances, potentially affecting local levels of predation. We look to determine whether foraging areas are different at different times of the breeding season; we also look to see whether differences are apparent between years.

We use this information about where and when marine predators forage to identify candidate 'small-scale management units', these are areas where potential resource competition could exist between krill-dependent predators and the commercial fishery for Antarctic krill (*Euphausia superba*). The criteria used to identify these units are described as an example of how they could be used in other locations where the fishery operates.

**WG-EMM-02/34**

**Estimating penguin populations using image analysis of colour aerial photography.** P.N. Trathan (British Antarctic Survey, Biological Sciences Division, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 34 pp. (English, unpublished).

Penguin populations are potentially sensitive indicators of change in the Antarctic and sub-Antarctic and are used extensively to monitor changes in the marine ecosystem. Aerial photographic surveys may provide the most robust method for estimating breeding population size, particularly for large colonies, for colonies in areas of complex terrain, or for colonies where ground access is difficult.

Obtaining population estimates from aerial photographs is laborious and time consuming, and is usually carried out manually by counting individual birds on highly magnified prints. Here we present the results of a computer-based image analysis of digitally scanned colour aerial photographs of macaroni penguin colonies on Bird Island, South Georgia. We compare the results with conventional ground counts for the study colonies, highlighting various assumptions that contribute to differences in the population estimates. The software analysis method provides population estimates that are considered to be more reliable than the associated ground counts. The technique potentially provides a reliable method for carrying out large-scale wildlife management surveys.

**WG-EMM-02/35**

**Maximum entropy reconstruction of stock distribution and inference of stock density from line-transect acoustic survey data.** A.S. Brierley, S.F. Gull and M.H. Wafy (Gatty Marine Laboratory, University of St Andrews, Fife KY16 8LB, United Kingdom, andrew.brierley@st-andrews.ac.uk), 19 pp. *ICES Journal of Marine Science*, submitted (English).

We present a Maximum Entropy (MaxEnt) method for inferring stock density and mapping distribution from acoustic linetransect data. MaxEnt is founded on the bedrock of probability theory and allows the most efficient possible use of known data in the inference process. The method takes explicit account of spatial correlation in the observed data and seeks to reconstruct a distribution of density across the whole survey area that is both consistent with the observed data and for which the entropy is maximised. The method is iterative and uses the Bayesian approach of evaluating the posterior probability of a candidate solution under the constraint of the observed data to progress towards a converged solution. We apply the method to reconstruct maps of distribution of Antarctic krill throughout areas 100 x 80 km. Survey data were integrated at 0.5 km intervals along 10 80 km transects, giving approximately 1 600 observed data. We inferred krill density for all 32 000 0.5 x 0.5 km cells in the area. The method is computationally demanding but appears to work well, even in cases when the distribution of density is highly skewed. The MaxEnt technique has proved powerful for reconstruction of quantitative images from incomplete and noisy physical data (e.g. radio telescope data) and we suggest that it could be of benefit to the fisheries acoustic community, increasing the accuracy of acoustic estimates of stock density and generating superior maps of stock distribution.

**WG-EMM-02/36**

**MaxEnt reconstructions of krill distribution and estimates of krill density from acoustic surveys at South Georgia, 1996–2000.** M.H. Wafy, A.S. Brierley*, S.F. Gull and J.L. Watkins (Gatty Marine Laboratory, University of St Andrews, Fife KY16 8LB, United Kingdom, *andrew.brierley@st-andrews.ac.uk), 9 pp. *CCAMLR Science*, submitted (English).

We present Maximum Entropy (MaxEnt) reconstructions of krill distribution and estimates of mean krill density within two survey boxes (dimensions 80 x 100 km) to the northeast and northwest of South Georgia. The reconstructions are generated from acoustic line-transect survey data gathered in the boxes in austral summers from 1996 to 2000. Krill densities had previously been determined at approximately 0.5 km intervals along transect for each of the 10 80 km transects in each box, providing about 1 600 krill density estimates per box. The MaxEnt technique uses a Bayesian approach to infer the most probable krill density for each of the 32 000 0.5 km x 0.5 km cells in each survey box, taking explicit account of the spatial relationship between densities in the observed data. Despite some very large interannual and regional (east box cf. west box) differences in mean krill density, the MaxEnt approach seems to work well, providing plausible maps of distribution. The maps appear to reveal some consistent 'hot spots' of krill distribution, knowledge of which could aid our understanding of mechanisms influencing krill distribution

and hence krill–predator interactions. The MaxEnt technique also yields mean krill densities for each survey. The confidence limits around these means are often narrower than for estimates based upon more conventional analyses (Jolly and Hampton, 1990).

**WG-EMM-02/37**

**The three-frequency method for species determination and assessing the size of two euphausiids (*Euphausia superba* and *Euphausia crystallorophias*).** M. Azzali, G. Lanciani and I. Leonori (Istituto di Ricerche sulla Pesca Marittima, Largo Fiera della Pesca, 60100 Ancona, Italy), 13 pp. *CCAMLR Science*, submitted (English)

This paper describes an acoustic method for identifying two euphausiid species and estimating their length. The approach is in fact an outgrowth from both the fluid sphere and Bayes rule methodologies. Applications of the multi-frequency method are explored using data from three expeditions to the Ross Sea (1989/90; 1997/98 and 1999/2000) in which the environmental conditions, sampled areas and instrumental and sampling strategies varied. Thresholds and decision criteria used to differentiate between the two species are established on the basis of the echo-integrations made simultaneously at either two or three frequencies, and the results of net samplings. Acoustic estimates of euphausiid lengths derived using the fluid-sphere model are then compared with lengths collected from net samples. Finally, the criteria and algorithms developed are successfully applied to estimate the biomass of *Euphausia superba* in the Ross Sea area form survey data from December 1997 and January–February 2000. The results are compared with those obtained using the standard method.

**WG-EMM-02/38**

**Relationships between distribution of two euphausiid species and oceanographic characteristics in the Ross Sea (January–February 2000).** A. Russo, M. Azzali, E. Biffi, G. Lanciani and E. Paschini (Istituto di Scienze del Mare, Università di Ancona, Via Brecce Bianche, 60100 Ancona, Italy), 13 pp. *Antarctic Science*, submitted (English).

During the austral summer (21 January to 5 February) in 2000 an oceanographic cruise, devoted to study two krill species (*Euphausia superba* and *Euphausia crystallorophias*), was carried out in the Ross Sea area. Activities included acoustic, fishery and physical measurements. More than 2 370 n miles were acoustically sampled to determine the euphausiid biomass; during the echosurvey, every 6 hours a haul and a CTD cast (or a XBT launch) were performed, and a XBT was launched between consecutive hauling stations. This allowed to collect 34 CTD stations and 73 temperature profiles (XBT), so identifying main water masses and oceanographic features. Acoustic data were processed in order to distinguish between the two species. *E. superba* and *E. crystallorophias* swarms were recognised, and average length estimated, by means of the three-frequency method, based on the fluid sphere model. Net samples were considered the ground truth data, being compared to the acoustic estimates of krill species and size. Characteristics (dimensions, volume, weight, krill mean length) for each krill swarm were determined, and the krill average biomass per n miles$^2$ was computed along the ship route track. Adopted methodologies for cruise execution and for acoustic data post-processing allowed to obtain for the first time a detailed description of the krill distribution in the Ross Sea area related to oceanographic characteristics. Horizontal distribution of krill average biomass is showed separately for each species, and associated to thermohaline properties. Highest krill density biomass areas are closely investigated, and vertical sections with krill swarms weight and sea temperature are reported. Results indicate that the *E. superba* detected biomass was about one order of magnitude greater than that of *E. crystallorophias*. The first species was almost exclusively present in the northern area, interestingly only a limited portion of the continental shelf, while the second one dominated the

southern area, starting from the Ross Ice Shelf region until the zone close to the shelf break, with some presence in the open ocean region too. In the proper shelf break area, *E. crystallorophias* was practically absent, while *E. superba* was relatively abundant. The two species had a very limited, but with relatively high biomasses, overlapping area in the northernmost part of the Joides basin. Few other minor overlapping areas were detected. Swarms of both species were mostly found in the surface water layer (*E. crystallorophias* being located at quite deeper depths, often close to the seasonal thermocline zone) and they appeared to prefer cold waters, avoiding the warm Modified Circumpolar Waters and the warmest portion of the surface waters.

**WG-EMM-02/39**

**Seasonal variation in acoustic estimates of krill density at South Georgia during 2001/02.** C. Goss, S.A. Grant, N. Cunningham, J.L. Watkins, P.N. Trathan, E.J. Murphy and K. Reid (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 14 pp. (English, unpublished).

Four separate acoustic surveys of Antarctic krill (*Euphausia superba*) were conducted around South Georgia in the 2001/02 season: one in November 2001 (early); two during January 2002 (middle) and one in May 2002 (late). The surveys were the second in a five-year series of observations designed to complement and extend an existing time series of summer surveys maintained by the British Antarctic Survey regularly since 1996. Krill density in November was low (5 g $m^{-2}$), higher in both the two surveys in January (46 g $m^{-2}$ and 72 g $m^{-2}$ ) and had decreased to 12 g $m^{-2}$ by May. Our repeated surveys at South Georgia have revealed a similar pattern of change to that observed in 2000/01 and highlight the importance of understanding the relative contributions of physical and biological processes to krill population dynamics in the region.

**WG-EMM-02/40 Rev. 1**

**Defining fishing grounds in the Scotia Sea.** I.R. Ball, A.J. Constable, S. Kawaguchi and D. Ramm (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 21 pp. (English, unpublished).

This paper provides a method for delineating krill fishing grounds in Area 48 based on commercial catch data for the region held in the CCAMLR database. It also summarises available information on krill distribution and abundance and movement for the region, which can be used to help understand the relationship between the fishing grounds and the krill population. We define a fishing ground as being a predictable location where the fishery obtains relatively reliable catches from one year to the next over a number of years. The quantity of interest is not only the total catch obtained from a location, say a 10 x 10 n mile area, over the years but how important that location is to the fishery each year, which is judged by that location providing a reasonable catch in a given year and that the catch remains sufficiently high on average over a number of years. We call this value the normalised long-term average catch (shortened to the term 'normalised catch'). An important consideration is the threshold for the normalised catch, such that locations would generally only be considered for inclusion in a fishing ground if their values were greater than the threshold. A method for choosing a threshold is given. The boundary for a fishing ground should predominantly include only locations for which the normalised catch is greater than the threshold. Some simple criteria for designating fishing grounds are presented. The type of analytical tool needed to convert the data to a longitude–latitude grid of normalised catches and for determining boundaries on the grid according to the criteria is also discussed. The components of this process are developed using the commercial krill catch data available in the CCAMLR database.

**WG-EMM-02/41**

**Defining predator foraging ranges, illustrated using Adélie penguin foraging tracks from Mawson coast.** I.R. Ball, A.J. Constable, J. Clarke and L.M. Emmerson (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 8 pp. (English, unpublished).

One step toward defining small-scale management units is to determine the areas most likely to be foraged by predators from one year to the next, i.e. what is a predator's feeding range taking into account interannual variation in foraging locations? This paper considers the issues to be addressed in answering that question. The proposed method for defining foraging ranges is based on an approach used to define fishing grounds. The data which is considered as an example here consists of location/time recordings from a satellite-tracking system. This data is used to generate a map of feeding effort and this is used to delineate a feeding ground for Adélie penguins on the Mawson coast in eastern Antarctica. This method builds on existing methods but incorporates tools for pooling information across colonies, years and species to define individual species and pooled foraging ranges. The establishment of these foraging ranges for the purposes of small-scale management units may need to be examined in three parts. The first part is to determine whether the results would be different for different seasons, e.g. summer vs winter. The second part is to establish the combined foraging ranges across a number of species for which tracking information is available – pooled foraging ranges. The third consideration is whether some species with low colony biomass have large proportions of their foraging ranges falling outside of the specified pooled foraging ranges. If this makes those species vulnerable in the management process then consideration will need to be given to including those ranges as special extensions to the foraging grounds. Thus, a comparison of foraging ranges for individual species with the pooled foraging range would be a useful step in this process.

**WG-EMM-02/42**

**Deaths of Adélie penguins at Mawson November–December 2001 investigated.** K. Kerry and L. Irvine (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 3 pp. (English, unpublished).

Over 120 adult Adélie penguins were found dead in unusual circumstances on Welch Island near Mawson between 23 November and 4 December 2001. It is concluded that the most likely cause of death was severe injury from being crushed by ice at the ice–land interface. Circumstance surrounding the death of the penguins suggested initially that disease may have been implicated and so investigations were treated accordingly. The sampling protocols developed by CEMP were used in these investigations.

**WG-EMM-02/43**

**Comparison between the CCAMLR-2000 and KY 1988 surveys on environmental variability of krill in the Scotia Sea, Antarctica.** M. Naganobu, M. Brandon, K. Ito, K. Segawa and V. Siegel (National Research Institute of Far Sea Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan), 27 pp. *Deep-Sea Research* (CCAMLR-2000 Survey Special Issue), submitted (English).

