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 2001. It corresponds to the Twentieth 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(iii) scientific papers not intended for publication, which are listed as 'unpublished'; and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-XX/BG/11 (background document number 11 submitted at the Twentieth Meeting of the Scientific Committee); or WG-EMM-01/8 (document number 8 submitted at the 2001 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Unpublished papers must not be cited without written permission of the author(s).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-XX/BG/2
Beach debris survey – Main Bay, Bird Island, South Georgia, 1999/2000. M.J. Jessopp (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 19 pp. (English, unpublished).

During the 10th year of standardised beach surveys of man-made debris at Bird Island, South Georgia, a total of 408 items was collected. This represents a 92% increase on the total of 213 items collected in 1998/99, but is consistent with numbers in years prior to 1998/99. A dramatic increase (310%) in the number of items collected over winter (April–September) from 41 items in 1998/99 to 168 items in 1999/2000 and a 40% increase in the number of items collected during summer reflect a return to the levels observed prior to 1998/99. Debris associated with fisheries remains the major constituent of all beach debris collected. This is a cause for concern, and suggests that CCAMLR needs to intensify its campaign to reduce the amount of man-made debris jettisoned into the Southern Ocean by fishing vessels.

SC-CAMLR-XX/BG/3
Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Bird Island, South Georgia, during the 2000 winter and 2000/01 breeding season. M.J. Jessopp (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 26 pp. (English, unpublished).

Results of the survey of entanglements of Antarctic fur seals at Bird Island, South Georgia, for the 11th consecutive winter (2000) and 13th consecutive summer (2000/01) are reported here. The number of entanglements showed an increase from recent years, with 20 entanglements reported over winter and 22 during the summer breeding period. There were over three times more entanglements over the 2000 winter than in 1999, some of which can be explained by interannual variation in the fur seal population. Entanglements reported over summer were also up 57% on the previous year. Severe injuries accounted for 35% of entanglements over winter and 23% during the summer. As in previous years, most individuals observed entangled in debris were juveniles (80% of winter and 68% of summer observations). Of those entanglements where the animal could be sexed, males dominated the observations, comprising 67% of records over winter and 59% during the summer pup-rearing period. The higher proportion of entangled males in the winter compared to summer reflects the sex ratio of Antarctic fur seals ashore over the winter months at Bird Island. Plastic packaging bands accounted for the majority of all entanglements in both the summer and winter periods. The prevalence of these bands in the Southern Ocean marine environment is cause for concern, as the number of entanglements involving them has increased to levels comparable with those before the CCAMLR ban on their use. This highlights the need for continued monitoring and increased effort in ensuring correct disposal of debris with the potential to entangle wildlife at sea.

SC-CAMLR-XX/BG/4
Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Signy Island, South Orkney Islands, 2000/01. A.S. Lynnes (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 9 pp. (English, unpublished).

The results of the fifth annual survey of entanglement of Antarctic fur seals at Signy Island, South Orkney Islands, are reported for the 2000/01 summer season. This is the first year in which there were no sightings of seals with neck collars of man-made debris. Data are compared with results from a parallel study undertaken at Bird Island, South Georgia, in 2000/01. In contrast to Signy Island, these indicated that the number of entangled fur seals had increased (by 57%) compared to the previous year. The absence of entangled seals at Signy Island could be due to the relatively low numbers of seals coming ashore (10 091) – 51% fewer than 1999/2000. Notwithstanding this, the incidence of entanglement has been following a declining trend since 1998/99. Nevertheless, CCAMLR Members need to continue their campaign to ensure

that vessels are aware of, and comply with, regulations prohibiting the disposal of debris at sea.

SC-CAMLR-XX/BG/5
Beach debris survey – Signy Island, South Orkney Islands, 2000/01. A.S. Lynnes (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 15 pp. (English, unpublished).

During the 2000/01 austral summer the 11th annual beach debris survey was carried out at Signy Island, South Orkney Islands. Debris was cleared each month between November and March from three study beaches. The debris was counted, measured and classified by type, material, mass and size categories. A total of 16 items weighing 0.74 kg was collected. The number of items and the total mass of the waste recovered was the lowest ever recorded (decreases of 70% and 93% since 1999/2000 respectively). The number of plastic packaging bands (one) was also the lowest ever recorded and follows a declining trend since 1993/94. This may indicate that the ban on their use on board fishing vessels, adopted by CCAMLR in 1995/96, has been effective and should continue. Plastic waste was predominant, as in previous seasons, with the proportion of plastic items (56%) being the third highest reported since surveys began. Classifying the waste by source revealed that 44% had come from ships or fishing vessels and 6% were from Signy Research Station. The rest comprised wood (25%) and items with no obvious source (25%). The duration of sea-ice around Signy Island was prolonged in 2000/01 and may have limited the amount of marine debris washed ashore. However, with the exception of 1998/99, the quantity of waste recorded at Signy Island has been showing a declining trend since 1993/94. 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-XX/BG/7
Anthropogenic feather soiling, marine debris and fishing gear associated with seabirds at Bird Island, South Georgia, 2000/01. D.R. Roberts (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 oil, paint, marine debris and fishing gear associated with seabirds at Bird Island, South Georgia. In this, the eighth year of standardised recording, an unprecedented quantity of hooks (both with and without longline attached) and monofilament longline originating from fishing vessels was recorded in association with wandering albatrosses. Quantities of fishing gear remained within the levels of previous years for all other species. Marine debris, the vast majority of which was plastics, showed a 28% increase from the maximum of the previous year for grey-headed albatrosses, but a 24% decrease from the maximum of the previous year for wandering albatrosses. The recently noted trend of black-browed albatrosses regurgitating marine debris continued. Two female wandering albatrosses, feather-soiled by red paint on the head and neck, were observed. Human food waste was once again associated with wandering and black-browed albatrosses, and for the first time, with grey-headed albatrosses. One Antarctic prion stomach, out of five dissected, contained a small piece of plastic, this being the first occasion that marine debris has been found in association with this species at South Georgia.

SC-CAMLR-XX/BG/11 Rev. 2
IMALF assessment of new and exploratory fisheries by statistical area. Ad Hoc Working Group on Incidental Mortality Arising from Longline Fishing, 27 pp. (English, unpublished).

SC-CAMLR-XX/BG/16
Monitoring marine debris and its impact on marine living resources in Antarctic waters. E.N. Sabourenkov (Science Officer, CCAMLR Secretariat), 17 pp. (English, unpublished).

This paper was prepared by the CCAMLR Secretariat in response to a request from CEP-IV for information on actions taken by CCAMLR on marine debris from fishing vessels, especially in relation to compliance with Annex IV of

the Protocol on Environmental Protection to the Antarctic Treaty (CEP-III Final Report, paragraph 19).

A number of measures have been adopted and implemented by CCAMLR to monitor and assess the level of marine debris and its impact on marine living resources in Antarctic waters. Long-term programs have been initiated at a number of sub-Antarctic and Antarctic sites. These programs include surveys of beached marine debris, surveys of fishery-related marine debris associated with colonies of marine mammals and seabirds, ingestion by seabirds of plastic materials and entanglement of marine mammals in fishery-related debris. During recent years surveys of beached marine debris have been conducted in accordance with a standard method. Standard forms have been created for the collection and submission of data from other marine debris studies. All data collected are submitted to the CCAMLR database for analysis. As the number of long-term marine debris programs established by CCAMLR Members is still relatively small, the amount of information collected at present is insufficient to ascertain trends in the accumulation of debris and its impact on marine animals.

A special conservation measure was adopted by CCAMLR to regulate the use and disposal of plastic packaging bands on fishing vessels. In order to prevent pollution from marine debris in the CCAMLR Convention Area, a large proportion of which appears to originate from fishing vessels, CCAMLR launched an educational campaign aimed at fishermen. CCAMLR keeps the issue of marine debris under annual review.

SC-CAMLR-XX/BG/18 Rev. 1
The importance of pathology studies on top predators of the Antarctic marine ecosystem. O. Blank and D. Torres (Área Científica, Instituto Antártico Chileno (INACH), Rómulo Correa 375, Punta Arenas, Chile), 5 pp. (Spanish, unpublished).

This document summarises the position stated by the authors in four documents presented to the recent WG-EMM-2001 meeting, with respect to the detection of antibodies that protect against infections in Antarctic Pinnipedia during investigations carried out in the most recent three summer seasons at Site No. 2 (Cape Shirreff and San Telmo Islands). The discussion focuses on the points of the meeting's report which disagree with the views of the authors, and justifies the need to encourage and focus future investigations on the pathologies of top Antarctic predators. It is proposed that there is no need to wait for some catastrophic event to take place in order to study this subject, which is simply another active component of the Antarctic marine ecosystem. Therefore, support from the Scientific Committee is requested to carry out these investigations, given that the approval of this Committee would endorse the acceptance of the information presented. This type of information was non-existent until now, and is a step towards the understanding of the currently unknown dynamics and effects of the pathologies pertinent to the most important predators of the Antarctic marine ecosystem.

SC-CAMLR-XX/BG/21
Marine debris survey in the coastal region of the research station Artigas (BCAA), King George Island, during the 2000/01 season. Delegation of Uruguay, 8 pp. (Spanish, unpublished).

Uruguay has developed a program of surveying marine debris in the coastal areas near its research stations within the Antarctic Treaty Area; in the Convention Area this program covers Statistical Subarea 48.1, where the marine research station Artigas (BCAA), King George Island (or Isla 25 de Mayo), is situated. A marine debris survey was carried out on selected beaches along the coastal strip which are accessible from the station.

SC-CAMLR-XX/BG/22
Review of data submitted by Members on marine debris and its impact on marine living resources. CCAMLR Secretariat, 21 pp. (English, unpublished).

SC-CAMLR-XX/BG/24
Subdivision of large CCAMLR Statistical Areas for the management of the krill fishery. Delegation of Australia, 16 pp. (English, unpublished).

In this paper the boundaries of the CCAMLR statistical areas are examined for their relevance to the management of the krill fishery. A rationale for creating some new areas is developed based on data on krill distributions. The overall aim of the

exercise was to reduce the large size of many of the existing statistical areas to the point where all areas where krill occur could be surveyed by a single vessel. Areas where krill appeared to be generally absent were separated from those areas where krill appeared to be abundant. Areas where there were identified concentrations or 'stocks' were kept intact wherever possible. The resultant map of suggested management areas gives a series of subdivisions of far more regular size than the existing map of statistical areas.

SC-CAMLR-XX/BG/25
Marine debris collected at Cape Shirreff during the 2000/01Antarctic season. D. Torres, V. Vallejos, R. Hucke-Gaete, L. Osman and R. Vargas (Departamento Científico, Instituto Antártico Chileno, Casilla 16521, Correo 9, Santiago, Chile), 12 pp. (English, unpublished).

The eighth annual beach debris survey was carried out at Cape Shirreff (62º28'S, 60º48'W), Livingston Island, South Shetland Islands, during the austral summer of 2000/01. All debris was collected once a month during January and February 2001 from 36 sites after the snow had melted.

The debris was counted for each site, measured, weighed and classified into four categories: plastic, metal, glass and paper. A total of 1 774 articles weighing 124.5 kg was analysed. As in all previous Antarctic seasons, plastic material was the most abundant item, comprising 1 736 articles which represents 97.86% of the total. The other items consisted of: metal – 15 articles (0.85%), glass – 16 articles (0.90%), and paper – 7 pieces (0.30%).

It is important to note that 589 plastic bands were found, which represents 34% of all plastic items. Of these bands, 40 were ringlike and 48 were in the form of loops with knots. This demonstrates contravention of Conservation Measure 63/XV and Annex IV of the Madrid Protocol. Moreover, several articles, mainly plastics, were totally or partially oiled, as was a wing of a kelp gull (*Larus dominicanus*); as in previous seasons, some plastic articles were found partially burnt.

Sixty-three plastic items were identified as of Korean origin (3.6%), including several printed plastic bands, corresponding to 51% of the total identified items. For the first time an article from the Philippines was recorded.

It is necessary to reinforce the CCAMLR plan to distribute the poster and placards calling on all Parties to cooperate in the protection of the marine environment.

SC-CAMLR-XX/BG/26
Conservative management of the Antarctic krill fishery. The Antarctic and Southern Ocean Coalition, 4 pp. (English, unpublished).

SC-CAMLR-XX/BG/27
South American strategy for the conservation of albatrosses and petrels 'ESCAPE'. Delegation of Brazil, 3 pp. (English, unpublished).

The First South American Workshop on the Conservation of Albatrosses and Petrels was held in September 2001, in Punta del Este, Uruguay.

The measures proposed by the workshop are similar to CCAMLR's conservation measures. Additionally, ESCAPE encourages an Environmental Impact Assessment (EIA) prior to the opening of new fisheries, and the development of catch certification and of eco-labelling.

Cooperation between ESCAPE and CCAMLR will certainly help to minimise bird by-catch in longline fisheries.

SC-CAMLR-XX/BG/28
Measures taken by Brazil to minimise the incidental mortality of seabirds outside the Convention Area. Delegation of Brazil, 3 pp. (English, unpublished).

SC-CAMLR-XX/BG/30
Modelling whale distribution: a preliminary analysis of data collected during the CCAMLR–IWC Krill Synoptic Survey, 2000. S. Hedley, S. Reilly, J. Borberg, R. Holland, R. Hewitt, J.L. Watkins, M. Naganobu and V.A. Sushin (NMFS Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA). SC/53/E9: 19 pp. (English).

We use data collected during the CCAMLR–IWC Krill Synoptic Survey (2000) to investigate relationships between cetacean density, krill density and oceanographic conditions. We explore the use of generalised additive models (GAMs) to

model these relationships, and show how these models can provide abundance estimates for subareas within the survey region, as well as for the survey region itself. Abundance estimates from a simple conventional line transect analysis are also presented.

Working Group on Ecosystem Monitoring and Management

WG-EMM-01/5
CEMP indices 2001: analysis of anomalies and trends. CCAMLR Secretariat, 54 pp. (English, unpublished).

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

WG-EMM-01/5 Appendix
CEMP index data report (all data). CCAMLR Secretariat, 135 pp. (English, unpublished).

WG-EMM-01/8
From KYM to GYM: The development of the krill yield model. CCAMLR Secretariat, 9 pp. (English, unpublished).

In 2000, WG-EMM asked the Secretariat to compile the documentation of the krill yield model. This paper provides a starting point for a set of reference documents which could be held electronically on the CCAMLR website and/or on CD-ROM.

WG-EMM-01/9
CEMP indices and the development of ecosystem assessments. CCAMLR Secretariat, 13 pp. (English, unpublished).

In 2000, WG-EMM asked the Secretariat to review the historical development of CEMP indices and ecosystem assessments. This paper provides a starting point for such a review and for a set of reference documents which could be held electronically on the CCAMLR website and/or on CD-ROM.

WG-EMM-01/10
Demography of Antarctic krill in the Elephant Island area (Antarctic Peninsula) during austral summer 2001. V. Siegel, B.I. Bergström, U. Mühlenhardt-Siegel, M.A. Thomasson (Sea Fisheries Research Institute, Palmaille 9, D-22767 Hamburg, Germany), 18 pp. (English, unpublished).

A net sampling survey was carried out for krill in an established standard station grid around Elephant Island from 27 January to 4 February 2001. Results show a spatial separation of the juvenile and spawning stocks. The station grid was extended to the south where a large proportion of small size classes, i.e. one-year-old juvenile krill, was found. Krill density was significantly higher than during past years (between 198 and 230 krill/1 000 m^{-3}, i.e. between 40 and 46 m^{-2} or 11.3 g m^{-2}). The proportional recruitment index for the entire survey area for the 1999/2000 year class was R1 = 0.573, and the absolute index was RI1 = 131.4 * 1000 m^{-3}, which is among the highest values for the past 20 years. The high krill abundance and the high recruitment index reflect the end of a succession of years with poor recruitment success. The maturation index (G, according to gravid stages), which is discussed as an indicator of a successful spawning season, was G = 0.99, indicating an early initiation of the spawning season. This is thought to be the first step for a successful spawning event and a later potentially successful recruitment of the 2000/01 year class. The spatial extent of the station grid is discussed in the light of a representative coverage of the stock and the estimated recruitment index.

WG-EMM-01/11
Comparison of temperature near South Georgia in December–February, 1989–1990, 1990–1991, 1999–2000 and 2000–2001 using satellite data and information on krill catches in Subarea 48.3. G. Vanyushin (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia), 15 pp. *CCAMLR Science*, submitted (English).

Monitoring of the sea surface temperature (SST) in Subarea 48.3 using satellite data (GOES-E, Meteosat), use of *in situ* data and the further analysis of maps of SST anomalies and dynamics provide a limited

but consistent set of data on hydrological conditions in the survey area. Analysis based on data obtained from expeditions and in the literature, as well as CCAMLR materials could allow us to assess, with a certain degree of reliability, the potential situation for the krill fishery in Subarea 48.3 during the entire forthcoming year by the beginning of summer. The reliability of the krill fishery forecasts could be assessed only by the actual results of fishing activities under various hydrological conditions. This work is an attempt to perform such an analysis using various materials obtained in 1989–1991 and 1999–2001.

WG-EMM-01/12

Sources of variance in studies of krill population genetics. S.N. Jarman and S. Nicol (CSIRO Marine Research, GPO Box 1538, Hobart 7001, Tasmania, Australia). *CCAMLR Science*, 9: in press (2002). (English).

There has been a long-term interest in the population genetics of Antarctic krill species because of their ecological and economic importance. The possibility that there are distinct genetic stocks of these species would affect the design of management strategies for their conservation. A recent resurgence of interest in identifying distinct stocks of swarming krill species has been driven by the development of genetic technologies that are more sensitive to subtle population structure than older methods. Previous studies of the population genetics of the Antarctic species *Euphausia crystallorophia* and *E. superba* and the boreal species *Meganyctiphanes norvegica* that used allozymes found no evidence of genetic population structure. More recent investigations using sequence variation in mitochondrial DNA (mtDNA) have exposed genetic differentiation between samples taken from different parts of each species' range. However, the underlying assumption of these studies that differentiation between samples is caused primarily by restricted gene flow between widely separated sampling sites may be incorrect. Our recent study of *E. crystallorophias* mtDNA variation has indicated that there is significant genetic differentiation between samples taken within one region. This has important implications for the design of future studies of krill population genetics, which must be able to accommodate this sympatric variance component as well as variance attributable to differences between regions. Genetic differentiation between stocks of krill in different regions can therefore not be adequately assessed unless multiple samples are taken from each region.

WG-EMM-01/13

Distribution and size of Antarctic krill (*Euphausia superba* Dana) in Polish commercial catches in the Atlantic Sector of Antarctica from 1997 to 1999. E. Jackowski (Sea Fisheries Institute, Kollataja 1 Street, 81-332 Gdynia, Poland), 27 pp. *CCAMLR Science*, submitted (English).

The distribution and internal structure of commercial krill concentrations were investigated in the regions of the South Shetland, Elephant, South Georgia and South Orkney Islands in spring and summer from 1997 to 1999. The concentration densities varied with area and season. The densest concentrations were found near the South Shetland Islands. Concentrations at night were several times less dense than those during the day. From February to April concentration density increased, while in May and June it decreased. From February to June the period of daylight becomes progressively shorter, therefore it must be assumed that there are factors other than daylight which have an impact on the degree of krill concentration. The internal structure of the concentration was very diverse and the mean density varied from 11 to 31 370 specimens per 1 000 m^3. At night, the krill concentrations were scattered throughout the water, however no clear evidence of vertical migration was found. From February to April, the night concentrations occurred in much shallower waters than during the day, while in May and June they occurred at the same depths as the day concentrations or sometimes even deeper. The day concentrations in February–April were in shallower waters, while from April to June they were found in deeper waters. The size structure of krill was diverse during all periods and in all areas, however a decrease in krill size was observed as the season progressed.

WG-EMM-01/14

An investigation of avoidance by Antarctic krill of RRS *James Clark Ross*

using the *Autosub-2* autonomous underwater vehicle. A.S. Brierley, P.G. Fernandes, M.A. Brandon, E. Armstrong, D.G. Bone and the *Autosub* Team (Gatty Marine Laboratory, University of St Andrews, St Andrews, Fife KY16 8LB, United Kingdom), 18 pp. (English, unpublished).

The autonomous underwater vehicle (AUV) *Autosub-2* was deployed on eight missions ahead of RRS *James Clark Ross* in the northern Weddell Sea and in the Bransfield Strait to assess avoidance of the research vessel by Antarctic krill (*Euphausia superba*). The AUV was equipped with the same type of scientific echosounder as the research vessel (Simrad EK500 operating at 38 kHz and 120 kHz) and measured the density of krill along transects acoustically (g m^{-2} wet mass) prior to the ship's arrival. We hypothesised that if krill avoided the ship, perhaps in response to radiated noise, then the ship should detect less krill than the AUV (which is very quiet). We were unable to detect any significant difference between the amount of krill detected by the ship or the AUV, either at the transect level or at finer scales within transects. We conclude, therefore, that avoidance by krill of RRS *James Clark Ross* will not significantly bias krill abundance estimates by this vessel.

WG-EMM-01/15

Multiple acoustic estimates of krill density at South Georgia during 2000/01 reveal significant intra-annual and spatial variability. A.S. Brierley, C. Goss, S.A. Grant, J.L. Watkins, K. Reid, M. Belchier, I. Everson, M.J. Jessopp, V. Afanasyev and J. Robst (Gatty Marine Laboratory, University of St Andrews, St Andrews, Fife KY16 8LB, United Kingdom), 18 pp. *CCAMLR Science*, submitted (English).

Three separate acoustic surveys of Antarctic krill (*Euphausia superba*) were conducted around South Georgia in the 2000/01 season: in October 2000 (early-season); during late December/early January 2000/01 (mid-season), and in March 2001 (late-season). The surveys were the first in a newly planned five-year series of observations designed to complement and extend an existing time series maintained by the British Antarctic Survey regularly since 1996 (and on a more ad hoc basis since the early 1980s). We hoped that conducting several surveys in one season would provide information on short-term variability that could be used to place data from more restricted 'snap-shot' cruises in a broader context. The early- and late-season surveys were associated with logistic support voyages to South Georgia and were restricted to four transects within a box to the northwest of South Georgia. The dedicated mid-season survey covered that box in more detail (twice as many transects) and, in addition, examined boxes to the north, northeast and southwest of the island. Together these surveys provided temporally and spatially extensive coverage around South Georgia. Krill density in the western box in the early-season survey was very low (3.5 g m^{-2}) but rose significantly (P = 0.048) by mid-season (to 34.7 g m^{-2}). In a pattern that is consistent with observations from previous years, krill density in the western box mid-season was less than that in the eastern box (80.4 g m^{-2}). Analysis of data for the mid-season western survey box transect revealed no significant difference between the mean krill density derived from only those four transects surveyed early- and late-season or from the full eight transects. Our first occupation of a survey box off the central north coast of South Georgia mid-season revealed a krill density of 47.2 g m^{-2} that was intermediate between values for the eastern and western areas. The size structure of krill in the central region was a mix of those to the east (generally small) and west (generally large). Krill density to the southwest of South Georgia was 32.1 g m^{-2} mid-season. By March, krill density in the western survey area had fallen significantly (P = 0.04) from the mid-season high to 7.8 g m^{-2}. Our multiple surveys at South Georgia have revealed major intra-annual changes in krill density at the island and have shown that the timing of the acoustic survey can significantly affect the estimate of krill density. The multiple estimates of krill density will allow indices of reproductive performance of top-level predators to be compared to prey availability at more appropriate time scales than have previous single 'snap-shot' acoustic survey data. This is a crucial step in the elucidation of response functions of dependent species to

changes in krill abundance, and could be a useful contribution to ecosystem management.

WG-EMM-01/16
Notes on methods for measuring and estimating the status of krill. I. Everson (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 18 pp. (English, unpublished).

Standardisation of methods to measure krill and estimate maturity and feeding status is essential if studies involving intercomparison of datasets are planned. The methods used by workers from different institutes are outlined in the hope that standardisation by WG-EMM can be established and thus improve the quality of data from research surveys as well as through the CCAMLR Scheme of International Scientific Observation.

WG-EMM-01/17
The development of the role of the WG-EMM Subgroup on Methods. K. Reid (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 9 pp. (English, unpublished).

The WG-EMM Subgroup on Methods is potentially in a position to change its emphasis from considering methods for collecting data as part of CEMP to considering and developing methods for analysing and using those data to provide management advice. Within this expanded role there are four key areas: (i) to maintain the process of validation and checking of the existing CEMP database; (ii) to evaluate appropriate methods for analysis of existing parameters; (iii) to develop methods to combine parameters at appropriate spatial and temporal scales; and (iv) to develop methods to take CEMP data forward as management advice.

WG-EMM-01/18
Growth of Antarctic krill (*Euphausia superba*) at South Georgia. K. Reid. *Marine Biology*, 138: 57–62 (2001). (English).

Antarctic krill *Euphausia superba* has a central role in the ecosystem of the Southern Ocean and knowledge of its growth rate is central to determining the factors influencing population dynamics. The length of Antarctic krill in the diet of Antarctic fur seals *Arctocephalus gazella* at South Georgia revealed a consistent increase in size between c. 42–c. 54 mm over the period October–March, indicating growth rates much higher than predicted by existing models. Geographical variation in growth rate may result in 2-year-old krill at South Georgia attaining the same size as 3-year-old krill in the Antarctic Peninsula region. The effect of geographical variation in growth rate on the population structure of krill has important implication for comparing the fate of individual cohorts over large scales and in the interpretation of krill life cycles.

WG-EMM-01/19
Seasonal and interannual variation in foraging range and habitat of macaroni penguins at South Georgia. K.E. Barlow and J.P. Croxall (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 35 pp. *Marine Ecology Progress Series,* submitted. (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 macaroni penguins 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 days, 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 across the Polar Front 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 longer 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, the constraints on the penguins during 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-01/20
Growth rates of Antarctic fur seals as indices of environmental conditions. K. Reid (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 31 pp. *Marine Mammal Science*, submitted. (English).

The growth rates of Antarctic fur seal (*Arctocephalus gazella*) pups estimated from weighing cross-sections of the population were compared with measured/inferred changes in the availability of their main prey species, Antarctic krill (*Euphausia superba*) from 1989 to 2000. There was no relationship between growth rate and mass at weaning and there were counterintuitive indications of higher growth rates in years of low krill availability. Biases reflecting changes in the component of the population available for sampling appear to invalidate the widely held assumption that interannual differences in growth rates can reliably be derived from differences in the slope of a linear relationship based on cross-sectional population samples. A new index was developed, based on the deviation of pup mass at age in each year compared to the multi-year mean, that was not dependent on assumptions of linearity. The indices of growth deviates produced a more logical relationship with other indices of pup development and related more appropriately to variations in prey availability. The potential impact of methodological biases on the interpretation of growth rate suggests that comparisons of growth rates should not rely on assumptions regarding the underlying growth pattern.

WG-EMM-01/21
Environmental response of upper trophic level predators reveals a system change in an Antarctic marine ecosystem. K. Reid and J.P. Croxall. *Proceedings of the Royal Society, Ser B.*, 268: 377–384 (2001). (English).

In the Antarctic Peninsula region current, long-term changes in the physical environment have significant potential to affect populations of Antarctic krill *Euphausia superba*, a keystone foodweb species. To investigate this we analysed data on krill-eating predators from 1980–2000 at South Georgia. Indices of population size and reproductive performance showed declines in all species and an increase in the frequency of years of low reproductive output. Changes in the population structure of krill, and its relationship with reproductive performance, suggest that the biomass of krill within the largest size class was sufficient to support predator demand in the 1980s but not in the 1990s. We suggest that the effects of underlying changes in the system on krill population structure has been amplified by predator-induced mortality, resulting in breeding predators now regularly operating close to the limit of krill availability. Understanding how krill demography is affected by changes in physical environmental factors and by predator consumption and how, in turn, this influences predator performance and survival is one of the keys to predicting future change in Antarctic marine ecosystems.

WG-EMM-01/22
Are penguins and seals in competition for Antarctic krill at South Georgia? K.E. Barlow, I.L. Boyd, J.P. Croxall, I.J. Staniland, K. Reid and A.S. Brierley (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 29 pp. *Marine Biology*, submitted. (English).

The Antarctic fur seal and macaroni penguin 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. 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 expanded 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 use (i) satellite-tracking data to investigate the spatial separation of these two species whilst at sea during the breeding seasons of 1999 and 2000; and (ii) 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 spatially segregated. Over the last 12 years the prevalence of krill in the diet of the two predators differed with less krill in the diet of macaroni penguins than Antarctic fur seals in recent years. Krill in the diet of macaroni penguins was significantly correlated with estimated krill abundance between 1994 and 2000. We found little evidence for direct competition between fur seals and macaroni penguins as, although very similar in trophic niches, they showed significant segregation in their spatial resource use.

WG-EMM-01/23

Adélie penguin population change in the Pacific sector of Antarctica: relation to sea-ice extent and the Antarctic Circumpolar Current. P.R. Wilson, D.G. Ainley, N. Nur, S.S. Jacobs, K.J. Barton, G. Ballard and J.C. Comiso. *Marine Ecology Progress Series*, 213: 301–309 (2001). (English).

One of the longest continuing datasets involving a marine organism in the Antarctic is that of annual estimates of breeding population size of Adélie penguins *Pygoscelis adeliae* at colonies on Ross Island, Ross Sea, 1959 to 1997. The sizes of these colonies have displayed significant interannual variability during the 29-year period. We hypothesised that changes are related to natural environmental factors; and used path analysis to analyse annual variation in population growth in relation to physical environmental factors during that part of the record with comparable sea-ice satellite imagery from 1973 to 1997. The Ross Sea sector of the Southern Ocean lying north of Ross Island, from 150°E to 130°W, comprised our study area. Annual population growth measured during summer was explained best, and inversely, by the extent of sea-ice in the study area five winters earlier, and in some way related to the Southern Oscillation. Analysis of a subset of the sea-ice data from 1979 to 1997 indicated strong correlations to ice conditions in the eastern portion of the study area (174 to 130°W), and virtually no correlations to the western half (150°E to 175°W). This result supported other indirect evidence that the Ross Island penguins winter in the eastern Ross Sea/western Amundsen Sea. A demographic model indicated that variation in survival of juveniles and subadults might account for the observed population variation, and would also explain the 5-year lag as 5 years is the average age of recruitment to the summer breeding population. Extensive sea-ice during winter appears to reduce subadult survival, expressed subsequently when these cohorts reach maturation. We hypothesise that extensive (more northerly) sea-ice limits access of penguins to productive waters known to occur south of the southern boundary of the Antarctic Circumpolar Current, with starvation or increased predation disproportionately affecting less-experienced birds. The observed patterns of penguin population change, including those preceding the satellite era, imply that sea-ice extent has changed significantly over recent decades.

WG-EMM-01/24

An outline of the proposed aerial photographic survey at South Georgia for estimating breeding population sizes of land-based predators. P. Trathan and D. Briggs (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 12 pp. (English, unpublished).

This paper describes current research plans to estimate the size of land-based marine predator populations breeding at South Georgia with a view to providing critical data about interactions with commercial fisheries. The research will also develop methodologies that reliably assess

trends in the abundance of these populations. The research will focus on predator species that depend on marine resources that are also harvested by commercial fisheries, principally Antarctic krill. It will concentrate on those species for which there is a high probability of interaction with fisheries and significant potential for resource competition under existing fisheries management policies. The research will also develop new methods that reliably estimate predator population sizes whilst minimising the level of disturbance associated with data collection.

WG-EMM-01/25

Monitoring a marine ecosystem using responses of upper trophic level predators. I.L. Boyd and A.W.A. Murray (Gatty Marine Laboratory, University of St Andrews, St Andrews, Fife KY16 8LB, United Kingdom). *Journal of Animal Ecology*, in press. (English).

This study examined the changing status of the marine ecosystem at the island of South Georgia (Southern Ocean) using up to 27 variables measured over 22 years from three upper-trophic level predators that specialise in foraging upon krill (*Eupuasia superba* Dana). These variables included population size, breeding performance, offspring growth rate, foraging behaviour and diet. A method was developed for reducing these multivariate time series to a single vector, called a combined standardised index (CSI).

Sensitivity analyses showed that missing values had a large effect upon the accuracy of the CSI but this effect was reduced if the individual variables were highly correlated. The level of correlation and proportion of missing values within the empirical dataset were within the acceptable range. Individual variables had widely varying influence upon the CSI but, in general, those with longer time series had the greatest influence.

Principal components analysis showed that variables representing offspring growth tended to explain the greatest proportion of the variability in the CSI and this was followed by variables representing diet.

There were three years in which the CSI showed extreme and significantly low values. There was a significant non-linear functional response (similar to the Holling Type II functional response) between the overall CSI and krill biomass and a similar relationship existed when the CSI was calculated for each species individually.

Separate analysis of variables that were likely to be representative of changing population size showed the presence of a significant decline between 1977 and 1998. There was no trend in the CSI from variables representative of foraging conditions during the summer breeding season. The study has shown that the marine ecosystem at South Georgia shows acute but transient variability that is amplified in the response of upper-trophic level predators. There is less certainty that trends in populations are a consequence of shifts in the degree to which the ecosystem can support krill-feeding seals and penguins.

WG-EMM-01/26

Spatial distribution of foraging by female Antarctic fur seals. I.L. Boyd, I.J. Staniland and A.R. Martin (Gatty Marine Laboratory, University of St Andrews, St Andrews, Fife KY16 8LB, United Kingdom), 33 pp. Ecology, submitted. (English).

The study tested the hypothesis that the distribution of critical habitat for foraging by female Antarctic fur seals breeding at the island of South Georgia was influenced by physical gradients in the oceans and also by the need to avoid local competition for food. It also tested the hypothesis that fur seal predation was capable of causing local depletion of prey species. When foraging in support of dependent offspring, fur seals travelled down physical gradients defined by the bathymetric features of the continental shelf around the island of South Georgia. Fur seals foraging from different sites followed the same pattern of travel. There was no detectable difference in this behaviour among years when there were different amounts of prey available. Females were constrained to forage mainly within 100 km of the location at which the offspring was being raised. When this constraint was removed at the end of lactation, females foraged to much greater ranges and there was evidence that they dispersed to specific regions associated with the continental shelf east of Patagonia (>1 000 km) and to the northern edge of the Antarctic pack-ice (500 km). A model of the spatial distribution of foraging by lactating female fur seals predicted spatial

distributions that were consistent with past observations from ship-based surveys. The model also allowed estimation of the spatial impact of fur seals on krill. This suggested that, in extreme cases and assuming that krill influx is limited, female fur seals could eat most of the krill present in some regions where they forage intensively. However, mean consumption was about one-tenth of the mean density of krill.