We assessed the environmental variability of Antarctic krill (*Euphausia superba*) distribution with comparison between the CCAMLR-2000 Survey and similar scale datasets partially by the Japanese RV *Kaiyo Maru* survey in the 1987/88 austral summer season in the Scotia Sea. There were distinct differences between the 2000 and 1987/88 surveys with regard to sea-ice extent, oceanographic structure and krill distribution. The sea-ice cover in 1987/88 extended northward widely during the last winter season such that sea-ice remained around the South Orkney Islands until December 1987. In contrast, the sea-ice cover in 1999/2000 reduced southward such that no sea-ice remained around the South Orkney Islands in December 1999. The Antarctic Surface

Water mass, consisting of Winter Water and Summer Surface Water, in 1987/88 extended northward and covered a large area in the Scotia Sea. In contrast, the Antarctic Surface Water in 2000 reduced southward. Geographical distribution of krill, which approximates the area of the Antarctic Surface Water, in 1987/88 extended northward with high density. In contrast, the distribution of krill in 2000 reduced southward with low density. To generally understand the above relationships between oceanographic structure and krill distribution, we introduced integrated water temperature from the surface to 200 m ($\overline{Q}_{200}$) as an environmental index indicating the structure of the upper ocean, that is referred to as the Environmental Index (EI$\overline{Q}_{200}$). The isoline of EI$\overline{Q}_{200}$ = 0.0°C was located near 60°S northward off the South Shetland Islands in 1987/88. In contrast, the isoline of 0.0°C in 2000 was located in the Bransfield Strait and Weddell Sea southward off the South Shetland Islands. The Antarctic Surface Water in 1987/88 clearly developed northward compared with 2000 reduced southward. The geographical distribution of krill ranged over the area under the isolines of EI$\overline{Q}_{200}$ = 1.0°C in the western waters and 2.0°C in the eastern waters of the Scotia Sea. Krill density became higher with the colder isolines of EI$\overline{Q}_{200}$ = 0.0°C, especially south of its steep gradient, namely, the Southern Boundary of the Antarctic Circumpolar Current. It suggested that the geographical distribution of three krill size clusters in the 2000 survey (Siegel et al., 2002) corresponded with the distribution pattern of EI$\overline{Q}_{200}$ on the whole.

**WG-EMM-02/44**

**Short note: time series of Drake Passage oscillation index (DPOI) from 1952 to 1988.** M. Naganobu and K. Kutsuwada (National Research Institute of Far Sea Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan), 3 pp. (English, unpublished).

Naganobu et al. (1999) assessed variability in krill recruitment and density with respect to hypothesised environmental factors, notably the strength of westerly winds (westerlies) deduced from sea-level pressure differences across the Drake Passage, sea-ice cover and chlorophyll-*a* in the Antarctic Peninsula area from 1982 to 1998. There were found to be significant correlations between these factors and krill recruitment. The westerlies were found to be a particularly significant environmental index. Fluctuations in the westerlies across the Drake Passage were referred to as the Drake Passage Oscillation Index (DPOI).

The authors planned to extend the time series of DPOI using historical data. They searched the historical data and found the time series for Rio Gallegos from the 1950s to 1988 on the websites of the Carbon Dioxide Information Analysis Centre, and those for Esperanza from the 1940s to 1998 at British Antarctic Survey. A time series of DPOI from 1952 to 1988 was then calculated. Time series from 1988 onwards will be calculated once appropriate data have been obtained.

The total number of monthly datasets used from 1952 to 1988 was 420. The mean, median and mode were 13.6, 13.8 and 14.0 hPa respectively. The maximum, minimum and range were 27.5, -6.4, and 33.9 hPa respectively, and standard deviation 6.2. The linear regression declined as a whole from 1952 to 1988. A time series of three-month running means suggested a considerable seasonal variability in the climate. A time series of 12-month running means indicated a lack of seasonal variability in various yearly changes. Periods of high DPOI (not less than 16 hPa) were mostly observed in the period before 1964 and since 1964, only in 1973 and 1986–1988. Periods of low DPOI (less than 14 hPa) were of longer duration after 1964. A low DPOI (less than 10 hPa) occurred in 1967 and 1980. Intervals between the years of low DPOI were generally observed to last for around three years except for the six years between 1958 and 1964.

**WG-EMM-02/45**

**Assessing the feasibility of regional surveys of land-based predator abundance in the Southern Ocean: a framework for decision making and planning.** C. Southwell (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, colin.southwell@aad.gov.au), 12 pp. (English, unpublished).

In 2000 WG-EMM discussed the need for region-wide and circum-Antarctic estimates of abundance of land-based predators. At the 2001 meeting of WG-EMM it was proposed that a workshop be held in 2002 to assess the feasibility of such broad-scale surveys, and a small intersessional correspondence group was formed to scope out the terms of reference and method of operation for the workshop. The intersessional group developed a draft decision-making framework for planning regional-scale surveys and agreed that it be applied at the workshop to a selected region as a means of both assessing and/or developing the framework and undertaking preliminary plans for the region. The framework is designed to be general enough to apply to any species or scale, and addresses the issues of survey specification, survey design, review and use existing information, and estimation of availability (proportion of total population not able to be surveyed) as an integral part of the survey design. The framework also recognises that new technologies and methodologies need to be considered for use wherever possible.

**WG-EMM-02/46**

**An assessment of temporal variability and interrelationships between CEMP parameters collected on Adélie penguins at Béchervaise Island.** L.M. Emmerson, J. Clarke, K. Kerry and C. Southwell (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 17 pp. *CCAMLR Science*, submitted (English).

We examined temporal variability in a series of CEMP parameters collected over the period from 1991/92 to 2001/02 on Adélie penguins at Béchervaise Island. Parameters relating to chick survival (brooding counts, 2/3 crèche counts and fully crèched chick counts) show large temporal variability while the other parameters were more stable. We also explored the correlation between CEMP parameters, and the correlation of each parameter with breeding success. Breeding success was measured in terms of: (i) the absolute number of chicks on the island which fully crèche; and (ii) the number of chicks crèched per nest with eggs. We found a low degree of correlation between incubating and brooding nest counts which supports the notion that events occurring during the hatching period are crucial for chick survival. The sex of the foraging birds and the timing of foraging trips were important in determining whether foraging trip duration was correlated negatively to breeding success. Additionally, we examined within-season penguin weights, the simplest output from the Automated Penguin Monitoring System (APMS), in terms of their correlation with breeding success. This analysis showed that lower weights of females at the time they depart after egg laying would appear to be the first indication that a season may have low breeding success. The results obtained throughout these analyses indicate that knowledge of the sex of birds is important for understanding interrelationships between CEMP parameters and breeding success.

**WG-EMM-02/47**

**Post-fledging and winter migration of Adélie penguins (*Pygoscelis adeliae*) in the Mawson region of east Antarctica.** J. Clarke, K. Kerry, C. Fowler, R. Lawless, S. Eberhard and R. Murphy (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 29 pp. *Marine Ecology Progress Series*, submitted (English).

Seven fledging Adélie penguin (*Pygoscelis adeliae*) chicks and four post-moult adults were satellite tracked using the Argos system during the winters of 1995–1997 and 1998 respectively. Six fledglings departed from Béchervaise Island near Mawson station (67°35'S, 62°49'E) during late February 1996 and 1997 and were tracked for up to five months before transmissions stopped. The

seventh chick left Magnetic Island near Davis station (68°33'S, 77°54'E) in February 1995 and was tracked for 32 days. All fledglings travelled northward initially, then westward along the edge of the fast-ice or in the pack-ice. Fledglings had travelled between 536 and 1 931 km to the west of their natal colonies by the time transmissions ceased. Adult Adélie penguins were tracked between March and October 1998, following completion of their annual moult at Béchervaise Island. Instruments were factory set to transmit intermittently for the first five months and one day in four thereafter. Adult birds travelled westward until July after which time they moved north within the expanding pack-ice into known areas of high krill concentration before returning eastward toward their breeding sites. Penguin movements over the winter months were closely related to those of sea-ice in the region. Ice motion patterns were in turn influenced by gyral oceanic current systems and wind. We propose that large gyral oceanic systems provide a means for Adélie penguins to reduce costs of transport as they travel into regions of high productivity during winter and return to their breeding colonies in spring. Locations of boundaries of oceanic gyres may thus be useful to CCAMLR in the regulation of the Antarctic krill fishery as a means of delimiting management regions.

**WG-EMM-02/48**

**Demographic characteristics of the Adélie penguin population on Béchervaise Island after 12 years of study.** J. Clarke, K. Kerry, A. Townsend and L.M. Emmerson (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 24 pp. *CCAMLR Science*, submitted (English).

Demographic parameters (age-specific mortality rates, fecundity levels and population numbers) were analysed for the Béchervaise Island Adélie penguin colony in eastern Antarctica after 12 years of CEMP monitoring. A life table was constructed, and predicted rates of population growth and breeding success calculated. As for most long-lived seabird species, growth/decline rates of the Adélie penguin population at Béchervaise Island were found to be more sensitive to changes in annual survival rates, especially of young breeding adults, than to changes in fecundity parameters. These findings are discussed briefly in relation to other CEMP parameters, environmental factors and fishery regulation.

**WG-EMM-02/49**

**Broadbandwidth total target strength measurements of Antarctic krill (*Euphausia superba*) from reverberation in a cavity.** D.A. Demer and S. Conti (National Marine Fisheries Service, Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA, david.demer@noaa.gov), 37 pp. *ICES Journal of Marine Science*, submitted (English).

Total scattering cross-sections ($\sigma_t$) of Antarctic krill, *Euphausia superba*, were acoustically measured over a broadbandwidth (36 to 202 kHz) using a new technique [J. De Rosny and P. Roux, 2001, *J. Acoust. Soc. Am.* 109 (6): 2587–2597]. From 18 February to 9 March 2002, mean total target strengths ($TTS = 10\log(\sigma_t/4\pi)$), were measured from groups of 57 to 1 169 krill (average standard length = 31.6 mm; standard deviation = 6.6 mm), at the Cape Shirreff field station, Livingston Island, Antarctica, and aboard RV *Yuzhmorgeologiya*. Chirp pulses were sequentially transmitted with an omnidirectional emitter into one of three glass carboys containing groups of krill swimming in 9.3, 19.3 or 45.9 *l* of seawater ($0.6 \leq$ temperature $\leq 3.6$°C). Between each pulse, the krill moved within the fixed-boundary-tank and the modulated reverberations were sensed bi-statically with three omnidirectional receivers. At each centre frequency ($f_c$), the coherent energy in 200-pulse ensembles identified sound scattered from the tank. The incoherent energy described total sound scattering from the krill. Thus, the *TTS* at each $f_c$ was extracted from a correlation analysis of energy reverberated in the tank. Measurement accuracy was determined using standard metal spheres for references [Demer et al., in press, *J. Acoust. Soc. Am.*], and the precision was

estimated from the variability in krill *TTS* measurements. Moreover, empirical estimates of mean $\sigma_t$ were statistically compared to a recently proposed krill scattering model based on the distorted wave Born approximation (DWBA) [McGehee et. al, 1998, *Deep-Sea Research II*, 45 (7): 1273–1294], which has been enhanced to account for the stochastic nature of sound scattering (*SDWBA*) [Demer and Conti, submitted, *ICES J. Mar. Sci.*], and integrated over all scattering angles ($SDWBA_{TTS}$). This study improves upon methods for acoustical identification and target strength estimation for Antarctic krill, thus reducing the uncertainty in biomass estimation using multi-frequency echosounder data and echo integration methods.

**WG-EMM-02/50**

**Reconciling theoretical versus empirical target strengths of krill; effects of phase variability on the distorted wave Born approximation.** D.A. Demer and S. Conti (National Marine Fisheries Service, Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA, david.demer@ noaa.gov), 19 pp. *ICES Journal of Marine Science*, submitted (English).

A model was recently proposed to predict the target strengths (*TS*) of Antarctic krill, *Euphausia superba*, versus incidence angle (θ) [McGehee et. al, 1998, *Deep-Sea Research II*, 45 (7): 1273–1294]. Based on the distorted wave Born approximation (DWBA), the model depends upon the coherent summation of scattering from elements of a discretised bent cylinder. It was empirically validated at 120 kHz near broadside incidence ($\theta \approx 90$ ), but large discrepancies were observed at other angles away from the main lobe. As the side-lobe measurements were both higher than the model predictions and above the noise floor, the authors noted that the differences were not entirely due to noise. In this study, the accuracy of the DWBA model is further explored. Results indicate that phase variability in the scatter from elements of a discretised bent cylinder (krill model) causes a dramatic flattening in the side-lobe regions of $TS(\theta)$, while negligibly affecting the main scattering lobe. These results are consistent with the krill *TS* measurements in McGehee et al. (1998). Thus, by accounting for phase-variability in the solution of the DWBA model, a more accurate and thus practical tool is developed for predicting krill *TS*.

**WG-EMM-02/51**

**Antarctic fur seals in the South Shetland Islands: pup production and population trends.** M.E. Goebel, V.I. Vallejos, W.Z. Trivelpiece, R.S. Holt and J. Acevedo (National Marine Fisheries Service, Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA, mike.goebel@noaa.gov), 24 pp. (English, unpublished).

Discovered in 1819, the South Shetland Islands soon became the focus of intensive sealing efforts. Abundant, but never quantified, Antarctic fur seal populations were exterminated by 1874 and did not begin recolonising until ~80 years later. The first reported pups born post-exploitation were found at Cape Shirreff, Livingston Island, in January 1960. In 1987, an archipelago-wide aerial and ground census identified breeding colonies and substantial increases in pup production. This paper reports the results of a ground survey of all known fur seal colonies from Smith to Elephant Islands from 30 January to 5 February 2002. Multiple counts of pups at each colony were conducted to establish confidence limits on pup production. Total pup production was 10 057 (±142); 85% were from Cape Shirreff (64%) and San Telmo Islands (21%). Dead pups accounted for 1.37% of the total. A comparison with previous censuses over a 15-year period (1987, 1992, 1994 and 1996) indicates the rate of increase in fur seal populations has diminished substantially. The averaged annual rate of increase from 1987 to 1994 was between 13.5 and 13.9%. From 1994 to 1996 it was 8.5% and from 1996 to 2002 the average annual rate was +0.9%. Pup production at individual colonies varied with some increasing and others decreasing. The San Telmo Islands had the largest decline from 2 684 pups in

1996 to 2 124 in 2002 (-3.5%/year). Pup production at Cape Shirreff increased from 4 968 to 6 453 pups (5.0%/year) during the same period. Cape Lindsey, Elephant Island and Seal Islands had averaged annual declines of -9.4 and -6.3% from 1996 to 2002.