WG-EMM-01/27

Integrated environment–prey–predator interactions off South Georgia: implications for management of fisheries. I.L. Boyd (Gatty Marine Laboratory, University of St Andrews, St Andrews, Fife KY16 8LB, United Kingdom). *Aquatic Conservation: Marine and Freshwater Ecosystems*, in press. (English).

The oceanography of the South Georgia region is principally that of the Southern Ocean rather than the South Atlantic. A combination of factors, including advection, local bathymetry and high local productivity, leads to relatively large concentrations of krill (*Euphausia superba*) in the region and this is a food source for large populations of penguins and seals that breed at South Georgia. A history of over-exploitation of the marine resources of the region has led to the development of ecosystem approaches to management. The current system for managing krill harvests includes precautionary features that account for interannual variability in krill populations and the food requirements of natural predators. However, in future it may be possible to use information from the natural krill predators to set reasonable levels of krill exploitation.

WG-EMM-01/28

Variability of krill biomass estimates in repeated mesoscale surveys in relation to the CCAMLR-2000 Survey. V.A. Sushin, F.F. Litvinov and V. Siegel (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 12 pp. *CCAMLR Science*, submitted (English).

One of the important questions in interpreting CCAMLR-2000 Survey results is how they reflect the current krill biomass: is it high, medium or low? A comparative analysis of krill biomass values derived from trawl catches was carried out. Retrospective data from three Soviet surveys, which covered the main part of the CCAMLR-2000 Survey area, were used: RV *Argos* (27 January to 16 March 1984) and RV Evrika (11 October to 14 December 1984 and 20 January to 9 March 1988). Similar gear (Isaacs-Kidd Midwater Trawl) and sampling methods were used, however sampling was carried out in the 0–100 m water layer instead of the 0–200 m layer as in the CCAMLR-2000 Survey. The krill biomass index calculated for the whole area of Soviet surveys does not reveal any significant changes, being in the range of 15.3–20.3 g/m^2. If one assumes that changes in mean weight density reflect biomass variability, it may be suggested that overall krill biomass in Area 48 has been quite stable during the last 17 years. It should be noted, however, that due to the difference in layers sampled during the CCAMLR-2000 Survey and Soviet surveys, the krill biomass derived from data collected in the 1980s may be overestimates compared to the CCAMLR-2000 Survey results (despite new data showing that krill is concentrated mainly above the 80–90 m layer), although the level of overestimation is unclear. If this is true and the level of overestimation is considerably high, we have to admit stability or an increase in krill biomass since the 1980s, however at present the rate of this increase is impossible to determine.

WG-EMM-01/29

Alternative methods for determining subarea or local area catch limits for krill in Statistical Area 48. G. Watters and R. Hewitt. *SC-CAMLR Selected Scientific Papers SC-CAMLR-SSP/9*: 237–249 (1992). (English).

CCAMLR Conservation Measure 32/X sets a 1.5 million tonne precautionary catch limit on krill (*Euphausia superba*) in Statistical Area 48. The measure also implies the application in future of precautionary limits could be applied to subareas or local areas. Nine alternative methods of determining subarea or local area krill catch limits are evaluated relative to six criteria: (i) the degree to which information on biological relationships is considered, (ii) the cost of data collection, (iii) the reliability of required information, (iv) the ease of enforcement, (v) the effects on current fishing patterns, and (vi) the potential for delay in implementing the alternative. An alternative is less likely to

adversely impact dependent species (e.g. penguins and seals) if the ecological relationships between krill and their predators are explicitly considered and the potential for delayed implementation is low. Therefore, we consider the following tradeoff to be important: choosing a biologically explicit alternative and delaying implementation, or choosing a biologically unrealistic alternative and implementing a management scheme immediately. We recognise that other tradeoffs may be equally important. Alternatives that allocate the 1.5 million tonne limit by evenly dividing the catch among subareas or by using historical catches to set limits can be categorised as having a low potential for delaying implementation, but they ignore information on biological relationships. Alternatives based on protective zones, critical periods, predator censuses, and predator–prey models include large amounts of biological information, but may not be practical in the near future. Alternatives based on continental shelf area, simple pulse fishing, and krill surveys are not biologically explicit and result in delayed implementation. None of the alternatives are categorised as being both biologically explicit and immediately available for implementation. However, two of the alternatives (i.e. protective zones and critical periods) are unsatisfactory only because they would alter current fishing patterns. These two alternatives could be implemented immediately if the CCAMLR Member nations to are willing to tolerate changes in current fishing patterns.

WG-EMM-01/30

Distribution of temperature, salinity, density and currents across Drake Passage in December 1994. M. Naganobu and K. Kutsuwada (National Research Institute of Far Sea Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan). 10 pp. (English, unpublished).

This paper describes the vertical distribution of temperature, salinity, density and currents across Drake Passage. The seventh Antarctic Ocean Survey cruise by the Japanese Fisheries Agency's vessel RV *Kaiyo Maru* was conducted in waters around the Antarctic Peninsula in the 1994/95 austral summer. Oceanographic observations were carried out from 1 to 9 December 1994 along the north–south line from 56°21'S 66°37'W to 61°49'S 58°28'W across Drake Passage. The Polar Front, recognised by a steep gradient in temperature, was located between 58°S and 59°S. The Antarctic Surface Water, defined as water temperature 0°C or less, was distributed from 58°40'S to the southernmost station, 61°49'S. In general, the current flows across the line eastward, except for a weak current through some sections. The maximum speed of the current was approximately 30 cm/s for the Polar Front Zone. Upwelling of the Warm Deep Water was suggested in the costal water north of the South Shetland Islands.

WG-EMM-01/32

Penguin demography and winter distributions in the Antarctic Peninsula region. W. Trivelpiece and S. Trivelpiece (Antarctic Ecosystem Research Division, Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA). *NSF Progress Report 2000/01*. (English).

Our long-term seabird research at Admiralty Bay has documented annual variability in the life history parameters of the breeding biology and ecology of Adélie, gentoo, and chinstrap penguins. Long-term data acquired on these species including: survival and recruitment, population size and breeding success, diets and foraging ecology, provide clear evidence linking offshore biological and physical processes to their effects on dependent predators in the Southern Ocean. Our most recent results present a conceptual model linking increasing temperatures and decreasing sea-ice cover in the Antarctic Peninsula region to declines in krill and penguin populations. Winter temperatures in the Antarctic Peninsula region have increased 4–5°C over the last 50 years (Smith et al., 1996, 1999), affecting the periodicity of sea-ice cover in the region. This climate change, and the associated reduction in winter sea-ice cover, has profoundly impacted the Antarctic, krill-based food web (Loeb et al., 1997, Smith et al., 1999; Trivelpiece and Trivelpiece, in prep.).

WG-EMM-01/33

Seabird research on Cape Shirreff, Livingston Island, Antarctica, 2000/01. M. Taft, I. Saxer and W. Trivelpiece (Antarctic Ecosystem Research Division,

Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA). *US AMLR Field Season Report 2000/01*, in press. (English).

The austral summer 2000/01 marked the fourth full season of land-based predator research at Cape Shirreff, Livingston Island, Antarctica. Results of the monitoring activities undertaken in support of CCAMLR's WG-EMM, are summarised in the report.

WG-EMM-01/34

Interannual variability of polynya extent in the Antarctic Ocean. M. Naganobu and K. Segawa (National Research Institute of Far Sea Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan), 9 pp. (English, unpublished).

There are two general kinds of polynyas (ice-free areas within sea-ice borders) in the Southern Ocean: coastal and open ocean. Polynyas accelerate oceanic and atmospheric processes by exposing the ocean surface to the atmosphere. Additionally, we believe that coastal polynyas influence biological activity in the winter and spring seasons. However, there are no detailed reports on the location, time and shape of the coastal polynyas. Accordingly, we examined the transition of the coastal polynyas using satellite image data of sea-ice concentrations from the National Snow and Ice Data Center, USA (NSIDC).

Time series of polynya extent per day were calculated from 1978 to 1998 and converted to the yearly mean. The time series of the yearly mean in the whole Antarctic Ocean show an upward trend after the latter half of the 1980s. The time series trends around the Antarctic Peninsula resemble a pulse wave. For the whole Antarctic Ocean, peak years of polynya extent are 1981/82 (from July 1981 to June 1982), 1991/92 and 1995/96. For the Antarctic Peninsula area, peak years are 1980/81, 1987/88 and 1992/93.

WG-EMM-01/35

Analysis of krill trawling positions north of the South Shetland Islands (Antarctic Peninsula area), 1980/81–1999/2000. S. Kawaguchi and K. Segawa. *CCAMLR Science*, 8: 25–36 (2001). (English).

Inter- and intra-annual variability of commercial krill trawling positions for the 1980/81 to 1999/2000 seasons in the area north of the South Shetland Islands were analysed in relation to biological and environmental factors. Commercial fishing operations concentrated on the outer shelf in the early 1980s, along the shelf slope in the mid to late 1980s, and from the shelf across to the outer shelf in the early to late 1990s. Intra-annually, trawling positions generally started from the outer shelf and proceeded towards the shelf later in the season. Trawling positions seemed to be primarily governed by the distribution of larger mature krill, especially at the beginning of fishing operations each season. In summer, biological factors that affect product quality, such as salp abundance and the proportion of green krill, also seemed to have an increasing effect on trawling positions. Ice conditions for recent fishing periods were also demonstrated to have an effect.

WG-EMM-01/36

CPUEs and body length of Antarctic krill during the 1999/2000 season in Area 48. S. Kawaguchi and M. Naganobu (National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan), 29 pp. (English, unpublished).

Four Japanese krill fishing vessels operated in Area 48 during the 1999/2000 split-year. Fishing was carried out from December to June in Subarea 48.1, in December, March and May to June in Subarea 48.2 and in June only in Subarea 48.3. Trawling positions, CPUEs and body length of Antarctic krill during the period are described. The krill length-frequency distribution was compared with those obtained simultaneously by the CCAMLR international observer; good agreement was demonstrated. The possibility of intra-annual variability of two krill stocks (Antarctic Peninsula and Weddell Sea stocks) is discussed.

WG-EMM-01/38

Scientific observer's report of commercial krill fishing carried out by the Japanese stern trawler *Niitaka Maru*, 13 December 2000 to 26 January 2001. T. Hayashi, S. Kawaguchi and M. Naganobu (Tokai University, 3-20-1 Orido, Shimizu, Japan), 11 pp. (English, unpublished).

Japan deployed one scientific observer on a Japanese krill trawler, *Niitaka Maru*,

from 13 December 2000 to 26 January 2001. Observations were undertaken according to the *CCAMLR Scientific Observers Manual*. Fishing effort, processing method, fish by-catch, biological measurements of krill and product types are described in the report. The trawler made an anti-clockwise trip around the South Shetland Islands, during which the vessel encountered a swarm that was rapidly moving southwards. The vessel twice encountered icebergs, and caught some small-sized krill around them; such krill was not caught in other locations. The patches seemed to be relatively dispersed compared to the previous season.

WG-EMM-01/39
Krill conversion factors. I. Everson (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 9 pp. (English, unpublished).

Published information on conversion factors to estimate krill removals from the amounts of different krill products is examined and a range of values produced. These are broadly in line with those currently in use, although the differences are such that use of the traditional factors may introduce large errors into the estimation of removals. It is uncertain whether discarding is a common practice in the fishery. If it is, then the use of any of the conversion factors will result in a serious under-estimation of total removals.

WG-EMM-01/40
Changes observed in krill length-frequency distribution during repeated sampling on the South Georgia shelf in January–February 2000. V.A. Sushin and F.F. Litvinov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 7 pp. *CCAMLR Science*, submitted (English).

Krill sampling was carried out northwest and northeast of South Georgia in 2000, initially during a collaborative venture of AtlantNIRO and BAS on 5–8 and 10–13 January, and then during a bottom trawl fish survey on 3 and 22 February. The comparative analysis revealed a strong difference in krill inhabiting waters northwest and northeast of South Georgia. According to the data analysed, this difference did not disappear in time, instead a certain increase in krill length was observed in the Western box area, most probably due to higher water surface temperature there. On the other hand, the difference observed may be due to different origin of krill: krill to the west of the island is brought there by the cold Weddell Sea waters, and krill to the east is brought, at least partly, by rather warm ACC waters which provide more favourable conditions for krill growth.

WG-EMM-01/41
Improvements in data collection and analytical methodologies on krill biomass estimation based on the results of acoustic surveys. S.M. Kasatkina, A.P. Malyshko and O.A. Berezhinsky (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 9 pp. *CCAMLR Science*, submitted (English).

This paper discusses the role of survey results in improving data collection and analytical methodologies related to a critical factor in any acoustic survey, i.e. identification of detected aggregations by species. Krill biomass estimates obtained as a result of processing the same acoustic datasets are compared using two methods of delineating of back-scattering attributed to krill: a two-frequency method and one based on subjective visual classification of echograms taking into account species composition of trawl samples. It has been shown that variance in biomass estimates arising from the use of the two methods for processing krill survey results (Subarea 48.4, January 2000) exceeds 80%.

It is concluded that considering changes that have taken place in acoustic survey technologies and methodologies, analysis of inter-year variability of krill biomass based on acoustic survey results is essential.

WG-EMM-01/42
Characteristics of krill aggregations in the South Sandwich Islands subarea from January–February 2000. S.M. Kasatkina, A.P. Malyshko, V.N. Shnar and O.A. Berezhinsky (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 14 pp. CCAMLR Science, submitted (English).

Results of the Subarea 48.4 survey (17 January–1 February 2001) showed that krill spatial distribution was characterised

by the presence of non-aggregated, scattered forms, as well as swarms. Differences between spatial distribution patterns of different types of krill aggregations in relation to water mass structure and dynamics are demonstrated.

The distributional features and physical characteristics of some 2 400 krill swarms detected and sized acoustically are described. Results of comparisons between swarm parameter means in different areas and seasons are given.

The horizontal and vertical distribution of krill biomass in the study area is examined in relation to the characteristics of the aggregations recorded. The effect of spatial distribution of different types of krill aggregations on the horizontal and vertical distribution of krill biomass has been shown. Most krill biomass (about 64%) was concentrated in swarms within the meander and eddy zones of the Weddell Sea (14% of the study area), being observed in the upper 80 m depth level.

Analysis of the spatial distribution patterns of different types of krill aggregations and the vertical distribution of krill biomass density was conducted to determine potential fishing grounds and the possibility of removing the recommended precautionary catch limit. It is demonstrated that fishing grounds could be located within the zones of swarm concentrations, where biomass density was 1.5 g/m^3. The biomass in potential fishing grounds amounted to about 1.7 million tonnes. Biomass removal corresponding to the recommended precautionary limit could be possible from such grounds despite low predicted catch per hour trawling.

WG-EMM-01/43

Pinniped research at Cape Shirreff, Livingston Island, Antarctica, 2000/01. M.E. Goebel, B.W. Parker, A.R. Banks, D.P. Costa and R.S. Holt (Antarctic Ecosystem Research Division, Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA). *US AMLR Field Season Report 2000/01*, in press. (English).

The long-term objective of the US AMLR field research program is to describe the functional relationships between Antarctic krill, their predators, and key environmental variables. Every year on-land studies of predator foraging ecology and reproductive success have been coordinated with large-scale oceanographic surveys off the South Shetland Islands. Since 1996/97, US AMLR predator studies have taken place at Cape Shirreff, Livingston Island. This report summarises the pinniped portion of predator studies for the 2000/01 austral summer.

WG-EMM-01/44

Krill processing factors. D. Rogers (Top Ocean Inc. USA, Correo Central 596, Montevideo, Uruguay), 10 pp. (English, unpublished).

The wealth of earlier papers on the topic of krill processing is dominated by the works of Grantham (1977), *The Utilization of Krill*, Budzinski et al. (1985), *The Possibilities of Processing and Marketing of Products made from Antarctic Krill*, and works produced by McElroy (1980–82). These papers describe the fundamentals of product yields and the framework for determining market prices for krill products.

Yield Estimates from round (whole) krill are as follows (from McElroy, 1980–82):

whole uncooked krill – frozen	100%
whole cooked krill – frozen	90%
whole uncooked krill – centrifuged (gutted) frozen	80%
krill mince – centrifuged	60%
krill mince – uncentrifuged	80%
krill tail meat	15%
krill meal without stickwater recovery	15%
krill meal with stickwater recovery	21%.

In summary, krill production has some time of uncertainty ahead due to reforms in the industry, the departure of older vessels and technology and uncertain markets for the mid-term future for higher-value products for human consumption.

WG-EMM-01/45

Seasonal and interannual variability of krill, salp and other zooplankton populations in the northwest Antarctic Peninsula region: summer 2001 in relation to the long-term AMLR dataset. V. Loeb (Moss Landing Marine Laboratories, Moss Landing, Ca., USA), 29 pp. (English, unpublished).

The US AMLR Program conducted large-area surveys in the Elephant Island–South Shetland Island region from 18 to 30 January

2001 (Survey A, 101 stations) and from 12 February to 12 March 2001 (Survey D, 96 stations). Krill, salps and other zooplankton were collected at each station using a 180 cm Isaacs-Kidd Midwater Trawl fitted with 505 µm mesh nets. Data obtained from these surveys were compared to assess seasonal variations in distribution, abundance and demography of Antarctic krill (*Euphausia superba*) and salps (*Salpa thompsoni*), and distribution and abundance of biomass-dominant copepod species and other common zooplankton taxa. Comparisons were also made with data obtained during the 1992–2000 AMLR field seasons to assess interannual variations. Mean and median krill abundance values in the Elephant Island area during the 2000/01 field season were intermediate to high in 1996 and low in 1999. Increased abundance relative to 1999 resulted in part from recruitment of the 1998/99 and 1999/2000 year classes as indicated by modest proportions of juvenile and immature stages. Large proportions of advanced female maturity stages, substantial larval krill concentrations and more developed larval stages during February–March reflected normal seasonal spawning in 2000/01. This is the third year in a row that spawning conditions have been favourable for krill recruitment success. Both large area surveys were characterised by wide-spread distribution of abundant salps, although extremely large concentrations like those of 1993 and 1998 were not encountered. Length-frequency distribution of the dominant aggregate stage indicated a curtailed production season. A dramatic 60% abundance decrease between the two surveys was apparently due to loss of large aggregates from the upper water column. Within the 1993–2001 Elephant Island dataset, prolonged salp budding periods with pulses of late-season aggregate production preceded years with increased salp population size, while curtailed budding periods preceded years with diminished salp populations. Assuming that these trends continue, reduced salp population size can be expected during the 2002 field season. Favourable krill spawning conditions in conjunction with reduced salp abundance improve the prospects of larval production and survival. Should winter sea-ice development and spring bloom conditions also be favourable, we may see strong recruitment success of the 2000/01 year class. Copepod abundance values in the Elephant Island area were among the highest observed over the past 20 years. This resulted from large concentrations of *Calanoides acutus*, *Metridia gerlachei* and *Calanus propinquus* and indicates enrichment in oceanic and coastal waters relative to other years.

WG-EMM-01/46

Detection of anti-*Brucella* antibodies in pinnipeds from the Antarctic territory. P. Retamal, O. Blank, P. Abalos and D. Torres. *Veterinary Record*, 146: 166–167 (2000). (English).

This paper describes the first detection of *Brucella* sp. antibodies in seals from the Antarctic territory. Sixteen Antarctic fur seal (*Arctocephalus gazella*) and one Weddell seal (*Leptonychotes weddellii*) sera were tested by the Rose Bengal test (RBT), complement fixation test (CFT), immunodiffusion (AGID) and c-ELISA. Antibodies against *Brucella* sp. were detected with the RBT, the CFT and the c-ELISA in six of the 17 samples involving the two animal species. It is concluded that a *Brucella* sp. described as affecting marine mammals in the northern hemisphere could be also present in the Antarctic territory.

WG-EMM-01/48

Detection of anti-*Brucella* antibodies in Weddell seals (*Leptonychotes weddellii*) from Cape Shirreff, Antarctica. O. Blank, P. Retamal, P. Abalos and D. Torres (Departamento Científico, Instituto Antártico Chileno (INACH), Rómulo Correa 375, Punta Arenas, Chile), 7 pp. (English).

A serological study was initiated to determine the presence of anti-*Brucella* antibodies in Antarctic marine mammals. For this study, blood and extra-vascular fluid samples were taken from 12 Weddell seals (*Leptonychotes weddellii*) at the Site of Special Scientific Interest (SSSI) No. 32 and CCAMLR Ecosystem Monitoring Program (CEMP) site No. 2 'Cape Shirreff and San Telmo Islands' (62°47'S; 60°27'W), located on Livingston Island (South Shetland Islands), Antarctica. Field work was carried out as part of INACH Project 018 'Ecological studies on the Antarctic fur seal, *Arctocephalus gazella*' and the laboratory analysis at the Departamento de Medicina Preventiva Animal,

Facultad de Ciencias Veterinarias y Pecuarias of the Universidad de Chile. The samples were tested by the conventional Rose Bengal test (RB) and two competitive enzymatic immunoassays: Compelisa® (Veterinary Laboratories Agency, UK) and c-ELISA (FAO/IAEA, 1994). In five of the samples studied, anti-*Brucella* antibodies were detected; the enzyme-linked immunosorbent assays (Compelisa®) were the most appropriate tests.

These results strongly confirm the presence of infections by bacteria of the genus *Brucella* in *L. weddellii* and underline the need to conduct complementary studies to understand the etiology and infection epidemiology of this genus in this region of the world.

WG-EMM-01/49

An update on Antarctic fur seal population dynamics and assessment of census error at SSSI No. 32, Livingston Island, South Shetlands, Antarctica (2000/01). R. Hucke-Gaete (Instituto de Ecología y Evolución, Universidad Austral de Chile, Casilla 567, Valdivia, Chile), 12 pp. (English, unpublished).

Cape Shirreff and the San Telmo Islands (SSSI No. 32) are home to the largest breeding population of Antarctic fur seals (*Arctocephalus gazella*) in the South Shetland archipelago. Since all censuses to date have been single counts and do not allow the calculation of confidence limits, a protocol was developed for assessing uncertainties in estimates based on these counts (inter and intra-observer error) and put into practice during the 2000/01 field season. Intra-observer error was between 0.15 and 1.74% CV, while inter-observer error was within 3% of the overall mean. The relationship between census error and pup numbers shows a linear trend, however some outliers (outside the 95% CI) could be identified and these corresponded to beaches for which variation cannot be entirely attributed to inter-observer error. It could be suggested that density of colonies, topography, tides and meteorological conditions can significantly affect pup censuses. These factors should all be assessed and taken into account when conducting regional surveys of land-based predators in the future. Censuses developed at the SSSI have proved to be quite precise, and this suggests that previously reported trends are not an artefact of counting error, thus supporting the hypothesis that the *A. gazella* population at SSSI No. 32 is reaching stability since more than 87% of *K* has already been attained.

WG-EMM-01/50

Some notes on the by-catch of fish caught by the fishing vessel *Niitaka Maru* in the vicinity of the South Shetland Islands (December 2000 to January 2001). T. Iwami, S. Kawaguchi and M. Naganobu (Laboratory of Biology, Tokyo Kasei Gakuin University, 2600 Aihara, Machida, Tokyo 194-0292, Japan), 15 pp. (English, unpublished).

Scientific observations of fish incidentally caught during commercial krill fishing by FV *Niitaka Maru* (3 910 tonnes) were made from 16 December 2000 to 26 January 2001 in the vicinity of the South Shetland Islands. Among 103 net hauls quantitatively examined, fish by-catch was found in 41 catches. *Lepidonotothen larseni* was the most abundant by number and weight, occurring in 20.4% of hauls sampled for by-catch; 51.2% of those contained fish. *Pleuragramma antarcticum* and *Champsocephalus gunnari* were the second in abundance by number and weight respectively. Most hauls were dominated by one species which constituted 63.4% of hauls that contained fish by-catch; a high degree of spatio–temporal separation among juveniles of different species was recognised. By-catch data from this survey provided a clear picture of the negative correlation between abundance of fish by-catch and krill CPUE. The relationship between towing time and the estimated number of individual fish in the by-catch of each haul was unclear.

WG-EMM-01/51

CCAMLR course in survey design and execution – a possible way to assure intellectual continuity and renewal in WG-EMM. B.I. Bergström and M.A. Thomasson (The Royal Swedish Academy of Sciences, Kristineberg Marine Research Station, Kristineberg 2130 SE-450 34, Fiskebäckskil, Sweden), 4 pp. (English, unpublished).

A proposal to conduct a CCAMLR course in survey design and execution at the Kristineberg Marine Research Station

is put forward to build upon the experiences gained in planning and executing the CCAMLR-2000 Krill Survey. The proposed course would recruit teachers and students from Member countries and illustrate both theoretical and practical aspects of krill survey work by planning and performing a 'miniature survey' in Gullmarsfjorden with the Nordic krill *Meganyctiphanes norvegica* as a model organism. It is argued that such an international course would help to assure that the collective wisdom of CCAMLR is maintained, developed and disseminated to younger scientists.

WG-EMM-01/52

Defining smaller management areas within CCAMLR. A.J. Constable and S. Nicol (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 12 pp. *CCAMLR Science*, submitted (English).

This paper discusses the principles required to develop small-scale management units and highlights a work program in this development. It provides the theoretical foundation for considering the scales of management units involving the integration of local populations of harvested species, foraging areas of predators, fishing grounds and the potential influences of the environment, including oceanography and the metapopulation structure of the harvest species. The integration of these three components requires two units: the 'harvesting unit', which is at the scale of the metapopulation of the harvested species, and the 'predator unit', which does not have to be a completely self-contained ecosystem but should be sufficiently self-contained such that fishing in that unit does not inadvertently affect predators being monitored in other units. Harvesting units are defined and a number of additional divisions of CCAMLR statistical areas are proposed on ecological grounds to complete the division of the CCAMLR area. The South Atlantic region (Area 48) is used to illustrate how to define predator units. The derived conceptual model is then used to formulate a work program for the development of fisheries for prey species, notably krill, in other harvesting units. The manner in which predator units can be used to help the CCAMLR Ecosystem Monitoring Program provide strategic advice on the effects of fishing is discussed. In general, the early acquisition of information from within a harvesting unit on the distribution of local populations of krill, the potential foraging density of predators (i.e. abundance of predators, distribution of colonies and foraging range) and the potential fishing grounds will provide the means for circumscribing predator units as well as undertaking an assessment of long-term annual yield. It is proposed that the early development of the fishery be concentrated in a small number of units to the extent that the fishing intensity in those units is equivalent to the intensity expected across all units once the catch limit had been reached. Other units in which fishing was not occurring could be monitored as well. This process could help predetermine whether or not the catch limit is likely to cause undesirable effects on predators in any of the predator units. In this way, whether or not local restrictions on harvesting are necessary can be determined well in advance of the catch limit being reached, as can the overall requirements for the monitoring program.

WG-EMM-01/53

Modelling Southern Ocean krill population dynamics: biological processes generating fluctuations in the South Georgia ecosystem. E. Murphy and K. Reid (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom). *Marine Ecology Progress Series*, in press (2001). (English).

Variability is a key feature of the pelagic ecosystems of the Southern Ocean and an important aspect of the variation is fluctuation in the abundance of krill, the major prey item of many of the higher predators. Direct impacts of variability in the large-scale physical environment, such as changes in ocean circulation, have been suggested as the main factor generating the observed fluctuations. So far, however, there has been little quantitative assessment of the importance of krill population dynamics in the observed variation. Here, analyses of a model of krill population development and predator diet data from South Georgia were used to examine seasonal changes in the population structure of krill. The krill population model was combined with a size-based selection function and used to generate expected

length-frequency distributions in the predator diet through a summer season. Comparison of the model solutions with the predator diet data indicates that the model can reproduce the observed pattern of variation and emphasises that adult population changes are a key aspect of the interannual fluctuations observed during some years. Low krill abundance was associated with reduced representation of the 3+ age group, whereas when krill were abundant the 3+ age class was the major age group present. The seasonal changes in the population structure in the predator diet involve a complex interaction of relative year class strength, timing of immigration, fluctuations in growth rates and dynamic predator selective effects. Development of the model to examine the interactive effects of changing krill growth and mortality rates will be a valuable next step. The dominance of the changes in krill population age structure underlines the fact that to understand the variability of the South Georgia ecosystem we must identify the major factors generating variability in population dynamics throughout the Scotia Sea.

WG-EMM-01/55

Note on demography of Antarctic seabirds. J.P. Croxall (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 3 pp. (English, unpublished).

At last year's meetings, WG-EMM and the Scientific Committee expressed an interest in summarised information on seabird demography, particularly in relation to generation time and productivity. This represents a substantial task with not inconsiderable resource implications. However, as an initial step, this paper attaches a tabulated review of most of the relevant data up to 1981 (Croxall, 1982). The most important subsequent demographic studies are referenced in the recent report of the SCAR Bird Biology Subcommittee (WG-EMM-00/16). The meeting is invited to consider how it wishes to proceed in respect of such data.

WG-EMM-01/56

Measurement of ocean temperatures using instruments carried by Antarctic fur seals. I.L. Boyd, E.J. Hawker, M.A. Brandon and I.J. Staniland. *Journal of Marine Systems*, 27: 277–288 (2001). (English).

The study aimed to test the utility of instruments deployed on marine mammals for measuring physical oceanographic variation and, using this method, to examine temperature variation in the coastal waters around South Georgia. There was a significant correlation between temperature measurements made using a towed undulating oceanographic recorder (UOR) and concurrent measurements from time-depth recorders (TDRs) fitted to lactating Antarctic fur seals foraging from the coast of South Georgia. Congruence was found at horizontal spatial scales from 0.01° x 0.01° to 0.5° x 0.5° (degrees of latitude and longitude), and at a vertical scale of 10 m. However, there was no significant correlation between temperature measured by TDRs in the top 5 m and sea surface temperature (SST) measured by satellite remote sensing. TDR data provided information about temperature variation vertically through the water column, and through time. The UOR data were used to recalibrate the TDR data in order to correct for the slow response time of the TDR thermistor relative to the speed of seal movements through the water column. Seasonal temperature variation was apparent, and temperatures also varied between regions, and with bathymetry. These results were consistent with the current interpretation of the coastal oceanography around South Georgia. In particular, the relationship between on- and off-shelf waters showed larger amounts of warmer surface water in a region in which more run-off was to be expected. The study also showed that Antarctic fur seals concentrate their activity in regions of colder, and presumably oceanic, water. Such instrumented animals could provide near real time data for assimilation into ocean models.

WG-EMM-01/57

Soviet krill fishery from 1977 to 1992, Part 1: distribution, fishing effort and interannual trends. F.F. Litvinov, V.A. Sushin, G.A. Chernega and O.A. Berezhinsky (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 14 pp. *CCAMLR Science*, submitted (English).

Data on the Soviet krill fishery from 1977 to 1992 are presented. The total fishing effort (FE) from 1977 to 1991 amounted to 50 086 fishing days. FE was distributed between Subareas 48.3 (45% of the total for the period), 48.2 (36%) and 48.1 (19%). There were 16 different types of fishing vessel, more or less similar in size and construction, indicated in the statistical data. Vessels of the type BMRT (33.2% of the total FE) and PPR (25.4) were most commonly used. The main aim of the Soviet krill fishery at that time was to maximise catch rather than quality, therefore the distribution of the Soviet krill fleet reflected the distribution of the most abundant krill aggregations. Monthly FE distribution between subareas revealed three types of FE distribution which can be grouped into years: Type I: 1981 and 1982, partly 1979/1980 – FE was concentrated in Subarea 48.1 in January–April, then moved to Subarea 48.3 via Subarea 48.2. Type II: 1983, 1984, 1985, and 1986 – FE was expended mostly in Subarea 48.2; since 1985 Subarea 48.3 is becoming more important. Type III: 1987, 1988 and 1989 – FE was expended mostly in Subarea 48.3, from March–April to September–November. Several groups of factors influencing FE distribution are discussed, however it is very difficult to determine the key one of them. However, it was found that the types of FE distribution correspond well to spatial and temporal variability of the zonal and meridional atmospheric processes. The prerequisites for expending fishing effort (i.e. extensive and stable krill aggregations, coupled with suitable ice and weather conditions) exist in the subarea where Southern atmospheric transfers are maximally developed at present. These phenomena occur in Subareas 48.1 and 48.2 under increased zonal transfers westward and in Subarea 48.3 under decreased transfers.

WG-EMM-01/58

Predation on fish by the southern elephant seal (*Mirounga leonina*) at King George Island, South Shetland Islands, as determined by stomach lavage. G.A. Daneri and A.R. Carlini (Museo Argentino de Ciencias Naturales, División mastozoología, Av. Angel Gallardo 470 c 1470 DJR, Buenos Aires, Argentina), 11 pp. (English, unpublished).

Between November and February of the years 1993/94, 1995/96, 1996/97, 1997/98, 1998/99 and 1999/2000, 153 southern elephant seals (*Mirounga leonina*) had their stomachs lavaged at King George Island in order to analyse their diet. The two major prey types were cephalopods and fish, occurring in 98.1% and 14% respectively of stomachs containing prey remains. The aim of this paper was to report data on fish prey obtained from seal stomachs throughout the whole study period. 145 sagittal otoliths were removed from 16 stomachs containing fish remains. Of these stomachs, nine belonged to adult females, six to juvenile males and one to a subadult male. The identification of otoliths revealed the predominance of myctophids as fish prey of seals, representing 76.5% of the fish consumed. The most frequent (75%) and abundant prey species was *Gymnoscopelus nicholsi* which numerically constituted 69% of the otoliths found.

This species was followed by the nototheniid *Pleuragramma antarcticum* which represented 11.7% in number and 31.3% in frequency of occurrence. Based on the great distances travelled by seals from their foraging grounds to their hauling sites and the differential rate of passage of fish and cephalopod remains through their gastrointestinal tract, an underrepresentation of the consumption of fish is highly probable. Moreover, according to the movements at sea of southern elephant seals tracked from King George Island, we suggest that while myctophids may be the dominant fish prey in areas close to their hauling sites, they are probably replaced by the Antarctic silverfish (*P. antarcticum*) as seals migrate southward towards higher latitudes where this species is highly abundant.

WG-EMM-01/59

Herpes virus antibodies in *Arctocephalus gazella* from Cape Shirreff, Livingston Island, Antarctica. O. Blank, J.M. Montt, M. Celedón and D. Torres (Departamento Científico, Instituto Antártico Chileno (INACH), Rómulo Correa 375, Punta Arenas, Chile), 12 pp. (English, unpublished).