**WG-EMM-02/52**

**A proposal for modifications to standard method C2: fur seal pup growth.** M.E. Goebel (National Marine Fisheries Service, Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA, mike.goebel@noaa.gov), 6 pp. (English, unpublished).

**WG-EMM-02/53**

**Foraging range and at-sea locations of female Antarctic fur seals, Cape Shirreff, Livingston Island, from 1999 to 2002.** M.E. Goebel, S.N. Sexton and D.P. Costa (National Marine Fisheries Service, Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA, mike.goebel@noaa.gov), 24 pp. (English, unpublished).

During the breeding season, Antarctic fur seals are central-place foragers, ranging from their colony to feeding areas hours to days offshore, returning periodically to suckle. Outside of this, little is known about a female's foraging strategy, her success on which depends not only her survival but that of her young. As such, a fundamental component to understanding the survival and reproductive success of fur seals is to identify habitat preferences. Our objective was to characterise the distribution and range of foraging females rearing pups at Cape Shirreff, Livingston Island, Antarctica. We instrumented 95 females with ARGOS satellite-linked transmitters prior to departures on foraging trips from late December to late February for four consecutive breeding seasons (1998/99–2001/02). We had 7 550 successful at-sea satellite locations (mean: 12/day/female, SE±0.11), after the data were filtered to eliminate positions that required females to travel >4 m/s. Foraging trip lengths averaged 4.0 days (SE±0.11). The mean range travelled offshore was 83.3 km (SE±2.9) and the maximum distance was 369.1 km. Foraging trip length was positively correlated with both foraging range ($r^2$ = 0.48, $F_{1.169}$ = 157.73, $P < 0.001$) and the total distance travelled ($r^2$ = 0.59, $F_{1.169}$ = 237.06, $P < 0.001$) indicating that foraging range can be estimated for females without satellite-linked instruments based on their trip duration alone. Trip duration, foraging range, and total distance travelled showed significant decreasing trends over the four years of our study. At-sea foraging locations in all years were centered over the mouth of a canyon at the continental shelf break ca. 40 km northwest of Cape Shirreff. A comparison of Cape Shirreff fur seal foraging locations and the krill fishery in Subarea 48.1 shows that the fishery, from 1999 to 2001, took 70% of the total Subarea 48.1 take within 100 km of Cape Shirreff and the foraging range of fur seals.

**WG-EMM-02/54**

**Atlas of coastal sea-ice in eastern Antarctica.** K. Michael, K. Hill, K. Kerry and H. Brolsma (Antarctic Cooperative Research Centre, University of Tasmania, Hobart, Tasmania, Australia), 43 pp.

**WG-EMM-02/55**

**The winter distributions of Adélie and chinstrap penguins from two breeding sites in the South Shetland Islands of Antarctica.** S.G. Trivelpiece and W.Z. Trivelpiece (National Marine Fisheries Service, Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), 11 pp. (English, unpublished).

Satellite telemetry was used to determine the winter movements and distributions of five chinstrap and six Adélie penguins from two breeding colonies in the South Shetland Islands, Antarctic Peninsula region, during the 2000 and 2001/02 austral winters respectively. Three chinstrap penguins from a breeding site in Admiralty Bay, King George Island (62°10'S 58°30'W), were instrumented with satellite tags in early March 2000, following their annual moult; similarly, two birds were tagged in late February at their breeding site on Cape Shirreff, Livingston Island (62°28'S 60°46'W). All

five chinstrap penguins were tracked for a minimum of three months each, while one bird was followed for five months. Locations were obtained using the ARGOS satellite system and data analyses revealed that four of the five chinstrap penguins foraged largely on the shelf to the north and northeast of the South Shetland Islands in ice-free areas. The fifth chinstrap penguin, from the colony on King George Island, proceeded northeast to the Elephant Island area and spent the next four to five months continuing to the east. This bird's signal was lost just to the west of the South Sandwich Island group in late July, approximately 1 300 km from its breeding colony. The migration path of this chinstrap penguin is remarkably similar to the only other record of a chinstrap penguin's winter migration reported by Wilson et al. (1998). Three Adélie penguins with PTTs were tracked from mid-February to early April 2001, following their moult in the King George Island breeding colony. All individuals remained in the Bransfield Strait adjacent to the western shore of the Antarctic Peninsula, within 150 km of the breeding colony where they were tagged. The following season, we attached PTTs to three Adélie penguins feeding large, nearly fledged chicks on King George Island in late January 2002. We tracked all three around the tip of the Antarctic Peninsula, deep into the Weddell Sea where they presumably hauled out to moult in late March–early April, between 69 and 70°S latitude. Our results suggest that Adélie and chinstrap penguins breeding in the same colonies during the summer may have vastly different migratory behaviours in winter. This may be a strategy evolved to avoid significant losses to any given breeding population by dispersing individuals to different winter ranges.

**WG-EMM-02/56**
**Proposal for a new Antarctic Specially Protected Area, Terra Nova Bay, Ross Sea.** Delegation of Italy, 12 pp. (English, unpublished).

**WG-EMM-02/57**
**Management plan for Site of Special Scientific Interest No. 36 – Eastern Dallman Bay.** Delegation of the USA, 8 pp. (English, unpublished).

**WG-EMM-02/58**
**Management Plan for Site of Special Scientific Interest No. 35 – Western Bransfield Strait.** Delegation of the USA, 10 pp. (English, unpublished).

**WG-EMM-02/59**
**Management plan for Site of Special Scientific Interest (SSSI) No. 1.** CCAMLR Secretariat, 11 pp.

**WG-EMM-02/60**
**The Ross Sea, Antarctica, where all ecosystem processes still remain for study.** D. Ainley (H.T. Harvey and Associates, San Jose, Ca., USA), 22 pp. (English, unpublished).

The Ross Sea is a well-defined embayment of Antarctica about the size of southern Europe, bounded by Victoria Land to the west; King Edward VII Peninsula, Marie Byrd Land, to the east; the Ross Ice Shelf to the south; and the Southern Ocean, Pacific Sector, to the north. Its waters are composed of two related biotic systems: the Ross Sea Shelf Ecosystem (RSShE) and the Ross Sea Slope Ecosystem (RSSlE). The RSShE is the last large marine ecosystems on earth (except the Weddell Sea) that has escaped direct anthropogenic alteration; the RSSlE, similar to all of earth's other marine ecosystems, has lost its large baleen whales but otherwise is intact. A huge multidisciplinary international scientific effort has been invested in studies of the geology, physics and biology of the Ross Sea over the past 45 years. In particular the activities of the USA, New Zealand and Italian Antarctic programs have been a model of international scientific cooperation and collaboration. The successful result is an incredible wealth of knowledge, including long-term biological datasets, not available anywhere else in the Antarctic, that have documented clear

signals of climate forcing, as well as top–down influences not confused by human exploitation or activity. Ironically, much remains unknown about how these ecosystems function. The Ross Sea is off limits to mineral extraction, but pressures on its biological resources are growing. The economic value of the resources should be weighed against the value of the system as a unique scientific resource. The Ross Sea represents an unparalleled natural laboratory in which the results of different fishery management strategies can be modelled in the context of short-term and decadal variation in biological populations, with these models applied elsewhere in the Southern Ocean and the world.

**WG-EMM-02/62**

**Fishing intensity of the Russian krill fishing fleet in Subareas 48.2 and 48.3.** S.M. Kasatkina and V.F. Ivanova (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, sea@ atlant.baltnet.ru), 19 pp. *CCAMLR Science*, submitted (English).

The purpose of this paper was to estimate the impact of the commercial fleet on the krill population in different months of the fishing season from 1987 to 1990, during which the Soviet fleet yield from Subareas 48.2 and 48.3 amounted to at least 95% of the total krill catch. The calculations were based on haul-by-haul data reported by the Soviet fleet, using a model of probabilistic–statistical theory of fishery systems developed at AtlantNIRO. The intensity of the impact of the commercial fleet on krill population, biomass and density of krill aggregated in the fishing grounds was assessed, based on records of 22 800 hauls. Analysis of the operation of the Soviet fleet during the seasons of high fishing pressure shows that fishing had no effect on the krill stock or, consequently, on krill-dependent predators. The krill fishery was not competitive with dependent predators for the krill resource, in terms of either the quantity of removals or intensity. In this case, there is some spatial overlap of the ecological niche of dependent species and the fishery, rather than a functional overlap.

**WG-EMM-02/63 Rev. 1**

**Distribution of the Soviet fishing fleet in Subarea 48.3 from 1986 to 1990.** V.A. Sushin, P.S. Gasiukov, A.V. Zimin and S.M. Kasatkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, sushin@atlant.baltnet.ru), 10 pp. (English, unpublished).

Analysis of the operation of the fishing fleet is one of the preconditions of the determination of small-scale management units for the krill fishery. This paper analyses the available data on haul-by-haul catch statistics for the Soviet krill fishery in Subarea 48.3 from 1986 to 1990 (15 000 hauls). During the fishing season from April to September, two main fishing grounds with a quasi-stationary boundary between them located at 37–37°30'W were distinguished. These fishing grounds are formed along the periphery of the around-the-island current of anticyclone pattern at the points where this current joins with the Weddell Sea water flow (the eastern ground) and the Antarctic Circumpolar Current (the western ground). Temporal–spatial variability of these grounds has been analysed. The eastern fishing ground remained for a longer time period – basically from April to August, while the western ground remained from August to September (in some years from June to September). The third fishing ground is defined as being in the Shag Rocks shelf area in the Antarctic Circumpolar Current meander. On the basis of the material presented, some aspects of interrelations between the krill fishery and krill predators were considered and the conclusion reached that the hypothesis of competition between these species for krill resources may be unfounded.

## Working Group on Fish Stock Assessment

**WG-FSA-02/4**

**A statistical method for analysing the extent of IUU fishing in CCAMLR waters: application to Subarea 48.3.** D.J. Agnew and G.P. Kirkwood (Renewable

Resources Assessment Group, Imperial College, Royal School of Mines, Prince Consort Road, London SW7 2BP, United Kingdom), 24 pp. *CCAMLR Science*, submitted (English).

This paper describes a new method for estimating illegal, unregulated and unreported (IUU) catch of fish and birds. It utilises high-quality, well-documented fisheries protection vessel (FPV) cruise data. It takes explicit account of both 'seen' and 'unseen' IUU fishing through a simulation model to arrive at statistically rigorous estimates and confidence intervals of fish and bird by-catch by IUU vessels. This method has not been used previously to estimate IUU activity in the Convention Area. We recommend its continued use in Subarea 48.3 and extension to other regions of the Antarctic.

Of the sources of information on IUU fishing, FPV cruises are the most consistent and reliable. The track of the FPVs on their cruises to South Georgia covers all possible areas of fishing for toothfish in Subarea 48.3. The method uses data from FPV cruises in Subarea 48.3, and the encounters between FPVs and IUU fishing activity, to estimate the total number of days of IUU fishing that could occur during each year. For each IUU incident detected by the FPV, we calculated a theoretical maximum time over which this IUU activity could have occurred. This was the time that elapsed between the FPV cruises that were immediately prior to and immediately subsequent to the incident, where these prior and subsequent cruises had not detected that same IUU activity (i.e. the same vessel). In other words, for each IUU incident we know when it was seen, and the closest adjacent times in which it was not seen – the difference being the theoretical maximum time that the vessel can have been present.

This theoretical maximum time was converted to actual IUU fishing time using a simulation model. For each year, the model simulated 1 000 IUU fishing incidents during the year, and from the known FPV cruise pattern calculated both the observed IUU activity and the known real IUU activity. We considered IUU activity to have been observed when the IUU vessel and the FPV were in the same place at the same time. When this occurred, the FPV was assumed to detect IUU activity according to an 'encounter probability'. The encounter probability was estimated from the known encounters of the FPV with licensed vessels. Thus for each encounter between an IUU vessel and an FPV we obtained an estimate of total IUU fishing time.

The total annual IUU catch of toothfish and birds was calculated using a second simulation model. Subarea 48.3 was divided into six areas for the purposes of calculation of fish and bird by-catch associated with IUU fishing. The catch rate of fish was calculated for each area and each year using reported catch and effort data. The catch rate of birds was calculated separately for summer and winter using previously published CCAMLR observer data obtained in the early licensed fishery (1997) when few vessels used mitigation measures. For each of 10 000 simulations, fish and bird catch rates were obtained randomly from parent distributions, for each IUU–FPV incident.

Three years were analysed, 1998/99, 1999/2000 and 2000/01. Each year covered fully the period 1 October–30 September, thus including one summer and one winter period. The estimated total toothfish catch attributable to IUU fishing was 667, 1 015 and 196 tonnes in 1998/99, 1999/2000 and 2000/01 respectively (a total over the three years of 1 879 tonnes). The estimated total bird by-catch was 574 birds, 2 200 birds and 544 birds respectively. 95% confidence limits were calculated to be 41–1 778, 472–1 744 and 23–481 respectively for fish and 122–1 823, 825–5 422 and 110–1 813 respectively for birds.

CCAMLR estimates of IUU catch over the fishing seasons 1998/99, 1999/2000 and 2000/01 are 664, 559 and 350 tonnes respectively. These are already taken into account in CCAMLR assessments. Revised assessments will have to take into account our new estimates, but preliminary investigations suggest that the effect on current population status and catch limit will be negligible. Our new figures show that the

level of IUU catch dropped considerably in 2000/01 to less than 5% of the total (legal + IUU) catch in Subarea 48.3. Surveillance records indicate that this decreasing trend has continued into 2002, probably as a result of increasing surveillance since 1999. Continual development of surveillance potential is required to inhibit the return of IUU vessels to Subarea 48.3.