This paper describes evidence of antibodies against a virus related with Alphaherpesvirinae sub-family, potentially a phocine herpesvirus (PhHV-1) that affects Antarctic fur seals (*Arctocephalus gazella)* from Cape Shirreff, Livingston Island, Antarctica.

Body fluid samples of 54 *A. gazella* were collected from 48 live animals and six dead ones during fieldwork from December 1999 to February 2000.

Blood, pleural, pericardic and peritoneal fluid samples were tested by microneutralisation test using bovine herpesvirus-1 (BHV-1) strain.

Antibodies against BHV-1 were detected in four (7.4%) samples. The utility of extravascular fluid for serological research in this matter is suggested. The microneutralisation test is also recognised as sensitive method for this research. This finding also confirms the extended distribution range of herpesvirus, which affects a large number of hosts, including *A. gazella*.

Scientific research on diseases in Antarctic wildlife is essential and needs to be included in the WG-EMM agenda, as diseases are an important factor which may affect population success. This also may provide information to be considered in the Antarctic Treaty System, in order to provide controls to the possible transmission of disease from or into the Antarctic environment.

WG-EMM-01/61

The distribution of various pelagic organisms estimated acoustically in the South Sandwich subarea during January and February 2000. S.M. Kasatkina and A.P. Malyshko (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 9 pp. (English, unpublished).

In this paper we discuss the results of acoustic estimation of the distribution of nectonic organisms, non-krill zooplankton and krill as detected by a multi-frequency echosounder in Subarea 48.4.

It is shown that myctophid fish species are dominant in the nectonic fraction of backscattering. The distribution pattern of nectonic organisms can be attributed, to a greater degree, to myctophid fish species.

Differences are noted between the spatial distribution of various groups of pelagic organisms. Based on survey results, the influence of water mass type on the distribution of different pelagic organisms that form backscattering layers is as follows: krill dominates the Antarctic pelagic community within surveyed areas occupied by Weddell Sea waters and the Frontal Zone of Weddell Gyre waters; myctophid fish prevail in the north of the area surveyed within Antarctic Circumpolar Current waters; zooplankton is distributed in Weddell Sea waters. Although the bulk of krill and zooplankton biomass is concentrated in the upper 80–90 m layer, high densities of myctophid fish are observed within the whole depth range of 0–350 m. At depths of more than 90 m most backscattering records can be attributed to myctophid fish species.

A comparative analysis of mean stratum *Sa* values obtained for krill and myctophid fish indicated that the latter's biomass could be considerable. The estimate of myctophid fish biomass which can be part of an alternative trophic chain in relation to krill is clearly of practical interest.

WG-EMM-01/62

Seasonal relationships in biological parameters and in the spatial distribution of Euphausiid populations sampled during the XIIIth and XVth Expeditions to the Ross Sea. M. Azzali, J. Kalinowski, G. Lanciani, I. Leonori and A. Sala (National Research Council, Institute for Marine Fisheries Research, Largo Fiera della pesca, 1, 60125 Ancona, Italy), abstract only. (English, unpublished).

This report summarises the results of krill studies from large-scale surveys conducted by the Italian Antarctic Oceanographic Cruises from December 1997 to January 1998 and January to February 2000.

A midwater sampler-trawl (Hamburg Plankton Net) was used to collect zooplankton and fish larvae.

Net sample data on euphausiids were analysed in order to: (i) obtain a general picture of interannual and seasonal variability of the distribution pattern and abundance of *Euphausia superba* and *E. crystallorophias* in the western Ross Sea (Antarctica) in relation to ice cover; and (ii) explore the population structure of *E. superba* and its possible spatial and temporal variations across the study area.

This paper demonstrates that in the Ross Sea during the late spring (1997/98), the spatial distribution of *E. superba* and *E. crystallorophias* was similar. Juveniles of *E. superba* were concentrated in a limited area of the shelf waters and, in general, the maturity stage of this species increased with decreasing latitude (from 76° to 71°S). By contrast, during the summer period, the two species inhabited different areas and there were no particular spatial distribution patterns in the biological characteristics of *E. superba*.

For both periods, the analysis of biological parameters indicated statistically significant differences in biological characteristics among the hauls (aggregations), while within each haul the parameters are homogeneous.

WG-EMM-01/63

A three-frequency method to determine the abundance and the size of two euphausiid species (*Euphausia superba* and *Euphausia crystallorophias*). M. Azzali, J. Kalinowski, G. Lanciani and I. Leonori (National Research Council, Institute for Marine Fisheries Research, Largo Fiera della pesca, 1, 60125 Ancona, Italy), abstract only. (English, unpublished).

Euphausia superba and *E. crystallorophias* dominate the biomass and play a key role in the Ross Sea pelagic ecosystem (Marr, 1962; Azzali et al., 1999). To estimate the abundance of each stock it is necessary to distinguish between *E. superba* and *E. crystallorophias* aggregations and to obtain information about the mean size (length) of the organisms in each aggregation.

In principle, the abundance of the two populations can be estimated by single-frequency acoustics, using the standard echo-integration method. This implies that species can be identified indirectly, from visual analysis of echograms, and directly from net samplings. The mean size of the crustaceans can be estimated from *in situ* target strength measurements, using the relationship between target strength and size, and from the catches.

Unfortunately, the precision and credibility of this method are often insufficient when applied in complex environmental and biological conditions, as in the Ross Sea.

Both species can form aggregations with similar shape, therefore visual separation of their echograms is difficult. The possibility of net sampling depends on the environmental conditions. In the Ross Sea, such a limitation is due mostly to the presence of ice cover. Moreover, uncertainties of net sampling arise due to the selectivity of the net and to net avoidance (Wiebe, 1972; Everson and Bone, 1986). This last bias particularity affects hauls carried out in daytime when the light is intense. The Ross Sea was investigated during the austral summer, in the absence of darkness. There are two methods for *in situ* target strength measurements: 'split beam' and 'dual beam'. The fundamental condition to apply both methods is the detection of an echo coming from an isolated organism, with no interference from noise or other targets. This means that organisms must occur in low concentrations and the echo level from a single organism must be greater by the detection threshold than the total noise level. For small organisms such as the euphausiids, living in a noisy environment (storms, ice) and in dense concentrations, the detection of single targets from a ship is virtually impossible.

Therefore, in the Ross Sea the standard echo-integration method can be applied sporadically, only in particularly favourable conditions.

In order to solve the above problems, since the first Italian expedition to the Ross Sea (1989/90), a two-frequency method for the detection of *E. superba* aggregations has been applied (Azzali et al., 1999). In the last two expeditions of 1997/98 and 1999/2000, a three-frequency method for detecting and estimating the size of euphausiids has been developed.

This paper explores applications of the multi-frequency method using data from three expeditions to the Ross Sea (1980/90; 1997/98 and 1999/2000), where the environmental conditions, the sampled areas, the instrumental and the sampling strategies varied.

Firstly, on the basis of the echo-integrations, made simultaneously either at two or three frequencies, and of the results of net sampling, the thresholds and the decision criteria to recognise the two species are established.

Next, the acoustic estimates of euphausiid lengths, derived from the fluid sphere model, are compared with lengths collected from net samplings.

Finally, the criteria and algorithms developed are effectively applied to estimate *E. superba* biomass found in the area of the Ross Sea investigated in December 1997 and in January/February 2001. The results are compared with those obtained from the standard method.

WG-EMM-01/64

Design of the Italian acoustic survey in the Ross Sea. M. Azzali and A. Sala (National Research Council, Institute for Marine Fisheries Research, Largo Fiera della pesca, 1, 60125 Ancona, Italy), abstract only. (English, unpublished).

This paper submits the design of the acoustic survey that should be carried out during the next Italian expedition to the Ross Sea (2002), for changes, improvements and suggestions.

WG-EMM-01/65

Ecosystem modelling for the Antarctic krill fishery. T. Antezana, J. Cornejo, E. Bredesen, P. Faundez, A.W. Trites and T. Pitcher (Departamento de Oceanografía, Universidad de Concepción, Casilla 160-C, Concepción, Chile). (English, unpublished).

Euphausia superba Dana (Antarctic krill) has been recognised as a key foraging species in the Antarctic ecosystem. This species serves as prey for many organisms in the ecosystem and has also been the target of a small industrial fishery since the mid-1970s. New quotas have recently been set but there is concern that the reduction in krill biomass due to fishing may have impacts on other krill predators such as penguins, seals and whales.

In order to evaluate the effects of krill fishing on the trophic web, it is necessary to have better knowledge of the ecosystem structure and dynamics. This can be achieved by studying community interactions, such as those between predators and prey, as well as competitors for a common resource. In this context we aim to investigate whether the krill fishery and the top predators are competing for krill biomass. This is a cooperative pilot project led by University of Concepción, Chile, with the Fisheries Centre at University of British Columbia, Canada.

In a pilot study, Ecopath with Ecosim 4.0 is being used to develop two mass-balance models of the Antarctic ecosystem, one for CCAMLR Subarea 48.1 and another for Subareas 48.2 and 48.3 combined. Organisms in the system were combined into groups (of one or more species) on the basis of their feeding behavior, growth rate and their present or potential fishing importance, in order to simulate the trophic interactions of the system. Both models will have the same structure to allow comparisons between the two. Although this modelling tool has some limitations and several assumptions, the construction of these models is a step towards identifying and investigating major gaps in knowledge and potential impacts of krill fishing on the ecosystem.

WG-EMM-01/66

Modelling the consequences of Antarctic krill harvesting of Antarctic fur seals. R.B. Thomson, D.S. Butterworth, I.L. Boyd and J.P. Croxall. *Ecological Applications,* 10 (6): 1806–1819 (2000). (English).

In terms of the convention governing the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), management advice for the Antarctic krill (*Euphausia superba*) fishery should take the needs of the predators of krill into account in order to reduce the risk of deleterious impacts on such predators (e.g. baleen whales and numerous fish, seal, penguin and flying bird species). A single species yield model is currently being used by the CCAMLR Scientific Committee to recommend an annual krill catch limit, which is expressed as a proportion ($\gamma = 0.116$) of a survey biomass estimate. This approach takes the needs of predators into account in only a crude way by assuming that a median krill escapement of 75% of its unexploited biomass would be sufficient to meet the needs of predators. A krill–predator modelling procedure is presented that could be used to directly assess the impact of krill harvesting on krill predator populations and therefore to revise this recommended harvesting level (γ) for Antarctic krill. Application of a deterministic form of this model to an Antarctic fur seal (*Arctocephalus gazella*) dataset from Bird Island, South Georgia, Antarctica, indicates that the level of krill fishing intensity (γ) that would reduce this

population to half the equilibrium size in the absence of krill fishing (γ_{half}) lies between 0.03 and 0.18, which includes the level recommended by CCAMLR. This large range results primarily from the sensitivity of the model to the maximum growth rate parameter, for which a range of 5–15% yr is investigated. A plausible range of values for this parameter (5–15% yr) results is estimated γ_{half} values from 0.04 to 0.23. Stochastic calculations (which take account of interannual fluctuations in the abundance of the krill population due to recruitment variability) yield higher estimated γ_{half} values than the less realistic deterministic calculations. However, simulation tests indicate that the estimated γ_{half} values are biased upward; this modelling approach is therefore likely to yield γ_{half} values that would lead to a depletion of the Antarctic fur seal population to more than half its pristine size.

WG-EMM-01/67
Quantifying habitat use in satellite-tracked pelagic seabirds: application of kernel estimation to albatross locations. A.G. Wood, B. Naef-Daenzer, P.A. Prince and J.P. Croxall. *Journal of Avian Biology*, 31: 278–286 (2000). (English).

We develop a new approach to quantifying habitat use within the foraging ranges of satellite-tracked seabirds. We applied kernel estimation techniques to 167 days (3 738 locations) of data from black-browed and grey-headed albatrosses *Diomedea melanophris* and *D. chrysostoma* during the chick-rearing period of the breeding cycle at South Georgia. At this time the activity range of these two species covers an estimated 440 000 and 640 000 km^2, respectively, with very substantial overlap. In contrast, kernel estimation reveals that the main foraging areas of these two sympatric, congeneric species are very distinct. Based on location density categories accounting for 50% of locations, the foraging areas cover c. 81 500 and c. 119 700 km^2, respectively, with 42% and 50% of the range of one species overlapping with that of the other.

WG-EMM-01/73
Consideration of major issues in ecosystem monitoring and management. I. Everson (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom). *CCAMLR Science*, 9: in press (2002). (English).

The requirements of an ecosystem approach to the management of Southern Ocean resources are outlined. This highlights the need for information on harvested and dependent species, their interactions and the manner in which their populations vary naturally. Large-scale interactions are catered for in the Krill Yield Model (KYM). Smaller-scale interactions centre around three main categories, the availability of krill and variation in vital rates of the dependent species and the overlap between commercial fishing and predator foraging. The CCAMLR Ecosystem Monitoring Program (CEMP) provides a good framework within which to investigate krill availability. Vital rates can be investigated directly and also with respect to CEMP. Overlap between fishing and predator foraging is being monitored. A mechanism for bringing these various components together as an ecosystem approach to management is discussed.

Workshop on Approaches to the Management of Icefish (WAMI)

WAMI-01/4
The fishery for *Champsocephalus gunnari* and its biology at Heard Island (Division 58.5.2). R. Williams, E. van Wijk, A.J. Constable and T. Lamb (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 26 pp. (English, unpublished).

Commercial trawl fisheries in the modern era started within the Heard Island EEZ in 1997. This paper summarises the fishing activities to date and collates the information on the biology of the species gathered from the fishery and from a series of fishery-independent surveys conducted between 1990 and 2000. Icefish abundance varies widely between years and the fishery is dependent on periodic abundant year classes that can be followed through the population before disappearing in their fifth year. The occurrence of abundant cohorts is not synchronised between the Heard Island Plateau, Shell Bank or the Kerguelen Plateau, nor are the respective

spawning seasons. This suggests that the populations in the respective areas are mostly independent of one another.

WAMI-01/5

Acoustic assessment of potential bias in abundance estimates of mackerel icefish from trawl surveys. E. van Wijk, T. Pauly, A.J. Constable and R. Williams (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 22 pp. (English, unpublished).

In 2000, CCAMLR asked the Working Group on Fish Stock Assessment (WG-FSA) whether trawl surveys are the most reliable and appropriate method to survey stocks of mackerel icefish *(Champsocephalus gunnari)*. Recent acoustic data from the South Atlantic suggested that mackerel icefish may not always be distributed closely on the sea floor during the day as is generally thought, but that a significant proportion of the stock occurs in midwater. If this is the case, then bottom trawl surveys may underestimate the biomass of mackerel icefish. This paper addresses this question by comparing trawl and acoustic data taken contemporaneously during a survey for mackerel icefish in the Heard Island region (CCAMLR Division 58.5.2) in May 2000. The relationship between mackerel icefish catches and the acoustic signal is discussed. The vertical distribution of mackerel icefish in relation to the diel light signal and the potential for biased estimates of abundance from bottom trawl surveys are also investigated.

WAMI-01/6

Some thoughts on mackerel icefish distribution in relation to krill distribution. S.M. Kasatkina, Zh.A. Frolkina, A.P. Malyshko and V.A. Senioukov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 12 pp. *CCAMLR Science*, submitted (English).

This paper contains comparative analyses of the vertical and horizontal distribution of mackerel icefish and krill based on acoustic measurements and the results of bottom and pelagic trawl sampling.

The importance of studying krill and mackerel icefish interactions in order to understand the regularity of mackerel icefish distribution is shown.

WAMI-01/7

Assessment of the instantaneous natural mortality rate of mackerel icefish (*Champsocephalus gunnari*) from the South Georgia subarea. Zh.A. Frolkina and R.S. Dorovskikh (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 9 pp. (English, unpublished).

The applicability of various methods to the assessment of icefish natural mortality is analysed. On the basis of conclusions made, the parameters of Bertalanffy's growth equation and natural mortality rate are estimated.

WAMI-01/8

Possible causes of variation in the vertical and horizontal distribution of *Champsocephalus gunnari*. Zh.A. Frolkina and S.M. Kasatkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 22 pp. *CCAMLR Science*, submitted (English).

C. gunnari does not form aggregations during winter and inhabits areas inaccessible to fishing, therefore conducting census surveys during this period is of no value. In spring, during the feeding period, this species forms aggregations near the bottom and is therefore available for harvesting at the beginning of this period (September). Survey data collected for conducting stock assessments are of a high enough quality, however this season is far from suitable for census surveys because of severe ice conditions. Fish feed intensively during summer, performing vertical and horizontal migrations. We recommend against basing stock assessments on fish taken with bottom fishing gear since fish inhabiting the pelagic zone are not sampled. In autumn, pre-spawning fish migrate to spawning areas in near-bottom layers where they are easily accessible to fishing. The fish which do not spawn in a particular year, continue feeding during that year. However, the feeding intensity considerably decreases as fish gradually move to wintering areas. This species can also be fished during such migrations.

WAMI-01/9

Proposals for improvement of census surveys for the quantitative assessment of mackerel icefish – design of acoustic trawling surveys in Subarea 48.3. S.M. Kasatkina, Zh.A. Frolkina and P.S. Gasiukov

(AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 12 pp. (English, unpublished), (abstract not available).

WAMI-01/10 Rev. 1
Notes on *Champsocephalus gunnari* biology, availability, diet and spatial distribution in the South Shetland and South Orkney Islands (Subareas 48.1 and 48.2). C.D. Jones and J. Emery (NMFS Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), 41 pp. (English, unpublished).

Stocks of the mackerel icefish (*Champsocephalus gunnari*) in the Southern Scotia Arc region of the Southern Ocean (CCAMLR Subareas 48.1 and 48.2) have several different biological characteristics than stocks in the Northern Scotia Arc. The history of commercial *C. gunnari* exploitation in the Southern Scotia Arc was short lived and intense, and led to the collapse of the stocks. Stocks in this region are presently very low relative to historical levels, particularly around the South Orkney Islands. Aspects of the biology, patterns of distribution, maturity, diet and abundance based on recent scientific surveys conducted by the US AMLR Program are presented. During March, the species appears to use the shelf areas around Elephant Island and the lower South Shetland Islands differently, with juveniles favouring the western shelf of Elephant Island and larger, more mature fish favouring areas on western and northwestern parts of the Elephant Island shelf and the lower South Shetland Islands near Livingston Island. The dietary composition of *C. gunnari* appears to be more diverse in the South Orkney Islands, while their diet in the South Shetland Islands is almost entirely krill (*Euphausia superba*). The effect of *E. superba* density on the spatial distributions of *C. gunnari* abundance, size and feeding patterns in the South Shetland Islands for the 2001 survey is examined. Preliminary results suggest a complex relationship between spatial distribution, size composition and feeding intensity of *C. gunnari* and prey density patterns.

WAMI-01/11
By-catch of juvenile *Champsocephalus gunnari* during krill fishing in Subarea 48.2 in May–July 1999. V.A. Bibik and L.K. Pshenichnov (YugNIRO, 2 Sverdlov Street, Kerch 98300, Crimea, Ukraine), 3 pp. (English, unpublished), (abstract not available).

WAMI-01/12
Estimation of relative fishing power of vessels carrying out bottom trawl surveys off South Georgia. P.S. Gasiukov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 7 pp. (English, unpublished), (abstract not available).

WAMI-01/13
Biological reference points for *C. gunnari* based on the stock assessment using integrated statistical methods (XSA). P.S. Gasiukov and R.S. Dorovskikh (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 14 pp. (English, unpublished).

In the early 1990s WG-FSA carried out a stock assessment of *C. gunnari* using the Adapt-method. The data prepared for these calculations were used to revise previous assessments made using the method 'Extended Survivors Analysis' (XSA).

Based on a precautionary approach, the following reference points were calculated using ICES computer programs: B_{loss}, F_{max}, $F_{0.1}$, F_{low}, F_{med}, F_{high}, F_{loss}.

WAMI-01/14
Assessments of mackerel icefish. I. Everson, S.M. Kasatkina, C. Goss and M. Belchier (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 5 pp. (English, unpublished), (abstract not available).

WAMI-01/15 Rev. 1
Icefish fishery information. CCAMLR Secretariat, 15 pp. (English, unpublished).

WAMI-01/16
Distribution of mackerel icefish by size-group at South Georgia. A.W. North and I. Everson (British Antarctic Survey, Natural Environmental Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 9 pp. (English, unpublished).

The depth distribution of *C. gunnari* was investigated using data from nine groundfish surveys conducted between 1986 and 2000; these data were obtained

from representative randomly located hauls. The dataset for South Georgia (Subarea 48.3), but excluding Shag Rocks, comprised between 58 and 61 bottom trawls in each of eight depth strata with mean depths of 112, 137, 165, 185, 208, 230, 257 and 308 m. Fish were divided into size groups representative of age classes. Kruskal-Wallis tests on log-transformed median abundance (number of fish/km^2) indicated that depth of maximum abundance increased as the size of the fish increased. The size range of all year classes was contained within the sampling depth of the surveys. The results indicate that future surveys should be designed so as to provide a uniform sampling intensity over the depth range from 100 to 300 m.

Working Group on Fish Stock Assessment

WG-FSA-01/8
Seabird mortality in the Patagonian toothfish longline fishery around the Prince Edward Islands, 1996 to 2000. D.C. Nel, P.G. Ryan and B.P. Watkins (Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7701, South Africa. Present address: BirdLife – Seabird Conservation Programme, BirdLife South Africa, 27 Somerset Crescent, Lakeside 7945, Cape Town, South Africa). Antarctic Science, submitted. (English).

Sanctioned longline fishing for Patagonian toothfish around the Prince Edward Islands (a globally important seabird breeding site) commenced in 1996 following high levels of illegal, unregulated and unreported (IUU) fishing. Independent fishery observers accompanied all but two sanctioned trips between 1996 and 2000, allowing a thorough excellent understanding of the impact of this fishery on seabirds. Overall, white-chinned petrels (*Procellaria aequinoctialis*) were by far the most frequently killed species. However, during the first year, when lines were set during the day and night, a significant number of albatrosses (particularly grey-headed albatrosses (*Thalassarche chrysocome*)) were also killed. Birds were caught almost exclusively during their breeding seasons and most birds killed were breeding adult males from the Prince Edward Islands. Albatrosses and giant petrels were caught almost exclusively during day sets, whereas catch rates of white-chinned petrels did not differ between day and night sets. Albatrosses were caught closer to the islands than white-chinned petrels. Most white-chinned petrel carcasses were hooked in their wings and bodies, whereas albatrosses were caught most frequently in their bills. Albatross carcasses also contained large numbers of baits, indicating that fishers may be losing significant potential revenue by allowing these birds to access baited hooks. Rates of seabird by-catch in the sanctioned fishery decreased from 0.19 birds/thousand hooks to 0.034 birds/thousand hooks during the time of this study. This was probably mainly due to stricter implementation of mitigation measures and a progressive movement farther away from the islands over the years. We estimate that the combined impact of sanctioned and IUU longline fishing around the Prince Edward Islands over the past four years could have resulted in close to 7 000 seabird mortalities and could have had significant impacts on the breeding populations of several seabird species breeding on the Prince Edward Islands. This was mainly due to high levels of IUU fishing during 1996/97.

WG-FSA-01/9
Albatross and Petrel Mortality from Longline Fishing International Workshop (Honolulu, Hawaii, USA, 11–12 May 2000). 6 pp. (English).

WG-FSA-01/10
Foraging interactions of wandering albatrosses (*Diomedea exulans*) breeding on Marion Island with longline fisheries in the southern Indian Ocean. D.C. Nel, P.G. Ryan, J.L. Nel, N.T.W. Klages, R.P. Wilson and G. Robertson (Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7701, South Africa. Present address: BirdLife International – Global Seabird Conservation Programme, BirdLife South Africa, 27 Somerset Crescent, Lakeside 7945, Cape Town, South Africa). *Ibis*, submitted. (English).

Concerning numbers of wandering albatrosses (*Diomedea exulans*) are killed

when they attempt to scavenge baited hooks deployed by longline fishing vessels. We studied the foraging ecology of wandering albatrosses breeding on Marion Island in order to assess the scale of interactions with known longline fishing fleets. During incubation and large chick rearing, birds foraged farther away from the island, in warmer waters, and showed high spatial overlap with areas of intense tuna (*Thunnus* spp.) longline fishing. During small chick rearing, birds made shorter foraging trips and showed higher spatial overlap with the local Patagonian toothfish (*Dissostichus eleginoides*) longline fishery. Tracks of birds returning with offal from the toothfish fishery, showed a strong association with positions at which toothfish longlines were set and most diet samples taken during this stage contained fisheries-related items. Independent of these seasonal differences, females foraged farther from the islands and in warmer waters than males. Consequently, female distribution overlapped more with tuna longline fisheries, whereas males interacted more with the toothfish longline fishery. These factors could lead differences in the survival probabilities of males and females. Non-breeding birds foraged in warmer waters and showed the highest spatial overlap with tuna longline fishing areas. The foraging distribution of Marion Island birds showed the highest degree of spatial overlap with birds from the neighbouring Crozet Islands, during the late chick rearing and non-breeding periods. These areas of foraging overlap also coincided with areas of intense tuna longline fishing, south of Africa. As the population trends of wandering albatrosses at these two localities are very similar, it is possible that incidental mortality during the periods when these two populations show the highest spatial overlap could be driving these trends.

WG-FSA-01/11

Population trends of albatrosses and petrels at sub-Antarctic Marion Island. D.C. Nel, P.G. Ryan, R.J.M. Crawford, J. Cooper and O. Huyser. *Polar Biology*; in press (2001). Published online – http://dx.doi.org/10.1007/s003000100315. (English).

We report on the population changes of five species of Procellariiform seabirds breeding at Marion Island: wandering albatross (*Diomedea exulans*), grey-headed albatross (*Thalassarche chrysostoma*), northern giant petrel (*Macronectes halli*), southern giant petrel (*M. giganteus*), and white-chinned petrel (*Procellaria aequinoctialis*). The four large surface-nesting species (wandering albatross, grey-headed albatross and the northern and southern giant petrel) show similar population trends over the last 16–18 years. All were stable or decreasing during the 1980s, followed by a recovery period during the early to mid-1990s. Recently, all species have once again stabilised or decreased in numbers. Population trends of wandering albatross at Marion Island were strongly correlated with other Indian Ocean populations, but were different from the Atlantic Ocean population. These similarities suggest a common cause and can be explained by changes in tuna (*Thunnus* spp.) longline fishing effort in the southern Indian Ocean. A recent increase in tuna longlining, as well as recent large-scale Illegal, Unregulated and Unreported (IUU) longline fishing for Patagonian toothfish (*Dissostichus eleginoides*) close to Marion Island, could be contributing to the recent decreases in some of these species. Adoption of mitigation measures and an effective means of dealing with IUU longline fishing seem necessary to reduce the potential impacts of longline fishing on populations of albatross and petrel.

WG-FSA-01/12

Exploitation of mesoscale oceanographic features by grey-headed albatrosses *Thalassarche chrysostoma* in the southern Indian Ocean. D.C. Nel, J.R.E. Lutjeharms, E.A. Pakhomov, I.J. Ansorge, P.G. Ryan, N.T.W. Klages. *Marine Ecology Progress Series*, 217: 15–26 (2001). (English).

Breeding grey-headed albatross *Thalassarche chrysostoma*, tracked from Marion Island (Prince Edward Islands) during November–December 1997 and January–February 1998, showed a strong association with mesoscale oceanographic features, as identified by sea surface height anomalies, in the southern Indian Ocean. During incubation, most birds foraged to the north of the island, at the edges of anomalies created by the Agulhas Return Current in the Subtropical Convergence

and the Subantarctic zones. In contrast, during chick-rearing all tracked birds foraged to the southwest of the island, at the edges of anomalies along the South-West Indian Ridge. Previous work in this area has shown that these anomalies are in fact eddies that are created as the Antarctic Circumpolar Current crosses the South-West Indian Ridge. Diet samples taken during the chick-rearing period showed a predominance of fresh specimens of the predatory fish *Magnisudis prionosa* and the squid *Martialia hyadesi*. Myctophid fish and amphipods *Themisto gaudichaudii*, both known prey of *M. hyadesi*, were also well represented in our samples. Diet samples taken from tracked birds showed birds feeding at edges of positive anomalies returning with fresh specimens of *M. prionosa* and *M. hyadesi*. Predatory fish and squid are thus presumably concentrated at these features. Eddies formed at the South-West Indian Ridge have also been shown to drift closer to Marion Island, within the foraging range of penguins and seals breeding on Marion Island. We therefore suggest that these mesoscale oceanographic features may be an important component of the 'life-support' system enabling globally significant populations of seabirds and seals to breed at the Prince Edward Islands.

WG-FSA-01/13

Report on a BirdLife South Africa workshop to design a medium-sized grant application to the Global Environment Facility (GEF) to address the problem of seabird mortality by longline fishing in developing countries (Cape Town, 2–6 April 2001). D.C. Nel and J. Cooper (BirdLife International – Global Seabird Conservation Programme, BirdLife South Africa, 27 Somerset Crescent, Lakeside 7945, Cape Town, South Africa), 2 pp. (English, unpublished).

WG-FSA-01/14

Population status, breeding biology and conservation of the Tristan albatross *Diomedia [exulans] dabbenena.* P.G. Ryan, J. Cooper and J.P. Glass. *Bird Conservation International*, 11: 35–48 (2001). (English).

Tristan albatross *Diomedea* [*exulans*] *dabbenena* is the most genetically distinct of the five taxa that form the wandering albatross superspecies, and has been listed as Endangered. It breeds only on Cough and Inaccessible Islands in the Tristan da Cunha group, central South Atlantic Ocean. The entire breeding population was surveyed during 1999–2000. A mid-September survey at Cough Island recorded 1 129 chicks, equivalent to an annual breeding effort by approximately 1 500 pairs. Only one chick was present at Inaccessible Island in 1999, and another pair laid an egg in 2000. The annual breeding effort at this island has not exceeded three pairs since the 1950s. None were found during an incomplete survey at Tristan, where the species bred in the past, but birds were seen flying over the island. A complete survey and attempts to promote recolonisation of Tristan are warranted. Breeding success at Cough Island averaged 63%, and no birds that bred successfully attempted to breed the following year. Breeding success was greater and less variable in a large colony at Gonydale than at a peripheral colony at Tafelkop. Young birds returned to the island after 3–4 years (4–5 years old), and the modal age of first breeding was 8 years, with some individuals breeding as young as 6 years. Most chicks (81%) recruited to their natal colony, but some recruited to colonies up to 3 km from their natal site. Among adults, fidelity to partners and breeding colony was high. Of nine birds recovered away from the island, at least four were killed by longline fishing. Despite its known mortality on longlines, the Cough Island census exceeded demi-population estimates from the 1970s and early 1980s, possibly due to incomplete coverage by previous surveys and a poor breeding season in 1998. Given the lack of evidence for a population decrease, Tristan albatross should be listed as Vulnerable. It is the third rarest albatross species, however, and its population size warrants monitoring. We provide guidelines for repeatable censuses at Cough Island.

WG-FSA-01/15

Longline fishing at Tristan da Cunha: impacts on seabirds. N. Glass, I. Lavarello, J.P. Glass and P.G. Ryan. *Atlantic Seabirds*, 2 (2): 49–56 (2000). (English).

Tristan da Cunha and Gough Islands in the central South Atlantic Ocean support globally important seabird populations. Two longline fisheries occur within Tristan's

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

WG-FSA-01/16

Length-at-age in juvenile Patagonian toothfish *Dissostichus eleginoides*. J.R. Ashford, I. Everson, C.D. Jones and S. Bobko (Center for Quantitative Fisheries Ecology, Old Dominion University, Technology Building Room 102, 4608 Hampton Boulevard, Norfolk, Va. 23529, USA), 13 pp. *CCAMLR Science*, submitted. (English).

The fishery for Patagonian toothfish is one of the most valuable in the CCAMLR Convention Area. Age-based models are used to assess the status of the stocks of this species. Although age can be estimated using otoliths, it has proven difficult for these to be validated. During a recent trawl survey, the length density of juvenile toothfish in the catches had a clearly defined polymodal distribution. The age of each fish was estimated from the otoliths and the distribution of these ages matched closely the modal size groups. It is confirmed that one annulus, as seen on an otolith section, corresponds to one year's growth.

WG-FSA-01/17

Problems in estimating population length at age from commercial catches, the Patagonian toothfish as an example. I. Everson (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom), 32 pp. *CCAMLR Science*, submitted. (English).

Age-based fishery population models require information on size at age of the fished population and the commercial catch. Age–length keys can be produced by standardised random sampling of the commercial catches. This information does not necessarily reflect the size at age of the fished population and may be seriously biased. Through the use of a model, and using the Patagonian toothfish as an example, a method is developed to estimate size at age of the population using information collected from the commercial fishery.

WG-FSA-01/18

Modelling the impact of fishery by-catches on albatross populations. G.N. Tuck, T. Polacheck, J.P. Croxall and H. Weimerskirch. *Journal of Applied Ecology*, 38: in press (2001). (English).

1. Several albatross species, including the wandering albatross *Diomedea exulans*, have shown marked declines in abundance throughout their range. These seabirds are frequently taken as by-catch in longline fisheries and this mortality has been implicated in the population declines.

2. We developed a deterministic, density-dependent, age-structured model for assessing the effects of longlining on wandering albatross populations. We used demographic data from field studies at South Georgia and the Crozet Islands, data on albatross abundance from 1960 to 1995, and reported effort data from the tuna longline fisheries south of 30°S, to model estimated by-catch levels and other population parameters in the model.

3. The model used two alternative assumptions about patterns of at-sea distribution of wandering albatross (uniform between 30°S–60°S; proportional to the distribution of longline fishing effort between these latitudes).

4. Our model was able to predict reasonably closely the observed data from the Crozet Islands wandering albatross population, but the fit to the South Georgia population was substantially poorer. This probably reflects: (i) greater overlap in

the Indian Ocean than in the Atlantic Ocean between the main areas of tuna longline fishing and the foraging ranges of wandering albatrosses from the Crozet Islands and South Georgia, respectively; and (ii) greater impact of poorly documented longline fisheries, especially the tuna fisheries in the south Atlantic and the Patagonian toothfish *Dissostichus eleginoides* fishery, within the foraging range of wandering albatrosses from South Georgia.

5. The model results suggest that the marked decline in both populations, and subsequent recovery of the Crozet Islands population (but not the continued decline of the South Georgia population), can be explained by the tuna longline by-catch. They further indicate that populations may be able to sustain some level of incidental take. However, the likely under-reporting of fishing effort (especially in non-tuna longline fisheries) and the delicate balance between a sustainable and unsustainable level of by-catch for these long-lived populations suggest great caution in any application of such findings.