The revised calculations of IUU catch should be taken into account in assessments of toothfish in Subarea 48.3.

**WG-FSA-02/5**

**The rate of incidental mortality of birds in the IUU longline fishery in Subarea 48.3.** D.J. Agnew and G.P. Kirkwood (Renewable Resources Assessment Group, Imperial College, Royal School of Mines, Prince Consort Road, London SW7 2BP, United Kingdom), 12 pp. *CCAMLR Science*, submitted (English).

Information on the rates of incidental mortality of birds experienced by IUU vessels is extremely difficult to obtain. CCAMLR has, in the past, used data from the 1997 legitimate fishery, when a large number of birds were caught and when the implementation of mitigation measures was low, to approximate the IUU situation. This paper describes analyses undertaken using the 1997 data to refine the estimates of IUU bird by-catch rates for use in our analysis of the impact of IUU fishing in Subarea 48.3 (WG-FSA-02/4).

**WG-FSA-02/6**

**The role of fish in the Antarctic marine food web: differences between inshore and offshore waters in the southern Scotia Arc and west Antarctic Peninsula.** E. Barrera-Oro (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina, eboro@muanbe.gov.ar and esteban@eboro.cyt.edu.ar), 38 pp. *Antarctic Science*, in press (English).

The role of fish in the Antarctic food web in inshore and offshore waters is analysed taking as an example the coastal marine communities of the southern Scotia Arc (South Orkney Islands and South Shetland Islands) and the west Antarctic Peninsula. Inshore, the ecological role of demersal fish is more important than that of krill. There, demersal fish are major consumers of benthos and also feed on zooplankton (mainly krill in summer), and are links between lower and upper levels of the food web; they are common prey of other fish, birds and seals. Offshore, demersal fish depend less on benthos and feed more on zooplankton (mainly krill) and nekton, and are less accessible as prey of birds and seals. There, pelagic fish (especially lanternfish) are more abundant than inshore and play an important role in the energy flow from macrozooplankton to higher trophic levels (seabirds and seals). Through the higher fish predators, energy is transferred to land in the form of fish remains, pellets (birds), regurgitations and faeces (birds and seals). But in the wide context of the Antarctic marine ecosystem, krill (*Euphausia superba*) plays the central role in the food web because it is the main food source in terms of biomass for most of the high level predators from demersal fish up to whales. This has no obvious equivalent in other marine ecosystems. In Antarctic offshore coastal and oceanic waters, the greatest proportion of energy from the ecosystem is transferred to land directly through krill consumers, such as flying birds, penguins, and seals. Beside krill, the populations of fish in the Antarctic Ocean are the second most important element for higher predators, in particular the energy rich pelagic Myctophidae in open waters and the pelagic Antarctic silver fish (*Pleuragramma antarcticum*) in the high Antarctic zone. Although the occurrence of these pelagic fish inshore has been scarcely documented, their abundance in neritic waters could be higher than previously believed.

**WG-FSA-02/9**

**Fishery information for WG-FSA-02.** CCAMLR Secretariat, 11 pp. (English, unpublished).

**WG-FSA-02/10**

**CCAMLR Survey Database: development during 2002.** CCAMLR Secretariat, 9 pp. (English, unpublished).

**WG-FSA-02/11 Rev. 1**
**A summary of observations on board longline vessels operating within the CCAMLR Convention Area.** CCAMLR Secretariat, 11 pp. (English, unpublished).

**WG-FSA-02/12 Rev. 1**
**Summary of observations aboard trawlers operating in the Convention Area during the 2001/02 season.** CCAMLR Secretariat, 8 pp. (English, unpublished).

**WG-FSA-02/13 Rev. 2**
**A summary of scientific observations related to Conservation Measures 29/XIX, 63/XV and 173/XVIII.** CCAMLR Secretariat, 8 pp. (English, unpublished).

**WG-FSA-02/14**
**Summary of an observation aboard a pot vessel operating in the Convention Area during the 2001/02 season.** CCAMLR Secretariat, 3 pp. (English, unpublished).

**WG-FSA-02/15**
**Observations on the diet of Antarctic toothfish (*Dissostichus mawsoni*) from the Ross Sea, Antarctica (CCAMLR Statistical Subarea 88.1).** J.M. Fenaughty, D.W. Stevens and S.M. Hanchet (Silvifish Resources Ltd, PO Box 17-058, Karori, Wellington, New Zealand, jmfenaughty@clear.net.nz), 13 pp. *CCAMLR Science*, submitted (English).

The diet of Antarctic toothfish (*Dissostichus mawsoni*) captured by bottom longline in the Ross Sea was studied during the 2001 (3 937 stomachs examined) and 2002 (5 426 stomachs examined) summer fishing seasons. Fish sampled in 2001 were caught in 317–2 154 m depths and ranged in length from 58 to 190 cm total length (TL), while fish sampled in 2002 were caught in 815–1 623 m depths and ranged in length from 62 to 197 cm TL. A high proportion of stomachs sampled were empty (34% in 2001 and 49% in 2002) and the remaining stomachs often contained prey in advanced stages of digestion, making prey identification difficult. Fish were the most important prey category (86% of stomachs in 2001 and 78% in 2002), in particular icefish (family Channichthyidae) and Whitson's rattail (*Macrourus whitsoni*). Squid, bait and prawns were also important prey items.

**WG-FSA-02/16**
**Population dynamics of wandering albatrosses (*Diomedea exulans*) at sub-Antarctic Marion Island: longline fishing and environmental influences.** D.C. Nel, F. Taylor, P.G. Ryan and J. Cooper (Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7701, South Africa, dnel@savethealbatross.org.za), 31 pp. (English, unpublished).

The Prince Edward Islands support the largest breeding population of the vulnerable wandering albatross (*Diomedea exulans*). The number of birds breeding in this population has fluctuated over the past three decades and appears to be the result of both real changes in the size of the population and changes in the proportion of the population that attempts to breed in a given year. We describe changes in several demographic parameters that appear to be influenced by both environmental and anthropogenic effects. The proportion of first-time breeders in the population was positively correlated with the maximum ENSO index, while the annual survival rates of breeding adults was negatively correlated with Japanese pelagic longline fishing effort in the Southern Indian Ocean. Adult survival rates were significantly correlated with those recorded on neighbouring Possession Island (Crozet Islands) but differed from those at South Georgia, suggesting common factors operating at ocean-basin scale. The average survival rate of adult females was lower than that of males. Males who lost partners took 40% longer than females to find a new mate, suggesting a male-biased population. Survival rates of juvenile males and females did not differ. The age distribution of first-time breeders has shifted progressively towards younger birds during the 1990s. Higher than expected survival rates of breeding adults during the late 1990s may be linked to

large amounts of supplementary food being made available by the initiation of a longline fishery for Patagonian toothfish (*Dissostichus eleginoides*) close to the islands during this time. Overall, breeding success was better than recorded at other localities, indicating that breeding conditions at Marion Island were favourable. The implementation of international conservation initiatives to reduce the impact of longline fishing on this species and improve its conservation status, is recommended.

**WG-FSA-02/17**

**Seabird by-catch in the Patagonian toothfish longline fishery at the Prince Edward Islands: 2001/02.** B.P. Watkins (Marine and Coastal Management, Private Bag X2, Roggebaai 8012, South Africa, bwatkins@mcm.wcape.gov.za), 7 pp. (English, unpublished).

This paper summarises the seabird by-catch by sanctioned longline fishing for Patagonian toothfish (*Dissostichus eleginoides*) in the Exclusive Economic Zone around South Africa's Prince Edward Islands, from 1 July 2001 to 30 June 2002. Data were obtained from fishery observers on board all nine sanctioned fishing trips. Fishing effort was 2.9 million hooks, a 36% reduction on the number of hooks set in 2000/01 (Ryan and Watkins, 2001). The number of seabirds reported killed by the observers was three birds: two white-chinned petrels (*Procellaria aequinoctialis*) and one grey petrel (*P. cinerea*). The average seabird by-catch rate by sanctioned vessels was 0.001 birds/thousand hooks which is a significant drop from the previous season when 0.009 birds were killed per thousand hooks.

**WG-FSA-02/18**

**Progress report of Chilean research on albatross ecology and conservation.** J. Arata and C.A. Moreno (Instituto de Ecología y Evolución, Universidad Austral de Chile, Casilla 567, Valdivia, Chile), 15 pp. (English, unpublished).

**WG-FSA-02/19**

**Brief information on the results of bottom trawl and acoustic trawl surveys carried out by RV *Atlantida* in South Georgia (Subarea 48.3) from January to March 2002.** V.N. Shnar, V.A. Khvichia and A.P. Malyshko (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, sea@atlant.baltnet.ru), 9 pp. (English, unpublished).

The results of research carried out during expeditions of RV *Atlantida* in the southern hemisphere during the summer–autumn period from 30 January to 14 March 2002 are presented. This research included a bottom trawl survey on the shelf of South Georgia, Shag Rocks and Black Rocks (53°10'–55°30'S 35°40'–42°50'W), an acoustic survey with control hauls targeting recorded aggregations on the South Georgia shelf (53°10'–55°30'S, 34°00'–39°40'W), and a series of oceanographic observations.

**WG-FSA-02/20**

**Some biological characteristics of Antarctic fish stocks in the Elephant Island, South Shetland Island region, in January–February 2002.** K.-H. Kock, C.D. Jones, J. Appel, G. von Bertouch, D.F. Doolittle, M. la Mesa, L. Pshenichnov, R. Riehl, T. Romeo, S. Schöling and L. Zane (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany, kock.ish@bfa-fisch.de), 24 pp. (English, unpublished).

Germany conducted a bottom trawl survey on board the RV *Polarstern* around Elephant Island and the lower South Shetland Islands in January–February 2002 in close collaboration with the US Antarctic Marine Living Resources (AMLR) Program. Length–weight relationships were similar in the two areas for those species for which an extended length range was covered (*Chaenocephalus aceratus*, *Champsocephalus gunnari*, *Lepidonotothen larseni*, *L. squamifrons*), but were more variable in species where the length range caught was limited as in *Notothenia rossii*

or *Chionodraco rastrospinosus*. Information on gonadosomatic indices was provided for *C. aceratus*, *C. gunnari*, *C. rastrospinosus*, *Cryodraco antarcticus*, *Notothenia coriiceps* and *Trematomus eulepidotus*. Dietary studies demonstrated that *C. gunnari* fed on krill, and to an unusually large extent, on fish. *C. aceratus* up to 30–35 cm in length took primarily krill and mysids. When they grew larger they likely became more sedentary and fed primarily on fish. *C. rastrospinosus* preyed primarily on krill and to a minor extent on fish. *C. antarcticus* took primarily fish.

**WG-FSA-02/21**

**Mesoscale abundance of fish in a 'box' west of Elephant Island.** K.-H. Kock, C.D. Jones, J. Appel, G. von Bertouch, D.F. Doolittle, M. la Mesa, L. Pshenichnov, R. Riehl, T. Romeo, S. Schöling and L. Zane (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany, kock.ish@bfa-fisch.de), 15 pp. (English, unpublished).

Germany, in close collaboration with the US Antarctic Marine Living Resources (AMLR) Program, conducted an investigation of a 7 x 10 n mile 'box' between 100 and 300 m depth to the west of Elephant Island (Subarea 48.1) in order to study the mesoscale abundance of demersal finfish species. Diversity in the box was relatively low. The most abundant species were *Gobionotothen gibberifrons* and *Champsocephalus gunnari*. Their distribution was very patchy even on a mesoscale. Concentrations of both species were found in a comparatively small band primarily along the 200 m isobath (160–240 m). Length distribution changed with fishing depth in *C. gunnari*, where larger fish were found predominantly in the stratum 200–300 m.

**WG-FSA-02/22**

**Demersal longlines with integrated weight: a preliminary assessment of sink rates, fish catch success and operational effects.** G. Robertson, M. McNeill, B. King and R. Kristensen (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 17 pp. (English, unpublished).

Conservation Measure 216/XX requires vessels fishing in Subarea 88.1 to sink longlines at 0.3 m/s to 15 m depth. Sink rates can be achieved by adding external weights to lines or by using lines with weights integrated into the rope fibres. The sink rates to 15 m depth of 9 mm demersal longlines with integrated weight (IW) were tested against unweighted longlines and lines with externally attached weights (6 kg/49 m) in the New Zealand ling fishery. Longlines with 0 g/m (unweighted), 25 g/m, 50 g/m, 75 g/m and 100 g/m IW averaged 0.11 m/s, 0.227 m/s, 0.272 m/s, 0.317 m/s and 0.353 m/s respectively. The longline with externally attached weights sank at 0.32 m/s. IW longlines sank instantly, reaching 1 m depth in 6–9 s whereas unweighted lines took >20 s to reach this depth. Catch rates of ling varied with line weight but results are indeterminant due to the small sample sizes. No operational effects of using IW lines were evident during the trial. IW longlines containing 50 g/m added weight are recommended for testing in a subsequent trial to examine the effectiveness of IW longlines in reducing seabird mortality in autoline longline fisheries.

**WG-FSA-02/23**

**The status of black-browed albatrosses (*Thalassarche melanophrys*) at Diego de Almagro Island, Chile.** K. Lawton, G. Robertson*, J. Valencia, B. Wienecke and R. Kirkwood (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, *graham.robertson@aad.gov.au). *IBIS*, in press (English).

The document reports the status of black-browed albatrosses at Diego de Almagro Island, Chile. Diego de Almagro holds about 15 600 breeding pairs distributed in six colonies on near-vertical cliffs and rock stacks on the west (Pacific) coast of the island. The black-browed albatross population at Almagro represents about 2% of the global population size for the species.

**WG-FSA-02/24**

**Standing stock estimates of finfish biomass from the 2002 RV *Polarstern***

**bottom trawl survey around Elephant Island and the South Shetland Islands (Subarea 48.1) with some notes on the composition of catches taken north of Joinville Island–D'Urville Island.** K.-H. Kock, C.D. Jones, J. Appel, G. von Bertouch, D.F. Doolittle, M. la Mesa, L. Pshenichnov, R. Riehl, T. Romeo, S. Schöling and L. Zane (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany, kock.ish@bfa-fisch.de), 42 pp. (English, unpublished).

Germany conducted a bottom trawl survey on board the RV *Polarstern* around Elephant Island and the South Shetland Islands in January–February 2002 in close collaboration with the US Antarctic Marine Living Resources (AMLR) Program. Information on species composition, biomass and size distribution of the abundant fish species was provided. Estimates of total biomass for Elephant Island and the South Shetland Islands separately were computed for *Notothenia rossii*, *N. coriiceps*, *Lepidonotothen larseni*, *L. squamifrons*, *Gobionotothen gibberifrons*, *Champsocephalus gunnari*, *Chaenocephalus aceratus* and *Chionodraco rastrospinosus*. For these species, biomass estimates were found to be comparable to survey results obtained in 1998 and 2001 for most species. Length compositions in the most abundant species resembled closely those in previous years. The proportion of juvenile *G. gibberifrons*, the most abundant species in the region, decreased significantly since 1998. No indication was found for the presence of a significant adult stock of *N. rossii* at Elephant Island where the species was known to occur in some quantities prior to commercial exploitation in 1979/80. It should be noted that more than 95% of the population of *N. rossii* prior to exploitation was confined to a comparatively small area north of the island and may have been missed by a survey not specifically directed at *N. rossii*. It is suggested to conduct a specific survey targeting *N. rossii* in the near future to properly assess the status of this stock.

**WG-FSA-02/25**

**How fast do demersal longlines sink?** G. Robertson, E. Moe, R. Haugen and B. Wienecke (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, graham.robertson@antdiv.gov.au), 8 pp. *Fisheries Research*, submitted (English).

Longlines that sink fast reduce the time available to seabirds to attack baited hooks and are important in efforts to minimise seabird by-catch in longline fisheries. We measured sink rates in still water of longlines made by Fiskevegn, the world's leading manufacturer of demersal longlines. Lines with integrated weight (lead cores) sank two–three times faster (45–52 cm/s) than conventional (unweighted) lines. Conventional lines made from 9 mm polyester sank at 23 cm/s compared to 18 cm/s for Silver lines of the same diameter. Samples of lines set by hand in still water sank significantly faster than longlines set from a fishing vessel.

**WG-FSA-02/26**

**Fecundity and size at sexual maturity of the bigeye grenadier (*Macrourus holotrachys*) at South Georgia (CCAMLR Subarea 48.3).** T.M. Mulvey, S.A. Morley, M. Belchier and J.D. Dickson (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 17 pp. (English, unpublished).

Fecundity and size at sexual maturity were investigated in 486 bigeye grenadier (*Macrourus holotrachys*) caught as by-catch in the Patagonian toothfish longline fishery conducted around South Georgia. Macroscopic and histological investigations revealed that absolute fecundity ranged from 22 000 to 260 000 eggs, a relatively high number for a macrourid. Mature ovaries were found to contain eggs at different stages of development suggesting that *M. holtrachys* may have an extended spawning season. Analyses of size at sexual maturity indicate that $L^{mat50}$ occurs at 29 cm (pre-anal length) whilst $L^{int50}$ occurs at 20.57 cm. The large difference between these values strongly

suggests that yolk deposition and final ovarian development is a prolonged process in *M. holotrachys* which probably lasts for a period of more than a year. Sex ratios of specimens caught in the longline fishery are highly skewed with females outnumbering males by a ratio of 32:1 which may represent the true ratio of females to males within the population or could suggest that females are more susceptible to capture by longlines than males.

**WG-FSA-02/27**

**Fecundity and egg size of Lithodid crabs from CCAMLR Subarea 48.3.** S.A. Morley, M. Belchier, J.D. Dickson and T.M. Mulvey (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 16 pp. (English, unpublished).

The fecundity and egg size of three species of lithodid crab caught in CCAMLR Subarea 48.3 was examined. Relative fecundity ($eggs^{-g\ body\ weight}$) and egg size was found to differ significantly between species. The highest relative fecundity and smallest egg size was found in *Paralomis spinosissima* which is found in shallower waters, whereas the lowest relative fecundity values and largest eggs were recorded in the deeper living species, *Neolithodes diomedeae*. In all species fecundity was observed to increase with increasing body size. Evidence is presented that closely related sympatric species and species found at different depths may employ quite different reproductive strategies.

**WG-FSA-02/28**

**Movement and growth of tagged toothfish around South Georgia and Shag Rocks (Subarea 48.3).** T.R. Marlow, D.J. Agnew and I. Everson (Marine Resources Assessment Group, 47 Prince's Gate, London SW7 2QA, United Kingdom), 14 pp. *CCAMLR Science*, submitted (English).

In 2000 the UK started a toothfish (*Dissostichus eleginoides*) tagging program. The aims were to investigate the spatial and temporal movement of fish and to validate growth estimates. Since then approximately 2 260 toothfish have been tagged and released during groundfish surveys and CCAMLR observer trips. Of these, about 900 have also been injected with either strontium chloride or oxytetracycline which places a marker on the otolith indicating the date of injection and release. To date, 50 fish have been recaptured, mostly from around Shag Rocks where there is greatest fishing activity. Most of the fish recaptured to date were tagged and released during the experimental pot fishing in 2000 and 2001, and have been at liberty from one to two years. Four fish were tagged and recaptured from the same longline vessel in 2002 after up to two months at liberty. The fish tagged during the groundfish surveys may not yet be large enough to be available to the longline fishery and there have been no recaptures of these fish tagged at South Georgia or elsewhere in the South Atlantic. Similarly, tags originating from elsewhere (e.g. the Patagonian shelf) have not been recaptured at South Georgia. Thirteen tags have been recovered at 42°S after about one year at liberty from some opportunistic tagging carried out on a toothfish pot vessel in international waters at that latitude in 2001.

**WG-FSA-02/29**

**Notes for identifying the three macrourid species, *Macrourus holotrachys, M. whitsoni* and *M. carinatus* in CCAMLR Subarea 48.3.** S.A. Morley, M. Belchier, M.G. Purves, T.M. Mulvey and J.D. Dickson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 10 pp. (English, unpublished).

Digital pictures and morphological measures are presented to aid CCAMLR observers with the identification of three macrourid species caught as by-catch in the fishery for Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3. Scaling under the snout was used to separate *Macrourus holotrachys* (no scales) from both *M. whitsoni* and *M. carinatus* (which are both scaled). The relative positioning of the second dorsal fin and the anal fin can also be used to distinguish *M. holotrachys*

from *M. whitsoni* and *M. carinatus*. To distinguish *M. whitsoni* from *M. carinatus* two scale counts were used. *M. whitsoni* has a head ratio (head length/inter orbital distance) of less than 5.2 whilst *M. carinatus* has a head ratio of greater than 5.2. There was some overlap in the ranges of most of these measures and so a single character will not always successfully identify a species. However, combinations of two or more characters should be successful. Genetic analysis of liver samples will confirm species identification.

**WG-FSA-02/30**

**Progress report on attempts to conduct an experiment on the effectiveness of mitigation measures used with the double-line system of longline fishing.** G. Robertson and P. Virtue (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 3 pp. (English, unpublished).

**WG-FSA-02/31**

**Information on the spawning season and gonadosomatic indices of *Dissostichus mawsoni* from Subarea 88.1 in the 2001/02 season.** G.J. Patchell (Sealord Group Ltd, PO Box 11, Nelson, New Zealand, gjp@sealord.co.nz), 17 pp. (English, unpublished).

Data on maturity, gonadosomatic index (GSI) and length/weight of Antarctic toothfish (*Dissostichus mawsoni*) were collected from Subarea 88.1 in the 2001/02 season by the New Zealand bottom longline vessels *Janas* and *San Aotea II* operating in the exploratory fishery. The onset of the spawning season was identified as late autumn (May). A significant difference in the condition of fish between summer and autumn was noted, and this may be a result of migration for spawning. The maximum GSI recorded for females was 26% with a 7.5 kg ovary. The maximum GSI was 43% for a stage 3 male weighing 20 kg, with the testes weighing 8.6 kg.

**WG-FSA-02/32**

**Review of identity and biology of species of the family Macrouridae, from the CCAMLR fishery in the Ross Sea, Antarctica.** P.M. Marriott and P. McMillan (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 14-901, Kilbirnie, Wellington, New Zealand, p.marriott@niwa.co.nz), 16 pp. *CCAMLR Science*, submitted (English).

Samples of macrourid rattail by-catch from the toothfish fishery in Subareas 88.1 and 88.2 in 2002 were identified by observers and returned to New Zealand for subsequent confirmation of their identity by NIWA researchers. Two species were found, *Macrourus whitsoni* and *M. holotrachys*. A previously aged sample from 1999 was confirmed as being *M. whitsoni* based on otolith comparisons and the geographic source of the aged sample. This confirms the preliminary age estimates from the ageing study.

Regression equations relating total length to snout–vent length, total length to weight, and snout–vent length to weight were generated. For all regressions there were significant differences between the sexes and between the data origins (NIWA and observer). Observer data were derived from fresh specimens and NIWA data were derived from frozen-and-thawed specimens.

The age and length at maturity for *M. whitsoni* males is 12 years and 46 cm TL, for females it was 14 years and 50 cm TL.

**WG-FSA-02/33**

**Evidence to support the annual formation of growth zones in otoliths of Antarctic toothfish (*Dissostichus mawsoni*).** P.L. Horn, C.P. Sutton and A.L. DeVries (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, p.horn@niwa.co.nz), 13 pp. *CCAMLR Science*, submitted (English).

Antarctic toothfish (*Dissostichus mawsoni*) from the Ross Sea (CCAMLR Subarea 88.1) have been aged assuming that one translucent zone is formed annually in the otoliths of this species. However, no evidence to validate this assumption has previously been presented. In the current work, sagittal otoliths were examined from *D. mawsoni* that had been injected with oxytetracycline some years

before recapture. The number of zones between the fluorescent oxytetracycline line and the otolith margin indicates that one translucent zone is formed annually in otoliths of post-mature *D. mawsoni*. Otoliths from four distinct juvenile length-frequency modes were also examined, and the translucent zones counted. Zone counts were consistent within modes, and increased by one in each consecutive mode. This indicates that the modes represented year classes and that one translucent zone is formed annually in otoliths of juvenile *D. mawsoni*. Mean fish lengths at ages 0.5, 1.5, 2.5 and 3.5 years were estimated to be 14, 28, 37 and 46 cm TL respectively. These estimates agree with growth curves calculated previously from a sample of data that was large but lacked any fish younger than 3.5 years. Counting translucent zones in the otoliths of *D. mawsoni* appears to be a valid method for determining the age of this species.

**WG-FSA-02/34**

**Fish stock assessment survey in Subarea 48.3.** I. Everson, T.R. Marlow, M. Belchier, R. Forster, S.A. Morley, A. North, J. Szlakowski and S. Wilhelms (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 7 pp. (English, unpublished).

This report presents the results from a fish stock assessment survey undertaken by the UK in January and February 2002 within Statistical Subarea 48.3 (South Georgia). We are extremely grateful to the UK Government in respect of South Georgia and the South Sandwich Islands for funding the survey.

**WG-FSA-02/35**

**Bottom trawls used in UK fish surveys in Subarea 48.3.** I. Everson, P. Hicken, T.R. Marlow, A. North, M. Belchier, C. Jones and T. Daw (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 9 pp. (English, unpublished).

Information on trawl configuration during UK demersal fish surveys is reviewed and the main causes of variation considered. Default values and equations are provided for all surveys in order to estimate swept area and headline height.

**WG-FSA-02/36**

**Seabird interactions/mortality with longliners and trawlers in the Falkland/ Malvinas Island waters.** Delegation of the United Kingdom, 90 pp. (English, unpublished).

Falklands Conservation (FC) estimated that between 1995 and 2000 the breeding population of black-browed albatross (*Thalassarche melanophrys*) in the Falkland/ Malvinas Islands declined by 87 500 pairs. This decline was the driving force for the FC Seabirds at Sea Team investigating seabird interactions and mortality associated with the two Patagonian toothfish (*Dissostichus eleginoides*) longliners and the large trawling fleet operating in the Falkland/Malvinas Island waters in 2001/02.

**WG-FSA-02/37**

**Research under way in New Zealand on seabirds vulnerable to fisheries interactions.** S. Moore and J. Molloy* (*Department of Conservation, Wellington, New Zealand), 13 pp. (English, unpublished).

**WG-FSA-02/38**

**The New Zealand toothfish fishery in Subareas 88.1 and 88.2 from 1997/98 to 2001/02.** S.M. Hanchet, P.L. Horn, M.L. Stevenson and N.W.McL. Smith (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, s.hanchet@niwa.cri.nz), 21 pp. (English, unpublished).

Results from the 2002 season of the New Zealand toothfish fishery in Subareas 88.1 and 88.2 are reviewed and compared to previous seasons. Catch and effort data and biological information for Antarctic toothfish (*Dissostichus mawsoni*) and Patagonian toothfish (*D. eleginoides*) are presented. The catch for the 2002 season was almost double that for 2001, and CPUE was the highest for any year. The principal by-catch species continues to be

the rattail (*Macrourus whitsoni*), with skates, particularly *Amblyraja georgiana*, the only other significant by-catch.

**WG-FSA-02/39**
**Information on incidental mortality of seabirds and other protected species in the US west coast pelagic longline fishery.** Delegation of the USA, 11 pp. (English, unpublished).