WG-FSA-01/19
Global relationships amongst black-browed and grey-headed albatrosses: analysis of population structure using mitochondrial DNA and microsatellites. T.M. Burg and J.P. Croxall. *Molecular Ecology*, 10: in press (2001). (English).

The population structure of black-browed (*Thalassarche melanophris* and *T. impavida*) and grey-headed (*T. chrysostoma*) albatrosses was examined using both mitochondrial DNA (mtDNA) and microsatellite analyses. mtDNA sequences from 73 black-browed and 50 grey-headed albatrosses were obtained from five island groups in the Southern Ocean. High levels of sequence divergence were found in both taxa (0.55–7.20% in black-browed albatrosses and 2.10–3.90% in grey-headed albatrosses). Black-browed albatrosses form three distinct groups: Falklands, Diego Ramirez/South Georgia/Kerguelen, and Campbell Island (*T. impavida*). *T. melanophris* from Campbell Island contain birds from each of the three groups, indicating high levels of mixture and hybridisation. In contrast, grey-headed albatrosses form one globally panmictic population. Microsatellite analyses on a larger number of samples using seven highly variable markers found similar population structure to the mtDNA analyses in both black-browed and grey-headed albatrosses. Differences in population structure between these two very similar and closely related species could be the result of differences in foraging and dispersal patterns. Breeding black-browed albatrosses forage mainly over continental shelves and migrate to similar areas when not breeding. Grey-headed albatrosses forage mainly at frontal systems, travelling widely across oceanic habitats outside the breeding season. Genetic analyses support the current classification of *T. impavida* as being distinct from *T. melanophris*, but would also suggest splitting *T. melanophris* into two groups: Falkland Islands, and Diego Ramirez/ South Georgia/Kerguelen.

WG-FSA-01/20
Summary of observations aboard trawlers operating in the Convention Area during the 2000/01 season. CCAMLR Secretariat, 8 pp. (English, unpublished).

WG-FSA-01/21
A summary of observations on board longline vessels operating within the CCAMLR Convention Area. CCAMLR Secretariat, 13 pp. (English, unpublished).

WG-FSA-01/ 22
A summary of scientific observations related to Conservation Measures 29/XVI and 63/XV. CCAMLR Secretariat, 13 pp. (English, unpublished).

WG-FSA-01/24
The impact of longline fishing on seabirds in the north-east Atlantic: recommendations for reducing mortality. E. Dunn and C. Steel. *NOF Rapportserie Report*, 5, 2001 (ISSN 0805-4932, ISBN 82-7852-048-8). (English).

WG-FSA-01/25
Foraging location and range of white-chinned petrels *Procellaria aequinoctialis* breeding in the South Atlantic. S.D. Berrow, A.G. Wood and P.A. Prince. *Journal of Avian Biology*, 31: 303–311 (2000). (English).

The foraging range and principal feeding areas of white-chinned petrels breeding at South Georgia were determined

using satellite telemetry. Foraging trips during incubation lasted 12–15 days and covered 3 000–8 000 km and 2–11 days and 1 100–5 900 km during chick-rearing. Adults covered less distance per day during chick-rearing (71 km) than during incubation (91 km) but the proportion covered at night (47%) was the same. Mean (31–34 km/h) and maximum (80 km/h) flight velocities were similar during both periods of the breeding season and during day and night. Between incubation shifts, white-chinned petrels travelled to the Patagonian shelf; during chick-rearing they foraged more extensively. Most locations were between 30° to 55°W and 52° to 60°W around South Georgia, Shag Rocks and south to the South Orkney Islands. Diet samples from known foraging locations suggested birds fed mainly on krill and squid. They caught the squid *Brachioteuthis picta* and *Galiteuthis glacialis* around Shag Rocks, South Georgia, and also at sites close to the South Orkney Islands; *Illex argentinus* on the Patagonian shelf. Dispersal of adults after breeding failure was south to the South Orkney Islands then west to the Falkland Islands. This study confirms that breeding white-chinned petrels are amongst the widest-ranging of seabirds; they may minimise competition with other Procellariiformes in the South Atlantic by their more extensive foraging range. The nature and extent of their range also brings substantial risk of high mortality rate in South Atlantic longline fisheries.

WG-FSA-01/26 Rev. 1
Status of white-chinned petrels *Procellaria aequinoctialis* linnaeus 1758, at Bird Island, South Georgia. S.D. Berrow, J.P. Croxall and S.D. Grant. *Antarctic Science*, 12 (4): 399–405 (2000). (English).

The white-chinned petrel (*Procellaria aequinoctialis*) is an abundant, widespread petrel breeding in tussock grassland at sub-Antarctic islands. Over the last decade it has been killed in large numbers in temperate and sub-tropical longline fisheries. However no data are available on the global population status. We assessed the status of white-chinned petrels at Bird Island, South Georgia, by comparing the distribution and density of occupied burrows in 1981 and 1998. In both surveys white-chinned petrels burrows occurred in one-quarter of the 460–47 736-m^2 quadrats surveyed. The total number of burrows in each quadrat was consistent between each survey but we estimate an overall decrease of 28% in those occupied (with considerable variation between sites). Concurrent data on breeding frequency and success showed that white-chinned petrels are essentially annual breeders at Bird Island; breeding success was consistent at around 44%. Significant factors determining densities of occupied burrows were crown height and percent tussock cover (accounting for 77% of variance). The former has decreased significantly, the latter increased significantly between 1981 and 1998 but there was no relationship between white-chinned petrels occupancy rate and habitat modification due to the presence of fur seals (*Arctocephalus gazella*). This suggests that any population decline is due to factors operating away from the breeding colony, such as those attributed to fishing.

WG-FSA-01/28
Seabird by-catch by tuna longline fisheries off southern Africa, 1998–2000. P.G. Ryan, D.G. Keith and M. Kroese. *South African Journal of Marine Sciences*, 24: in press (2001). (English).

The incidental mortality of seabirds in tuna longline fisheries is estimated for the continental South African Exclusive Economic Zone (EEZ). Fishery observers accompanied 13 fishing trips and observed 108 sets (143 260 hooks) during the period 1998–2000. Despite most lines being set at night, seabird by-catch rates were high, with a mean of 1.6 birds killed per 1 000 hooks. Japanese vessels (1% effort observed) had a higher by-catch rate (2.6 birds per 1 000 hooks, range per trip 0.1–5.4) than South African vessels (0.8, range 0.0–4.3; 17% effort observed), possibly as a result of gear differences. Bird by-catch differed regionally in relation to the numbers of birds attending vessels. In international waters off the Northern Cape and southern Namibia, where there are few birds, only one bird was caught on 93 600 hooks (0.01 birds per 1 000 hooks). Shy *Thalassarche cauta*, black-browed *T. melanophris* and yellow-nosed *T. chlororhynchos* albatrosses, and white-chinned petrels *Procellaria aequinoctialis* were killed most frequently. Based on 1998–1999 fishing effort, simple extrapolation suggests that 19 000–30 000

seabirds are killed annually in South Africa's EEZ, of which 70% are albatrosses. Confidence in these estimates is low, given the small proportion of effort observed, but it is clear that urgent steps are needed to reduce seabird by-catch within South African waters.

WG-FSA-01/29
Seabird mortality and the double-line system of longline fishing. G. Robertson, C. Carboneras, M. Favero, P. Gandini, C. Moreno and A. Stagi (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia) 12 pp. (English, unpublished).

The double-line system of longline fishing is the commonest method of longline fishing used in the Convention Area. The double-line method is also widely used outside the Convention Area (particularly by South American nations) in waters that attract Convention Area seabirds on winter migration flights. It is likely that Convention Area seabirds will continue to decrease in number unless mortality in double-line system fisheries is greatly reduced. The effectiveness of Conservation Measure 29/XIX in reducing seabird mortality is unknown because observed vessels have never fully complied with the provisions of the measure. We propose that experiments be conducted to determine the extent to which the provisions of the conservation measure can reduce seabird mortality by double-line system vessels.

WG-FSA-01/30
Preliminary analysis of seabird by-catch in the South Georgia icefish fishery. D.J. Agnew, N. Ansell, J.P. Croxall (Renewable Resources Assessment Group, Imperial College, Royal School of Mines, Prince Consort Road, London SW7 2BP, United Kingdom), 11 pp. (English, unpublished).

We conducted a preliminary analysis on the numbers of birds caught as by-catch in the trawl fishery for icefish (*Champsocephalus gunnari*) in Subarea 48.3. From December 2000 to February 2001, 92 birds were caught, principally black-browed albatrosses and white-chinned petrels, with 93% of the birds being caught in February. GAM/GLM analysis suggested that month and vessel were significant factors affecting the probability of a haul catching birds, but no significant factors were found that could explain the number of birds caught. Differences in the numbers caught in the last three years also suggest that there may be a year effect. We were unable, with the limited data available, to separate these various hypotheses and identify conclusively the causes of seabird by-catch in the icefish fishery. More work by scientific observers is required to enable effective mitigation measures to be designed for this potential problem. CCAMLR protocols and data formats for such observer studies need to be developed.

WG-FSA-01/31
Exploratory jig fishery for squid in Subarea 48.3 June 2001. Joint submission by the United Kingdom and the Republic of Korea, 6 pp. (English, unpublished).

WG-FSA-01/32
Distribution, demography and discard mortality of crabs caught as by-catch in an experimental pot fishery for toothfish in the South Atlantic. M.G. Purves, D.J. Agnew, G. Moreno, T. Daw, C. Yau, G. Pilling (Renewable Resources Assessment Group, Imperial College, Royal School of Mines, Prince Consort Road, London SW7 2BP, United Kingdom), 48 pp. (English, unpublished).

Between March 2000 and April 2001, two commercial fishing vessels undertook trials at South Georgia of a method of fishing for toothfish (*Dissostichus eleginoides*) using pots. A significant by-catch of lithodid crabs (three species of *Paralomis* spp.) was encountered. *Paralomis spinosissima* occurred in shallow water, generally shallower than 700 m. *P. anamerae*, not previously reported from this area, had an intermediate depth distribution from 400–800 m. *P. formosa* was present in shallow waters but reached much higher catch levels (and, presumably, densities) between 800 and 1 400 m. Differences were also noted in depth distribution of the sexes and the size of crabs. Depth, soak time and area were found to significantly influence crab catch rates. Very few crabs (3% of *P. spinosissima* and 7% of *P. formosa*) were males above the legal size limit and could therefore be retained. All other crabs were discarded. Most crabs

(>99% of *P. formosa*, >97% of *P. spinosissima* and >90% of *P. anamerae*) were lively on arrival on deck and at subsequent discard. Mortality rates estimated from re-immersion experiments indicated that on the vessel which emptied pots directly onto the factory conveyor belt 85–90% of crabs would survive discarding, whereas on the vessel where crabs were emptied down a vertical chute prior to being sorted, survivorship was 39–58%. *P. anamerae* was the most vulnerable of the three species to handling on board and subsequent discarding. *P. spinosissima* seemed to be more vulnerable than *P. formosa*.

WG-FSA-01/33 Rev. 1
Results and standing stock biomass estimates of finfish from the 2001 US AMLR bottom trawl survey of the South Shetland Islands (Subarea 48.1). C.D. Jones, K.-H. Kock, D. Ramm, J.R. Ashford, S. Wilhelms, T. Near, N. Gong and H. Flores (National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), 46 pp. (English, unpublished).

The US AMLR Program conducted a bottom trawl survey in March 2001 of the South Shetland Islands (Subarea 48.1). Information on species composition, size composition, spatial distribution and dietary patterns are presented. Estimates of total stock biomass were computed for eight species: *Champsocephalus gunnari*, *Chaenocephalus aceratus*, *Chionodraco rastrospinosus*, *Gobionotothen gibberifrons*, *Lepidonotothen larseni*, *Lepidonotothen squamifrons*, *Notothenia coriiceps* and *Notothenia rossii*. Biomass estimates were compared to the results from the 1998 US AMLR survey. For most species, the standing stock has decreased slightly, although in most cases the 95% confidence levels from the 2001 surveys were considerably decreased. The results indicate that stocks of *N. rossii* have not recovered even after commercial fishing has ceased for 20 years. The overall abundance of finfish in the South Shetland Islands has yet to reach a level at which commercial exploitation would be advisable. The potential role of habitat structure in demersal finfish assemblages in the South Shetland Islands is discussed.

WG-FSA-01/34
By-catch fish species from Kerguelen Islands area (Division 58.5.1). L.K. Pshenichnov (YugNIRO, 2 Sverdlov Street, Kerch 98300, Crimea, Ukraine), 14 pp. (English, unpublished).

The Kerguelen Islands shelf is one of the main fishing areas in the Antarctic. The primary focus in relation to studying the biology of fish in this area has always been on the commercial species *Notothenia rossii*, *Lepidonotothen squamifrons*, *Dissostichus eleginoides* and *Champsocephalus gunnari*. This paper describes the occurrence and some biological features of non-commercial fish species which are regular components of by-catch taken by trawlers.

WG-FSA-01/35
Solutions to seabird by-catch in Alaska's demersal longline fisheries. E.F. Melvin, J.K. Parrish, K.S. Dietrich and O.S. Hamel (Washington Sea Grant Program, University of Washington, Seattle, Wa. 98105, USA). (English). Full report available at www.wsg.washington.edu/pubs/seabirds/seabird-paper.html.

This research program compared seabird by-catch mitigation strategies over two years (1999 and 2000) in two major Alaskan demersal longline fisheries: the Gulf of Alaska/Aleutian Island Individual Fishing Quota fishery for sablefish and halibut and the Bering Sea catcher-processor longline fishery for Pacific cod. We conducted tests over two years to account for interannual variation and allow for improvement and innovation. A key feature of this program was an industry–agency–academic collaboration to identify possible deterrents and test them on active fishing vessels under typical fishing conditions. We report the results of experimentally rigorous tests of seabird by-catch deterrents on the local abundance, attack rate, and hooking rate of seabirds in both fisheries. Based on our results, we recommend a suite of by-catch mitigation measures.

Among all deterrents tested, paired streamer lines proved to be the most comprehensive solution. Paired streamer lines successfully reduced seabird by-catch in all years, regions, and fleets (88% to 100% relative to controls with no deterrent), despite the fact that we saw orders

of magnitude variation in by-catch across years and in the case of the sablefish fishery, among regions. Paired streamer lines were robust in a wide range of wind conditions and required little adjustment as physical conditions changed. Functionally, paired streamer lines created a moving fence that precluded seabird attacks. Most significantly, this success came with no consequence to catch rates of target-fish or the rate of capture of other by-catch species, thus satisfying our primary goal.

Several additional measures are discussed, including eliminating directed discharge of residual bait and offal while setting gear and the need for report card and peer-review systems, as well as the need for national and international action.

WG-FSA-01/36
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), 7 pp. (English, unpublished).

WG-FSA-01/37
Abnormal distribution of the South Georgia ray (*Raja georgiana*) in February 2000. F.F. Litvinov, V.N. Shnar, V.A. Khvichia and O.A. Berezhinsky (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 4 pp. (English, unpublished).

Two sequential groundfish surveys conducted in January–February 2000 revealed very different distribution of *Raja georgiana*, a rather abundant species on the South Georgia shelf. In contrast to the first survey, the adult rays longer than 206 mm were not caught during the second survey. Possible reasons for this absence are discussed.

WG-FSA-01/38
Population structure of the Patagonian toothfish (*Dissostichus eleginoides*) in Australian waters. S.A. Appleyard, R.D. Ward and R. Williams (CSIRO Marine Research, GPO Box 1538, Hobart 7001, Tasmania, Australia), 14 pp. (English, unpublished).

MtDNA and microsatellite loci were used to investigate the population structure of Patagonian toothfish at two Australian fishing locations (Macquarie Island, five collections; Heard and McDonald Islands (CCAMLR Division 58.4.2), four collections) in the Southern Ocean. Additionally, a small sample of toothfish from the Shag Rocks/South Georgia fishing location (CCAMLR Subarea 48.3) was also examined. Striking mtDNA heterogeneity was detected among the three fishing locations; spatial and temporal collections within the same fishing location were not significantly different. There was weak and inconsistent heterogeneity at several microsatellite loci among the 10 collections, and no overall differentiation among the three fishing locations. The mtDNA heterogeneity suggests that gene flow between the two Australian fishing locations and more generally among the three locations within the Southern Ocean is restricted.

WG-FSA-01/39
Otolith and body size relationships in the bigeye grenadier (*Macrourus holotrachys*) in CCAMLR Subarea 48.3. S. Morley and M. Belchier (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 12 pp. *CCAMLR Science*, submitted (English).

A large sample of otoliths from bigeye grenadier (*Macrourus holotrachys*) caught as by-catch in the toothfish (*Dissostichus eleginoides*) fishery in Subarea 48.3 was measured and weighed, and the usefulness of otoliths as predictors of fish size was determined. Otolith mass provides a good measure of fish length, whereas otolith length and width measurements provide less accurate estimates of fish length. Seasonal variations in fish mass with reproductive condition need to be considered if predictions of mass from otolith mass are undertaken. Otolith size/fish size models should be derived for each fish population under investigation. The length of fish chosen in such studies should be representative of the size range consumed by predators.

WG-FSA-01/40
A simple investigation of the effects of % observer coverage on estimated bird catch rates. D.J. Agnew (Renewable Resources Assessment Group, Imperial

College, Royal School of Mines, Prince Consort Road, London SW7 2BP, United Kingdom), 6 pp. (English, unpublished), (abstract not available).