**WG-FSA-02/40**
**Review of rattail and skate by-catch, and analysis of rattail standardised CPUE from the Ross Sea toothfish fishery in Subarea 88.1, 1997/98 to 2001/02.** R.G. Blackwell and S.M. Hanchet (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand), 25 pp. (English, unpublished).

Little is known about the by-catch of skates, rays and macrourids in the target longline fishery for toothfish in the Ross Sea. Following concerns about the accuracy of reporting of by-catch raised by the 2001 CCAMLR by-catch subgroup, the processes for recording by-catch in this fishery were reviewed and the accuracy of data recording was investigated. Current systems were considered to be appropriate, and current by-catch protocols were found to perform adequately against CCAMLR guidelines.

Insufficient data have previously been available to evaluate the usefulness of a standardised CPUE analysis of macrourid by-catch in this fishery. The review of data suggested that the toothfish fishery has not yet had a detectable effect on the CPUE, and hence probably the abundance of rattails. Standardised CPUE analysis may be a useful method for the ongoing monitoring of this by-catch species, and continued monitoring of CPUE is suggested.

**WG-FSA-02/41**
**Preliminary standardised CPUE analysis of the New Zealand toothfish fishery in CCAMLR Subarea 88.1, from 1997/98 to 2001/02.** R.G. Blackwell and S.M. Hanchet (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand), 15 pp. (English, unpublished).

This report provides the first analysis of standardised catch per unit of effort (CPUE) from the exploratory fishery for Antarctic toothfish (*Dissostichus mawsoni*), which has operated in Subarea 88.1 for five seasons, from 1997 to 2002. Two analyses are presented. The first (all-ground) analysis reviewed catch from 1998 to 2002 (excluding the 1997 season as insufficient data were available), and included a number of areas that had been fished for only one season. The second (main-ground) analysis reviewed CPUE from the two main vessels involved in the fishery, and reviewed their catch from the main area of the fishery which had been consistently fished over most seasons.

For the all-ground analysis, variables area, season, length of line, soaktime, latitude and month in season entered the model, in order. This model explained 32% of the data variability, but was influenced by exploratory fishing activity. For the main-ground analysis, variables area, length of line, season, month, latitude, soaktime and type of set (research or exploratory) entered the model, in order. This model explained 34% of the data variability because it excludes fishing grounds that were fished for only one season. Annual indices from both models show an increasing trend over the duration of the fishery, except for the 2001 season. Fishing in 2001 was poor, as bad weather and thick ice conditions precluded access to the main fishing grounds. The index for 2002 is the highest in the series, which suggests that the New Zealand toothfish fishery is not under stress from the current level of fishing activity. However, both models have relatively low predictive power, and are a relatively poor fit to the data, and these trends should be interpreted with caution. This is due to the exploratory nature of the fishery, and the unbalanced nature of the distribution of effort among seasons. As only four years of data are available for analysis, these trends are considered to be preliminary indications only.

**WG-FSA-02/42**

**Morphometrics, maturity and movement of the Antarctic skates *Amblyraja georgiana* and *Bathyraja eatonii* in the Ross Sea.** M.P. Francis and N.W.McL. Smith (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand), 15 pp. (English, unpublished).

Regression equations relating total length (TL), pelvic length, disc width and weight are provided for *Amblyraja georgiana* by sex, and for both sexes combined. For all regressions, there were significant differences between the two sexes: females are broader and heavier than males at lengths greater than about 90 cm TL. There were insufficient data to adequately define length–length and length–weight relationships for *Bathyraja eatonii*, but preliminary regressions are provided for the two sexes combined. It is probable that large females are larger and heavier than males of the same size. The regressions for these species should be used with caution.

The length at 50% maturity for male *A. georgiana* is about 91 cm TL, and females appear to mature at a similar or slightly greater length. The length at 50% maturity of male and female *B. eatonii* could not be accurately determined, but may be around 90–100 cm, and greater than 100 cm respectively.

To date, c. 6 000 skates have been tagged in Subarea 88.1 from the 1999/2000 to the 2001/02 seasons. Returns suggest some long-term survival, small-scale migration within season, and limited movement between seasons. Results are considered preliminary, given the short time span of the program, and the confounding effect of spatial variation in fishing effort between seasons, resulting largely from changes in annual ice pattern.

**WG-FSA-02/43**

**Spatio–temporal trends of longline fishing effort in the Southern Ocean and implications for seabird by-catch.** G.N. Tuck, T. Polacheck and C.M. Bulman (CSIRO Marine Research, GPO Box 1538, Hobart 7001, Tasmania, Australia, geoff.tuck@csiro.au). *Biological Conservation*, in press (English).

Longline fisheries have expanded throughout the world's oceans since major commercial distant-water pelagic fleets began fishing for tuna and tuna-like species in the early 1950s. Along with the more recent development and expansion of demersal longline fleets for species such as Patagonian toothfish, these vessels are a major source of mortality to several species of seabird. Vessels can set many thousands of baited hooks in a day across many kilometres of water. These waters are often used as foraging areas by wide-ranging seabirds. Attracted by baits and offal, the birds can be caught on the baited hooks and subsequently drown. To provide a greater understanding of the potential impact of the Southern Ocean's longline fleets on seabird populations, this paper describes the trends in longline effort of the major pelagic and demersal fisheries in southern waters. The total reported effort from all longline fleets south of 30°S has been well over 250 million hooks per year since the early 1990s. However the spatial and temporal distribution of this effort has not been constant. While effort from the Japanese pelagic distant-water longline fleet declined through the 1990s, the Taiwanese fleet expanded dramatically. Likewise demersal fishing for toothfish increased markedly during the mid-1990s. These fisheries, along with substantial illegal longline fisheries, may be placing the long-term viability of many Southern Ocean species of seabird in jeopardy.

**WG-FSA-02/44**

**Mackerel icefish biomass and distribution on the results of acoustic survey carried out in February–March 2002.** S.M. Kasatkina, V.Yu. Sunkovich, A.P. Malyshko and Zh.A. Frolkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, sea@atlant.baltnet.ru), 33 pp. (English, unpublished).

Results of the acoustic survey of icefish carried out by the Russian RV *Atlantida* in February–March 2002 in Subarea 48.3 are

presented. Biomass and distribution of icefish were assessed using a multi-frequency echosounder EK500 and Sonar Data EchoView software.

Target strength estimates of icefish were made by comparing histograms of observed target strength *in situ* with the size composition of the ensonified fish, obtained by trawling.

Results of acoustic estimates of icefish biomass and abundance by size class in the pelagic zone and in the near-bottom 8 m layer (covered by bottom trawl survey) are discussed. The major part of the pelagic biomass was concentrated within 50 m of the bottom 8 m layer and amounted to 23 037.4 tonnes. This estimate can be considered to be the minimum value of the pelagic component of the icefish stock, since it does not take into account the biomass of the fish distributed within higher depth ranges where, according to the data from trawling and acoustic sampling, icefish are also available. The bottom biomass resulted in an estimate of 62 328 tonnes. The total acoustic estimate of the icefish biomass in the South Georgia subarea amounted to 92 600 tonnes. Nearly 30% of this biomass was concentrated in the pelagic zone. When acoustic estimates of pelagic and bottom components of the icefish biomass are compared, it is evident that the pelagic part of biomass makes up nearly 42% of the bottom biomass. Our acoustic estimate of the pelagic biomass constitutes about 60% of biomass obtained from bottom trawl surveys.

In addition to the above estimates, the abundance of juvenile fish (specimens less than 6 cm) was obtained in the sub-surface 50 m layer where, according to trawl samples, the latter predominated. The total abundance of young fish constituted 7 344.6 million individuals.

The horizontal and vertical distributions of krill with reference to the investigation of patterns of icefish behaviour and distribution are discussed.

**WG-FSA-02/45**

**Methods of comparative tests of bottom trawls (trawls systems).** A.S. Myskov, Zh.A. Frolkina, S.M. Kasatkina and P.S. Gasiukov* (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, *pg@atlant.baltnet.ru), 10 pp. (English, unpublished).

Proposals for comparative tests of bottom trawls are presented. The following items are discussed: place and time of trawling; preparatory work; comparative trawls; acoustic support; and processing of data.

**WG-FSA-02/46**

**Review of fish and invertebrate by-catch in trawl fisheries in Division 58.5.2.** E.M. van Wijk and R. Williams (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 21 pp. (English, unpublished).

This paper presents estimates of the total removals of fish and invertebrate by-catch by fishing season and fishing ground, from the *Dissostichus eleginoides* and *Champsocephalus gunnari* trawl fisheries in Division 58.5.2. On average, 94 % of hauls in the *D. eleginoides* fishery and 93% of hauls in the *C. gunnari* fishery were observed. The percentage of observed hauls was used as a scaling factor to convert observed by-catch weights to estimates of total by-catch removed from the fishery. By-catch in these trawl fisheries is very low. From 1996/97 to 2001/02, a total of 95 tonnes of by-catch was caught in the *D. eleginoides* fishery and 46 tonnes in the *C. gunnari* fishery. These values represent 1 and 2% respectively of the total catch weight (target and non-target species) in each fishery. The composition of the by-catch is described by fishing ground and fishery. The operation of the 'move-on' rule, which aims to minimise localised depletion of by-catch, is also discussed.

**WG-FSA-02/47**

**Preliminary assessment of *Champsocephalus gunnari* on the Heard Island Plateau (Division 58.5.2) based on a survey in May 2002.** A.J. Constable, R. Williams and T. Lamb (Australian Antarctic Division, Channel Highway,

Kingston 7050, Tasmania, Australia, andrew.constable@antdiv.gov.au), 10 pp. (English, unpublished).

A survey of mackerel icefish, *Champsocephalus gunnari*, was undertaken in Division 58.5.2 in the vicinity of Heard Island in May 2002 to provide the information for an assessment of yield in the 2002/03 CCAMLR season. This paper provides a preliminary assessment of yield using the assessment methods of CCAMLR and discusses the implications of these results in relation to previous CCAMLR assessments. The estimate of biomass of mackerel icefish for the population at Heard Island was not significantly different from previous years but the one-sided lower 95% confidence bound was greater than in 2001, probably because the population was more uniformly spread in the southeast with relatively high densities in that stratum. The composition of the population was observed to comprise a single large cohort of mostly three- and four-year-old fish in May 2002. Given the size of the fish, the expectation from current estimates of length-at-age parameters would be for most of the fish to be three year olds. However, given the abundance of fish in the population and the age structure of fish last year, it would be more reasonable to conclude that most of the fish are four years old, as this age class comprised the larger fraction (93%) of the population last year. Two assessments were undertaken as a result of the potentially different interpretations as to the composition of the larger cohort. If the cohort comprised mostly three-year-old fish, then the yield for 2002/03 is estimated to be 1 990 tonnes. If it comprises mostly four year olds then the yield would be 1 815 tonnes. It is also proposed that the minimum size of capture be increased for 2002/03 to protect the younger unassessed cohort of fish from being exploited as they potentially enter the fishery towards the end of the season.

**WG-FSA-02/48**

**Age, growth and size at sexual maturity of *Macrourus carinatus* from the CCAMLR fisheries in Division 58.5.2.** E.M. van Wijk, R. Williams and A.J. Constable (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 13 pp. *CCAMLR Science*, submitted (English).

Estimates of age and growth were determined from 156 *Macrourus carinatus* otolith samples collected during two research voyages to Heard and McDonald Islands (Division 58.5.2) in 1992 and 1993. The estimated range of ages was 4 to 25 years. Von Bertalanffy growth parameters were calculated for both sexes combined, resulting in values of: $L_\infty$ = 635 mm, $K$ = 0.088 and $t_0$ = -1.8. The size at sexual maturity of *M. carinatus* was determined from 162 specimens collected during commercial fishing operations in the Heard Island region in 2000. The size at which 50% of the fish population is mature, $L_{50}$, was 417 mm total length and the size at which 50% of the fish population have spawned for the first time, $L_{m50}$, was 512 mm total length. An updated length–weight relationship is provided from 633 specimens of *M. carinatus* collected from Heard and McDonald Islands and Macquarie Island. No difference was evident in the length–weight relationship from the two regions. Otolith and body size relationships were also calculated for *M. carinatus* from Division 58.5.2.

**WG-FSA-02/50**

**Implementation of the United States National Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries (NPOA-Seabirds).** K.S. Rivera (National Marine Fisheries Service, Alaska Region, PO Box 21668, Juneau, Ak. 99802, USA, kim.rivera@noaa.gov), 5 pp. (English, unpublished).

**WG-FSA-02/51**

**First Annual Report of the CCAMLR Otolith Network, 2002.** 16 pp. (English, unpublished).

This report presents results from the first exchange of otoliths under the auspices of the CCAMLR Otolith Network (CON), following the Workshop on Estimating Age in Patagonian Toothfish

held at the Centre for Quantitative Fisheries Ecology (CQFE), Old Dominion University, USA, from 23 to 27 July 2001. The National Institute of Water and Atmospheric Research, Nelson, New Zealand; Central Ageing Facility, Victoria Australia; and CQFE, each provided a sample of otoliths, processing and reading one randomly chosen otolith from each pair. Half of the remaining otoliths were sent to each of the other laboratories to process and read using their methodologies. Overall there was reasonable agreement in age estimations between all three readers, with no evidence of biases >2 years that would indicate major differences in the criteria used by the readers. Similarly, there was little evidence that the differences in preparation technique led to major biases or increases in variation in the ages estimated. Instead, there appears from these data to be a broad consensus on the otolith micro-features that need to be exposed during preparation, and the way to interpret them. Small biases and variance in several cases may be explained by apparent differences in the timing of formation of translucent zones between management areas, and readers' interpretation of the first few translucent zones. Future CON exchanges should: (i) define better how these differences in interpretation may affect age estimates; and (ii) achieve consensus on their interpretation.

**WG-FSA-02/53**

**Changes to seabird avoidance regulations in Alaska demersal longline fisheries based on scientific research on effectiveness of mitigation measures.** K.S. Rivera (National Marine Fisheries Service, Alaska Region, PO Box 21668, Juneau, Ak. 99802, USA, kim.rivera@noaa.gov), 9 pp. (English, unpublished).

The North Pacific Fishery Management Council (Council) recommended changes to the existing regulations for seabird avoidance measures required in the groundfish and halibut demersal longline fisheries off Alaska. One of the main recommendations is for the required use of paired streamer lines on larger vessels. Changes were based on research results from a two-year study conducted by the Washington Sea Grant Program (WSGP) on the effectiveness of seabird avoidance measures in the longline fisheries off Alaska. For complete details of the research, results and recommendations, see the WSGP final report. The report, *Solutions to Seabird By-catch in Alaska's Demersal Longline Fisheries*, is available at www.wsg.washington.edu/pubs/seabirds/seabirdpaper.html and was submitted to CCAMLR in 2001 (WG-FSA-01/35). Rigorous experimental tests of seabird avoidance measures on the local abundance, attack rate and hooking rate of seabirds in Alaska fisheries were conducted on vessels over 60 ft (18.3 m) LOA. Paired streamer lines of specified performance and material standards were found to successfully reduce seabird incidental take in all years, regions and fleets (88–100% relative to controls with no deterrent). This proposed action is prompted for two reasons: (i) an industry request to the Council to strengthen the seabird avoidance measures; and (ii) the availability of research results from a study on the effectiveness of seabird avoidance measures that suggest ways that the current seabird avoidance requirements can be improved.

The objective of the proposed regulatory change is to revise the current seabird avoidance requirements to improve their effectiveness at reducing the incidental take of endangered short-tailed albatrosses and other seabird species. The National Marine Fisheries Service is currently promulgating regulatory changes based on the Council's recommendations.

**WG-FSA-02/54**

**Identification of *Amblyraja* species in the longline fishery in CCAMLR Subarea 48.3.** M. Endicott, L.J.V. Compagno and D.J. Agnew (Renewable Resources Assessment Group, Imperial College, Royal School of Mines, Prince Consort Road, London SW7 2BP, United Kingdom, michael.endicott@ic.ac.uk), 14 pp. (English, unpublished).

We describe a previously unknown *Amblyraja*, *A. sp. anon*, from South Georgia. In the past this form has been classified as *Amblyraja georgiana. A. sp. anon* differs from *A. georgiana* in form, colour and patternation, maturity, male clasper length and distribution. It is larger than *A. georgiana*, with females attaining total lengths up to 122.5 cm and males 117.5 cm, compared with 96 cm and 101 cm respectively for *A. georgiana*. Male *A. sp. anon* attain 50% maturity at a total length of 97 cm, 13 cm greater than the length at 50% maturity for *A. georgiana.* Comparisons of colour and patternation were found to be consistent within each form, but significantly different between forms. Male *A. georgiana* were found to have proportionally longer claspers to total length (2.77% difference between averages) than male *A. sp. anon*. 94% of captures of *A. sp. anon* were found at depths >1 000 m, where 85% of *A. georgiana* were caught in depths between 300 and 500 m. We conclude that *A. sp. anon* is probably a separate species from *A. georgiana*. For the purposes of CCAMLR assessments and monitoring it should be treated as a separate species from *A. georgiana.*

**WG-FSA-02/55**

**Preliminary estimation of ray by-catch in the longline fishery in Subarea 48.3.** D.J. Agnew, J. Pearce and M. Endicott (Renewable Resources Assessment Group, Imperial College, Royal School of Mines, Prince Consort Road, London SW7 2BP, United Kingdom), 6 pp. (English, unpublished).

The total capture of rays in the Subarea 48.3 longline fishery is composed both of rays brought on board and a number that are knocked off the line or fall off before they reach the deck. We estimated total capture (ray numbers) for some vessels fishing in Subarea 48.3 in 2001 by utilising new information collected by observers on the rays appearing during their tally period. This estimate is entirely independent of vessel records of landed and discarded rays. For the one vessel that we have good species composition and mean weight data we have extended the number estimate to give capture weight by species.

**WG-FSA-02/56**

**A study of UK and Russian surveys using acoustics to augment trawling methods in shelf waters off South Georgia (Subarea 48.3).** S.M. Kasatkina, P.S. Gasiukov, C. Goss, I. Everson, M. Belchier, T.R. Marlow, A. North and M. Collins (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, atlant@baltnet.ru), 19 pp. *CCAMLR Science*, submitted (English).

In 2001/02 Russian and UK vessels undertook surveys of icefish at South Georgia. Both used acoustic and trawl methods, and this paper uses both datasets to explore the similarities and differences between the surveys and to discuss how much of the variation between the vessels was due to differences in the gear used and how much was due to natural spatial–temporal variability of the stock.

The acoustic surveys indicated that icefish were located not only near the seabed, but that a significant portion of icefish biomass was located in the water column. Thus the traditional approach of using bottom trawls to assess icefish standing stock has resulted in biased estimates lower than the true value: acoustic estimates are ~1.5 times greater. This should be taken into account in the forthcoming stock assessment during WG-FSA-2002.

These results show that the current system for the collection by observers of data for icefish stock assessment should be changed to include regular acoustic surveys. This will improve the stock estimates of this species, and to achieve this we recommend the development of new survey designs and corresponding methodology.

**WG-FSA-02/57**

**Progress report on age determination of mackerel icefish using otoliths.** P.S. Gasiukov, K. Shust and I. Everson (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, atlant@ baltnet.ru), 2 pp. (English, unpublished).

**WG-FSA-02/58**
**Workshop on austral summer 2002 fish surveys at South Georgia carried out by Russia and the UK** (9 to 20 September 2002, British Antarctic Survey, Cambridge, United Kingdom), 6 pp. (English, unpublished).

**WG-FSA-02/59**
**Standing stock estimates of mackerel icefish (*Champsocephalus gunnari*) from the UK and Russian bottom trawl survey in the 2001/02 season within Subarea 48.3.** (This paper was prepared during a joint UK/Russia workshop meeting from 9 to 20 September 2002 at British Antarctic Survey, Cambridge, United Kingdom [see WG-FSA-02/58]), 12 pp. (English, unpublished).

**WG-FSA-02/60**
**Behaviour of *Dissostichus eleginoides* fitted with archival tags at Heard Island: preliminary results.** R. Williams and T. Lamb (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 16 pp. (English, unpublished).

Thirty-nine *Dissostichus eleginoides* were released in the vicinity of Heard Island carrying archival tags in April 2002. Since then seven have been recaptured and the depth and temperature data they recorded are analysed here. Most of the fish had periods of active vertical movement alternating with periods of relative inactivity, loosely correlated with moon phase. The direction of vertical movement was influenced by the bottom topography, with fish on the relatively shallow plateau or in the bottom of a valley only moving upwards from their resting depth, while those on the intervening escarpment moved both upwards and downwards. Major vertical movements took place between 0500 and 1100 local time.

**WG-FSA-02/61**
**CMIX: user's manual and specifications.** W.K. de la Mare, A.J. Constable*, E.M. van Wijk, T. Lamb, D. Hayes and B. Ronai (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, *andrew.constable@antdiv.gov.au), 61 pp. (English, unpublished).

**WG-FSA-02/62**
**Generalised Yield Model: user's manual and specifications.** A.J. Constable, A.T. Williamson and W.K. de la Mare (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@antdiv.gov.au), 116 pp. (English, unpublished).

**WG-FSA-02/63**
**Fish Heaven Manual.** I.R. Ball and A.T. Williamson (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, ian.ball@aad.gov.au), 94 pp. (English, unpublished).

**WG-FSA-02/64**
**Revised selectivities for *Dissostichus eleginoides* taken by longliners in Subarea 48.3.** G.P. Kirkwood (Renewable Resources Assessment Group, Imperial College, Prince Consort Road, London SW7 2BP, United Kingdom), 12 pp. (English, unpublished).

Kirkwood and Agnew (WG-FSA-01/48) proposed an ad hoc method for estimating selectivity curves for toothfish taken by longliners around South Georgia and Shag Rocks, from 1995 to 1999. This method was applied by WG-FSA-01, with minor amendments, to estimate annual age-specific selectivities for the years 1995 to 2000 for input to the GYM assessment. In this paper, I propose a revised method for estimating the selectivities based on an assumption that the proportions of the total CPUE in an area for a particular length class that are taken in different depth zones are Beta-distributed. This removes some of the ad hoc nature of the former estimation method. The method is illustrated by application to data for 1995 to 2000.

**WG-FSA-02/65**
**Preliminary analysis on the Kerguelen Shelf icefish (*Champsocephalus gunnari*) stock from 1996/97 to 2001/02: no evidence of recovery!** G. Duhamel and

J. Claudet (Museum national d'histoire naturelle, Laboratoire d'ichtyologie générale et appliquée, 43 rue Cuvier, 752131 Paris Cedex 05, France, duhamel@mnhn.fr), 10 pp. (English, unpublished).

The icefish fishery on the Kerguelen Shelf ceased after the 1994/95 fishing season when 3 889 tonnes of *Champsocephalus gunnari* were landed (see CCAMLR *Statistical Bulletins*) because yields were not high enough and the lucrative fishery of Patagonian toothfish (*Dissostichus eleginoides*) diverted fishermen from these particular shallow-water fishing grounds. However, to monitor the situation in the area, fishery licences for trawlers have been accompanied by a requirement to conduct experimental cruises in the area in which fish aggregations have traditionally been found. Such cruises have been undertaken regularly by two trawlers from 1996/97 to 2001/02, the most recent season during which trawling took place in the Kerguelen EEZ. Preliminary results show no increase in icefish abundance in the surveyed area and biomass seems very low. It is a different situation from that of the Heard Island stock where biomass is sufficient to allow catches to be made. This situation is not clearly explained and various hypotheses are proposed: no recovery in a depleted stock, bad recruitment or emigration resulting from the ENSO 1998 effect in the vicinity of the islands, or an increase in predation by the growing population of fur seals (*Arctocephalus gazella)*. Other analyses (total and species-by-species biomass, quantity of the by-catch in the area) will follow this preliminary analysis.

*Champsocephalus gunnari* occurs on two fishing grounds around the Kerguelen Islands: the northeastern part of the Kerguelen Shelf and the Skif Bank (southwest of the shelf). A fishery developed mainly on the shelf from the 1970s to the 1990s with a cumulative catch up to 120 000 tonnes from 1980 to the present. Abundance was based on a succession of cohorts with a noted decrease from one cohort to another.

However with the increasing importance of *D. eleginoides*, fishermen abandoned the icefish fishery and data on stock became scarce. Short surveys were consequently made obligatory to enable the main fishing ground to be monitored from 1997 to 2002 and to allow the current status of the species in the northeastern sector of the shelf to be assessed.

**WG-FSA-02/66**

**Report on the pot fishing activities undertaken by FV *Viking Sky* from September to October 2001 in the South Western Atlantic Sector (37°–38°S and 42°S). Statistical Area 41.** O.D. Pin and H. Nión (Dirección Nacional de Recursos Acuáticos (DINARA), Montevideo, Uruguay), 13 pp. (Spanish, unpublished).

The northern geographical distribution of the Patagonian toothfish (*Dissostichus eleginoides*) extends to the Uruguayan Exclusive Economic Zone. Devincenzi recorded this species in Uruguayan waters, for the first time, in 1924. It is usually found by fishing trawlers at depths between 900 m and 1 200 m along the submarine continental ridges. Since 1997 some fishing vessels, such as the FV *Viking Sky*, began catching toothfish using cone-shaped bottom fishing pots with sardine and squid as frozen bait.

The *Viking Sky* conducted a fishing trip from 2 September to 11 October 2001, with a scientific observer from DINARA on board. The ship prospected for fishing grounds in both Uruguayan and international waters (FAO Statistical Area 41).

Three different fishing grounds were defined: Northern Zone I (37.48°–37.57°S, 53.43°–54.08°W), Northern Zone II (37.09°–37.42°S, 53.42°–53.40°W) and Southern Zone (42.17°–42.51°S, 57.57°–58.33°W).

The Southern Zone gave the highest fishing yield of 5.7 kg/pot/day, while Northern Zones I and II had very similar and inferior yields of 4.96 kg/pot/day and 5.38 kg/pot/day respectively.

The average, modal and median lengths were calculated for each sex. The majority of fish of both sexes sampled (84% of males and 89% of females) were at maturity stage 2, which means that most of the catch was made up of juveniles. The

selectivity of the fishing pots was determined to be for fish of 59 cm in length, as this was the minimum size caught.

Deep-water lobster (Crustacea) (*Thymops birsteini*) and grenadiers (*Macrourus* spp.) were caught as by-catch by the bottom pots.

**WG-FSA-02/67**

**Preliminary report on the fishing activities conducted by FV *Viarsa I* aimed at Patagonian toothfish (*Dissostichus eleginoides*) in the Eastern Indian Ocean (Statistical Area 57) from April to June 2002.** H. Nión and O.D. Pin (Dirección Nacional de Recursos Acuáticos, Montevideo, Uruguay), 15 pp. (Spanish, unpublished).

**WG-FSA-02/68**

**Short Note: Some software developments within the Australian Antarctic Division.** I.R. Ball and A.J. Constable (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, ian.ball@aad.gov.au), 5 pp. (English, unpublished).

**WG-FSA-02/69**

**Evaluation of the effects of illegal, unregulated and unreported (IUU) fishing on the legal catch of fisheries for *Dissostichus eleginoides*.** A.J. Constable (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@antdiv.gov.au), 13 pp. (English, unpublished).

CCAMLR currently establishes catch limits each year for Patagonian toothfish (*Dissostichus eleginoides*) that can be sustained over the generation time of the species, maintaining the population at a productive level with only a small chance of becoming depleted. The increasing levels of illegal, unregulated and unreported (IUU) fishing for toothfish in the CCAMLR Convention Area threatens the success of CCAMLR achieving ecologically sustainable fisheries as well as threatening the status of populations of this species. As a result of IUU fishing, the catch limits set by CCAMLR are being reduced each year to compensate for the effects of historical levels of IUU catches. To date, the rate of reduction of the legal catch limits does not seem to be commensurate with the rising levels of IUU catches. This paper explores the consequences of different rates of IUU fishing to the legally binding catch limits set by CCAMLR. The scenarios explored are with IUU annual catch at 0.33x, 1x, 2x and 4x a legal catch limit derived from an assessment based on the 2001 WG-FSA assessment which was approximately 3 000 tonnes. The IUU catches are applied with the legal catch limit being adjusted each year after the IUU catch and the legal catch were combined in the catch history and a new long-term sustainable annual catch was estimated using the GYM and applied as the legal catch limit for the following year, assuming no future IUU fishing. If there was no IUU fishing, the long-term sustainable annual yield is set according to the escapement part of the decision rule. With fishing at levels greater than the long-term sustainable yield because of IUU fishing, then the threat of depletion is increased and the legal catch limit needs to be reduced following each year that the total catch is above the sustainable levels. The closure of the legal fishery occurs when the spawning stock has been almost depleted to 20% of the pre-exploitation median biomass with a high probability of being depleted during the future projection period. Thus, low levels of IUU fishing may be tolerated, but only in the short term, while the spawning stock is above the target status of abundance. A long-term sustainable fishery requires that IUU fishing be at least reduced to levels that are much less than the long-term sustainable annual yield estimated using the CCAMLR assessment process. Continued IUU fishing at the rates reported by CCAMLR in 2001 will result in a closure of the legal fisheries in the Indian Ocean within the next 12 years, because it is in excess of the estimated long-term sustainable annual catch level. The rate of reduction of the legal catch limit is low because the effects of IUU fishing are averaged out in the assessment process over 35 years, assuming no more

IUU fishing takes place following the assessment. The consequence of IUU fishing is a precipitous decline in the legal catch limit once IUU fishing has mined the stock to a point that there is a high probability of the stock becoming depleted during the future projection period. Consequently, action to control IUU fishing would be too late if it was delayed until there was a significant reduction in the long-term annual yield obtained in the assessment process.

**WG-FSA-02/70**

**Preliminary assessment of *Dissostichus eleginoides* for the Heard Island Plateau region (Division 58.5.2) based on a survey in May 2002.** A.J. Constable, R. Williams and T. Lamb (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@antdiv.gov.au), 14 pp. (English, unpublished).

A survey of Patagonian toothfish (*Dissostichus eleginoides*) was undertaken in Division 58.5.2 in the vicinity of Heard Island in May 2002 to provide the information for an assessment of long-term annual yield in the 2002/03 CCAMLR season and beyond. This paper provides a preliminary assessment of yield using the assessment methods of CCAMLR, a summary of which is presented here. The estimate of biomass of juvenile Patagonian toothfish in the vicinity of Heard Island was similar to the results for 2001. The pooled length-density distribution for the 2002 survey shows that the younger year classes (ages 2 and 3) are likely to be much weaker than the current juvenile year classes (ages 4 to 8) in the survey area. The analysis also shows that larger fish seem to have left the survey area. The latest survey was used to update the recruitment series used in the assessment and resulted in estimates of recruitment being increased for some recent years. An assessment of the trend in illegal catches is expected to be undertaken at the Working Group on Fish Stock Assessment, including projections for the remainder of the season. Thus, a revision of the assessment provided here is expected to be needed following that work. The results indicate that the long-term annual yield based on the revised recruitment estimates is expected to be around 2 910 tonnes for 2002/03 CCAMLR season. This result is slightly greater than for the 2001/02 season because of the revision in the recruitment series. The time trend in spawning biomass, fishing mortality and recruitments arising from this assessment are presented.

**WG-FSA-02/71**

**An update on conversion factors for toothfish in the Ross Sea (Subareas 88.1 and 88.2).** J.M. Fenaughty and N.W.McL. Smith* (Ministry of Fisheries, Wellington, New Zealand, *smithn@fish.govt.nz), 7 pp. (English, unpublished).

This paper reports on continuing exploration of conversion factors and the relationship between product weight and length-frequency distribution in the exploratory fishery for *Dissostichus* spp. in Subarea 88.1 and more recently in Subarea 88.2.

**WG-FSA-02/72**

**United States research under way on seabirds vulnerable to fisheries interactions.** K.S. Rivera (National Marine Fisheries Service, Alaska Region, PO Box 21668, Juneau, Ak. 99802, USA, kim.rivera@noaa.gov), 7 pp. (English, unpublished).

**WG-FSA-02/73 Rev. 1**

**Food and feeding of two channichthyids, *Champsocephalus gunnari* and *Chaenocephalus aceratus*, around Elephant Island and in the South Shetland Islands (Subarea 48.1) in 2001 and 2002.** H. Flores, K.-H. Kock*, S. Wilhelms and C.D. Jones (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany, *kock.ish@bfa- fisch.de), 31 pp. (English, unpublished).

Data on food and feeding of two icefish species, *Champsocephalus gunnari* and *Chaenocephalus aceratus*, were collected in the Elephant Island–South Shetland Islands region during the AMLR cruise in March 2001 with RV *Yuzhmorgeologiya* and ANTXIX/3 in January–February 2002 with RV *Polarstern*. *C. gunnari* fed almost

exclusively on krill (*Euphausia superba*) in both years. *C. aceratus* fed on krill and other crustaceans as well as on fish. *C. aceratus* smaller than 30–35 cm relied primarily on krill and other crustaceans while larger fish preyed predominantly on fish. They fed mainly on locally abundant fish species which were *Gobionotothen gibberifrons* in 2001 and *Lepidonotothen larseni* and *C. gunnari* in 2002.

**WG-FSA-02/74**

**Age-at-length of Patagonian toothfish from the Falkland/Malvinas Islands.** J. Ashford, A. Arkhipkin, C. Jones and S. Bobko (Center for Quantitative Fisheries Ecology, Old Dominion University, Hampton Boulevard, Norfolk, Va. 23529, USA, jashford@odu.edu), 12 pp. (English, unpublished).

To provide an age–length key for use in modelling the age structure of the Patagonian toothfish (*Dissostichus eleginoides*) stock around the Falkland/Malvinas Islands, we used otoliths to estimate the age of a sample of 1 893 Patagonian toothfish captured by trawl and in the longline fishery. We used a thin section grinding machine to reveal a transverse plane through the otolith nucleus and between crenellations. Two readers undertook one reading each of the sections, estimating age using criteria agreed at the CCAMLR Otolith Network. Age estimates by the experienced reader were unbiased relative to reference ages. However, the second trainee reader consistently overestimated the age of younger fish, and her readings were not used in the analysis. Estimates of the von Bertalanffy parameters were $L_\infty$ = 129.3, $K$ = 0.12 and $t_0$ = -1.55 for females; for males, $L_\infty$ = 110.9, $K$ = 0.156 and $t_0$ = -1.12. Using these age data, we estimated total mortality to be $Z$ = 0.27.

**WG-FSA-02/75**

**Age-at-length of Patagonian toothfish from South Georgia.** J. Ashford, M. Belchier, C. Jones and S. Bobko (Center for Quantitative Fisheries Ecology, Old Dominion University, Hampton Boulevard, Norfolk, Va. 23529, USA, jashford@odu.edu), 17 pp. (English, unpublished).

To provide an age–length key for use in modelling the age structure of the Patagonian toothfish (*Dissostichus eleginoides*) stock around South Georgia, we used otoliths to estimate the age of a sample of 264 Patagonian toothfish captured in the longline fishery. We used a thin section grinding machine to reveal a transverse plane through the otolith nucleus and between crenellations. A single reader undertook three readings of the sections, estimating age using criteria corresponding to those given by the CCAMLR Otolith Network for toothfish from South Georgia. Age estimates during the first two readings were significantly biased relative to reference ages but the third reading, after the reader had read more than 3 000 otoliths, was not biased. For data pooled from this study and the South Georgia fisheries survey in 2000, estimates of the von Bertalanffy parameters were $L_\infty$ = 123.8, $K$ = 0.10 and $t_0$ = -2.1 for males; for females, $L_\infty$ = 144.9, $K$ = 0.085 and $t_0$ = -2.0. Using these age data, we estimated total mortality to be $Z$ = 0.054.

**WG-FSA-02/76**

**An updated assessment of the toothfish (*Dissostichus eleginoides*) resource in the Prince Edward Islands vicinity and extensions taking commercial catch-at-length data into account.** A. Brandão, D.S. Butterworth, B.P. Watkins and L. Staverees (Marine Resource Assessment and Management Group, Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa), 24 pp. (English, unpublished).

The CPUE-based age-structured production model (ASPM) assessment of this resource by Brandão et al. (2001) is updated to take account of further catch and effort data that have become available over the past year. This leads to an improved picture of resource status compared to a year previously, but a spawning biomass nevertheless still estimated to be heavily

depleted and at a level of only a few percent of its average pre-exploitation abundance. However, predictions from this assessment are at variance with the observed length-frequency distributions for the fishery. It is important that the assessment model be refined to provide a consistent explanation of all available data, as this might not only alter perceptions of the status of the Prince Edward Island resource, but also have important consequences for the assessments of other populations of toothfish in the CCAMLR region.

**WG-FSA-02/77**

**Age and growth of Scotia Sea icefish (*Chaenocephalus aceratus* Lönnberg, 1906) from the South Shetland Islands.** M. la Mesa, J. Ashford, E. Larson and M. Vacchi (Institute for Marine Fisheries Research, Largo Fiera della Pesca, 60125 Ancona, Italy, lamesa@irpem.an.cnr.it), 26 pp. (English, unpublished).

Samples of *Chaenocephalus aceratus* were collected during a trawl survey carried out around the South Shetland Islands in the austral summer 2002 (January–February). Fish were caught by commercial bottom trawl fishing down to 500 m depth, using a stratified randomised sampling design. As observed in other recent surveys within the same area, *C. aceratus* represented one of the predominant species. Overall, 357 specimens ranging from 13 to 67 cm (TL) were selected for the present study. Ages were estimated by counting annuli present in the sagittal otoliths, exposed by grinding and polishing along their sagittal plane. To estimate the precision of age data, we compared blind readings by readers from different institutes. The age range was 1–17 years for females and 1–15 years for males. Von Bertalanffy growth curves were fitted to the estimated age–length data for each sex. The estimated values of asymptotic length $L_\infty$ (cm) and $K$ (year$^{-1}$) were respectively 79.8 and 0.07 for females and 60.0 and 0.09 for males. The growth performance index ranged between 2 and 2.5, similar to that reported in other icefish. Sexual maturity was attained by females and males at about 10 and 9 years old respectively, at about 60% of their maximum estimated age. These results are compared with age and growth data available in the literature for *C. aceratus*, and discussed in the light of recent commercial exploitation.

**WG-FSA-02/78**

**Stock assessment of *Dissostichus eleginoides* in Subarea 48.3 using dynamic production models (DPM).** P.S. Gasiukov and R.S. Dorovskich (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, pg@atlant.baltnet.ru), 11 pp. (English, unpublished).

Dynamic production models (DPM) have been proposed for *Dissostichus eleginoides* stock assessment in Subarea 48.3. This type of model differs from the models currently used by the CCAMLR Working Group on Fish Stock Assessment as it does not require certain initial data and parameters (natural mortality, age selectivity, recruitment estimates, mean weight at age). In the calculations with DPM (with Schaefer and Fox production functions) the following were used: total yield for a series of years, abundance index describing inter-year biomass dynamics (standardised catch per unit effort for 1986–2001) and fishing effort estimates by years of fishing.

Both models showed that the *D. eleginoides* stock status at the initial period of intensive fishery was at the level of 22 000–24 000 tonnes. In 1989/90 stock size increased (to ~31 000 tonnes) and then gradually declined, having reached the minimum size of 12 000 tonnes in recent years.

The trends in biomass dynamic estimated by DPM are very similar with trends from the dynamic age-structured production model (ASPM) (Gasiukov and Dorovskich, 2000): DPM and ASPM display more than a twofold decline of total biomass from 1990 to the present.

**WG-FSA-02/79**

**Distribution, biological characteristics and biomass of icefish from the results of an inventory trawl survey carried out by RV *Atlantida* from January to March**

**2002.** Zh.A. Frolkina and P.S. Gasiukov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, sea@atlant.baltnet.ru), 16 pp. (English, unpublished).

Results of an icefish trawl survey carried out by the Russian vessel RV *Atlantida* in February 2002 in Subarea 48.3 are presented. During this period, the fish were mainly foraging. *Champsocephalus gunnari*, of 22 to 28 cm in length at age 2–3 years, predominated on all grounds of the subarea, except in the northeastern sector. During the survey, specimens 15 cm in length at age 2 predominated in pelagic catches. An unusual characteristic of *C. gunnari* biology in 2002 was a high internal fat condition index combined with low stomach fullness. On the eastern part of the shelf, a considerable number of pre-spawning specimens were detected, which was not usual for that month. Total biomass near the bottom estimated by different methods was 38 000–45 000 tonnes.

**WG-FSA-02/81 Rev. 1**
**Estimates of the total removal of *Dissostichus* spp. from inside and outside the Convention Area for the 2001/02 fishing season.** CCAMLR Secretariat, 6 pp. (English, unpublished).

**WG-FSA-02/82**
**Preliminary data on seabird by-catch along the Patagonian Shelf by Argentine longline fishing vessels from 1999 to 2001.** Delegation of Argentina, 6 pp. (English, unpublished).

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