WG-FSA-01/41
France research under way on Southern Ocean seabirds vulnerable to fisheries interactions – 2001. H. Weimerskirch (France), 7 pp. (English, unpublished).

WG-FSA-01/42
Summary of observations on board pot and squid jig vessels operating in the Convention Area during the 2000/01 season. CCAMLR Secretariat, 4 pp. (English, unpublished).

WG-FSA-01/43
Preliminary age and growth estimates for the ridge-scaled rattail (*Macrourus whitsoni*). P. Marriott and P.L. Horn (National Institute of Water and Atmospheric Research Ltd, PO Box 14 901, Wellington, New Zealand), 13 pp. (English, unpublished).

The objective of this project was to 'determine unvalidated age and growth of the main macrourid by-catch species from the Antarctic toothfish in the Ross Sea'. Rattail otoliths were randomly collected by CCAMLR observers from commercial vessels fishing for Antarctic toothfish during the 1999 season. Most of the rattail otoliths and the majority of the rattail by-catch of the fishery in the 1999 season were tentatively identified by observers as being *Macrourus carinatus*, whilst a few otoliths and about 5% of the by-catch was identified as *Macrourus whitsoni* (Hanchet and Horn, 2000). Because of uncertainty over species identity, approximately 64 whole rattails collected from the 1999, 2000 and 2001 fishing seasons were examined by two rattail identification experts: Andrew Stewart (Museum of New Zealand Te Papa Tongarewa) and Peter McMillan (NIWA). They identified 59 specimens as *M. whitsoni*, and five specimens as *Coryphaenoides armatus*. On the basis of this identification we have assumed in this report that the observer collected otoliths originally labelled as *M. carinatus* were in fact *M. whitsoni.* It is essential that rattails sampled be correctly identified before any accurate ageing and population modelling can be done. We therefore recommend that at least two rattails be randomly selected and kept from every longline set in the coming season so that their identity and distribution throughout the Ross Sea can be thoroughly examined.

A total of 300 otoliths from the 1999 season initially identified by observers as *M. carinatus*, were randomly selected, weighed, and their width and length measured. A further six otoliths initially identified by observers as *M. whitsoni* were treated in the same way. When examined macroscopically, the 300 otoliths appeared to form three morphologically distinct groups (A, B, and C). Bivariate plots of the otolith morphometric measurements showed some support for these three groups. It is uncertain at this stage whether these groups correspond to different species, sub-species, or are simply different 'morphs' of *M. whitsoni*. However, the otoliths from group B were similar to the six otoliths initially identified by observers as *M. whitsoni*, and the otoliths from group C were mainly from fish collected in the area to the north. Most (89%) of the aged otoliths were from group A, and these otoliths probably provide the most reliable data to use. Counts of growth zones from sectioned otoliths were used to determine ages. An ageing methodology was developed for these otoliths, but has not been validated. Growth parameters were estimated from these data both for all otoliths and those from group A. A maximum age of 55 years was observed, with fish having a reasonably slow growth rate and probable high age at maturity. These characteristics indicate a long-lived species with low productivity. Von Bertalanffy growth curves were fitted to length-at-age data. The calculated von Bertalanffy growth parameters were: males, L_8 = 78.3 cm, k = 0.050, t_0 = -5.30; females, L_8 = 87.0 cm, k = 0.068, t_0 = 1.34; all fish combined, L_8 = 85.7 cm, k = 0.048, t_0 = -3.89. Growth parameters for the group A otoliths only were very similar to those for the full dataset.

The best estimates of instantaneous natural mortality (M) based on the minimum age of the oldest 1% of fish in the longline catch were 0.08 for males and 0.09 for females. But because of the

uncertainty of these estimates it is recommended that a range of 0.05 to 0.12 be used for *M*.

WG-FSA-01/44
Longline sink rates of an autoline vessel, and notes on seabird interactions. N.W.McL. Smith. *Science for Conservation*, 183: 32 pp. (ISSN 1173-2946, ISBN 0-478-22154-1). (English).

A series of longline sink-rate trials were conducted with and without weights, from an autoline fishing vessel working the New Zealand ling (*Genypterus blacodes*) longline fishery on the Chatham Rise, New Zealand during July and August 1998. The autoline equipment is designed to sink without weights, and non-weighted longline line sink data were collected first to provide baseline information. Further trials were conducted with weights added to the longline as in normal fishing operations. A robust attachment method for Time Depth Recorders was developed. A tori line was used at all times by the vessel, and the design was refined during the voyage. The aerial section of the tori line appeared to provide an effective deterrent to most seabirds. Statistical analyses of the data from the line sink rate trials indicate that the weighting regimes used (5 kg per 400 m) had no effect on line sink rate. However, direct observations at sea indicated that weights did have an effect on line sink for 20–40 m either side of the attached weights. Data on line sink rate and tori line coverage suggest that quicker line sink rates could help decrease the incidental mortality of seabirds during autoline fishing. Seabird incidental mortality rate for the voyage was 0.0093 seabirds per 1 000 hooks set. Grey petrels (*Procellaria cinerea*) accounted for 90% of the observed incidental catch; of which 90% were foul hooked rather than having swallowed a baited hook. Fourteen species of large seabird and five species of small seabird were observed interacting with the vessel. The seabird community constantly changed in size, species composition, and relative proportion of each species present. A large proportion of the seabirds present at any one time were Cape pigeons (*Daption capense*). Seabird behaviour about the vessel varied with fishing activity. Four distinct community behaviours were noted: set behaviour, haul behaviour, steaming (no offal) behaviour, and steaming (offal) behaviour. A night vision scope was trialled and found to be of limited benefit because of ineffective range, and the mono-colour vision.

WG-FSA-01/45
Fishes collected during the Ross Sea exploratory fishery (Subarea 88.1) in 1999/2000 and 2000/01, and registered in the National Fish Collection at the Museum of New Zealand Te Papa Tongarewa. A.L. Stewart and C.D. Roberts (Fish Section, Museum of New Zealand Te Papa Tongarewa, Wellington, New Zealand), 11 pp. (English, unpublished), (abstract not available).

WG-FSA-01/46
A simple new method for monitoring longline sink rate to selected depths. J.M. Fenaughty and N.W.McL. Smith (Silvifish Resources Ltd, Wellington, New Zealand), 6 pp. (English, unpublished), (abstract not available).

WG-FSA-01/47
Australian research under way on Southern Ocean seabirds vulnerable to fisheries interactions – 2001. R. Gales (Resource Management and Conservation, Department of Primary Industries, Water and Environment, GPO Box 44A, Hobart 7001, Tasmania, Australia), 3 pp. (English, unpublished).

WG-FSA-01/48
Trends in mean lengths and selectivities for *Dissostichus eleginoides* taken by longliners in Subarea 48.3. G.P. Kirkwood and D.J. Agnew (Renewable Resources Assessment Group, Imperial College, Royal School of Mines, Prince Consort Road, London SW7 2BP, United Kingdom), 16 pp. (English, unpublished).

At its last meeting, WG-FSA noted a declining trend in the mean lengths of toothfish caught around South Georgia and Shag Rocks over the period from 1995 to 1999. We reanalysed the mean lengths of fish taken on individual longline sets from which length frequencies were sampled by observers and found the same declines in mean lengths for the period from 1997 to 1999 as previously noted by WG-FSA, but also that this trend was halted in 2000. A GLM analysis of these data shows that

both area and depth are highly significant factors in explaining part of this variation over time, but not all of it. Taking depth and area into account there is less of an apparent decline in mean length over the period from 1997 to 1999. The overall picture that emerges is one of variable mean lengths, both within and between seasons but with no consistent overall trend.

The analysis also suggested that the exploitable population around South Georgia and Shag Rocks is quite spatially and temporally heterogeneous in terms of its length distribution. Separately, it is known that the effort distribution is also highly heterogeneous. The combined effects of these findings were examined in a set of preliminary analyses of length densities by area and depth zone. The results indicate that the annual distribution of effort by area and depth zone does have an important effect on the overall length-specific selectivity and that it is also likely that historical changes over years in the depth distribution of effort have led to different length-specific selectivity curves applying in different years.

Combined length-specific selectivity curves were estimated for each of the years from 1997 to 2000. Notable differences were found amongst these, but there was a consistent tendency for fish over 90 to 100 cm to have a lower relative selectivity than smaller fish.

WG-FSA-01/49
Spatio-temporal trends in longline fisheries of the Southern Ocean and implications for seabird by-catch. G.N. Tuck and C. Bulman (CSIRO Marine Research, GPO Box 1538, Hobart 7001, Tasmania, Australia), 29 pp. (English, unpublished), (abstract not available).

WG-FSA-01/51
Information on the spawning season and size of maturity of *Dissostichus mawsoni* from Subarea 88.1 in the 2000/01 season. G. Patchell (Sealord Group Ltd, Nelson, New Zealand), 10 pp. (English, unpublished), (abstract not available).

WG-FSA-01/52
Age and growth of the Antarctic skates (*Bathyraja eatoni* and *Amblyraja georgiana*). M.P. Francis and C.Ó Maolagáin (National Institute of Water and Atmospheric Research Ltd, PO Box 14 901, Wellington, New Zealand), 11 pp. (English, unpublished).

A variety of ageing techniques was applied to samples of vertebrae and caudal thorns of *Bathyraja eatonii* and *Amblyraja georgiana* obtained from the Ross Sea. Best results were obtained from X-radiographs of thorns and vertebral half-centra. The two techniques gave comparable results for *B. eatonii*, but the vertebrae produced lower counts than thorns for *A. georgiana*, possibly because of resolution problems near the margin of the vertebrae. Therefore caudal thorns, and the vertebrae of *B. eatonii*, can be used to provide unvalidated estimates of the ages of the two species. Larger samples of these structures are required to confirm this, and to develop sex-specific growth curves.

We were unable to confidently determine the position of the first band in thorns or vertebrae. Thorn band counts increased with pelvic length in both species. If one thorn band is deposited per year, and if no allowance needs to be made for bands formed inside the egg case, both species grow at a similar rate and reach an age of at least 10 years. It is unlikely that our samples included the largest and oldest skates in the populations, so this is almost certainly an underestimate of the longevity of the two species.

WG-FSA-01/54
A first attempt at an assessment of the Patagonian toothfish (*Dissostichus eleginoides*) resource in the Prince Edward Islands EEZ. A. Brandão, B.P. Watkins, D.S. Butterworth and D.G.M. Miller (Marine Resource Assessment and Management Group, Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa), 29 pp. *CCAMLR Science*, submitted (English).

The history of the fishery for Patagonian toothfish in the Prince Edward Islands EEZ is reviewed briefly. It is characterised by very large illegal catches and a sharply declining longline CPUE trend. Application of a simple age-structured production model provides robust indication that the spawning biomass has been depleted to at

most a few percent only of its pre-exploitation level. Projections suggest that the annual catch limit should be reduced to at most about 400 tonnes. Implications for surveillance are discussed.

WG-FSA-01/55
Global status of albatrosses and *Macronectes* and *Procellaria* petrels. Source: BirdLife International, 2000: *Threatened Birds of the World*. Barcelona and Cambridge, UK: Lynx Edicions and BirdLife International. (English).

WG-FSA-01/56
Preliminary review of the sink rate of longline fishing gear in the toothfish fishery, 1997/98 to 2000/01. R.G. Blackwell, S.M. Hanchet, and N.W.McL. Smith (National Institute of Water and Atmospheric Research Ltd, PO Box 14 901, Wellington, New Zealand), 15 pp. (English, unpublished).

Longline fishing is restricted to night-time in most CCAMLR statistical reporting areas, to mitigate against accidental seabird by-catch. The toothfish longline fishery in the Ross Sea (CCAMLR Subarea 88.1) operates during the Austral summer when there are no periods of darkness. An alternative protocol has been developed which requires longline fishing gear to achieve a minimum sink rate of 0.3 m/sec, to a minimum depth of 15 m (SR15), as determined by time depth recorders (TDRs). This protocol has been followed by vessels operating in this fishery since the 1998/99 fishing year. Experience has shown that these TDRs may suffer technical malfunction and be lost on foul ground. Two observers are carried on each vessel, one from New Zealand and one from another CCAMLR nation. As the TDRs can only be attached to a small proportion of all the sets observed, the monitoring of line sink rate does not apply to all of the sets for each vessel.

Although the autoline fishing gear is designed to sink without additional weights, the minimum target sink rate required can only be achieved by the use of additional weights on the backbone. This report reviews available sink rate data from experimental trials, certification trials and from fisheries observer information collected during the operation of the exploratory fishery using a linear regression approach to examine the influence of gear and environmental parameters. Based on these data, a predictive model can be used to determine appropriate combinations of weighting schedule, vessel speed and other parameters required to achieve the target sink rate. This report reviews and updates the model developed in 2000 with data from the 2000/01 fishery.

Initial analysis of the regression model indicated that vessel specific variables, vessel ID, trip number, year, TDR and dry weight of gear, were confounded by the unbalanced nature of the available data. Only one vessel carried out all of the experimental sets, but this vessel did not complete any subsequent exploratory fishing. The variability remaining in the data after the regression model was fitted was associated with differences between fishing vessels and the TDRs used in the analysis.

The data were pooled across all vessels, and the relationship between available parameters and sink rate to 15 m (SR15) as explored using a multiple linear regression model that explained 60% of variability in the data. Within this model, added weight explained 45% of variability, and 15% was explained by setting speed. Three vessels operating in this fishery during 2000/01 used larger (11.5 mm) diameter rope for the backbone of the gear, and extra weight was required to overcome the added friction of the gear through the water. Rope diameter was offered to the model but was not found to be significant. The relationships between these gear parameters may be complex and this report should be considered as a preliminary analysis, as insufficient time was available to fully interrogate the data. The close spacing of added weight on these large diameter lines may have allowed these vessels to compensate for sea conditions without decreasing the setting speed of the gear, as the swell category variable did not enter the regression model. This may be confounded with short-term changes in sea conditions, as observer reports from the 2000/01 season indicate that large swell conditions may have been less predominant in 2000/01 than in previous fishing years.

Based on this preliminary analysis, ranges of values were identified where the target sink rate may be achieved with 90% and 95% confidence. The use of a predictive

sink rate model may avoid the need for routine deployment of TDRs in the toothfish longline fishery.

WG-FSA-01/57
An update on developments toward video monitoring of seabird incidental mortality. N.W.McL. Smith (Ministry of Fisheries, Wellington, New Zealand), 20 pp. (English, unpublished).

WG-FSA-01/59
Incidental capture of seabird species in commercial fisheries in New Zealand waters, 1999/2000. S. Baird (National Institute of Water and Atmospheric Research Ltd, PO Box 14 901, Wellington, New Zealand), 7 pp. (English, unpublished), (abstract not available).

WG-FSA-01/60
A discussion of some aspects and factors involved in the use of seabird mortality mitigation devices currently used by New Zealand longline fishing vessels. J.M. Fenaughty (Silvifish Resources Ltd, Wellington, New Zealand), 8 pp. (English, unpublished), (abstract not available).

WG-FSA-01/61
Seabird by-catch in the Patagonian toothfish longline fishery at the Prince Edward Islands: 2000/01. P.G. Ryan and B.P. Watkins (Percy FitzPatrick Institute, University of Cape Town, Rondebosch 7701, South Africa), 8 pp. (English, unpublished).

Seabird by-catch is summarised for the period from July 2000 to June 2001 for sanctioned longline fishing for Patagonian toothfish (*Dissostichus eleginoides*) in South Africa's Exclusive Economic Zone around the Prince Edward Islands. There was a slight increase in the number of fishing trips and hooks set in 1999/2000. The number of seabirds killed dropped dramatically from 268 in 1999/2000 to 76 in 2000/01. White-chinned petrels (*Procellaria aequinoctialis*) accounted for 85.5% of the six species killed.

WG-FSA-01/62
FAO'S NPOA–Seabirds: a progress report by BirdLife International. J. Cooper (Coordinator, BirdLife International Seabird Conservation Programme, Avian Demography Unit, University of Cape Town, Rondebosch 7701, South Africa), 2 pp. (English, unpublished).

WG-FSA-01/63
The New Zealand toothfish fishery in Subarea 88.1 from 1997/98 to 2000/01. S.M. Hanchet, P.L. Horn and M.L. Stevenson (National Institute of Water and Atmospheric Research Ltd, PO Box 14 901, Wellington, New Zealand), 28 pp. (English, unpublished).

An exploratory fishery for Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 88.1 has been in operation for four seasons. A large amount of data on both toothfish and associated by-catch from the fishing operations has been collected. The purpose of this report is to present the analysis of data collected in the 2001 season (this is part of the 2000/01 CCAMLR split-year), and to compare these results with previous years.

Due to heavy ice conditions in much of the Ross Sea, the location and depth of fishing in 2001 was quite different to previous seasons. Vessels were unable to go into many areas fished in previous years, and fished both shallower and deeper and both further north and south than previously. This had a large effect on the size and catch of toothfish and associated by-catch species. It also led to the exploration of many new areas, thus continuing the exploratory nature of this fishery. All five small-scale research units (SSRUs) and a total of 91 fine-scale rectangles (FSRs), including 74 new FSRs, were fished during the 2001 season. A total of 150 FSRs have now been fished by New Zealand vessels. The 100 tonnes FSR catch limit was almost reached on two occasions. CPUE declined during the fishing period, but this decline was not significant ($P > 0.30$). We conclude that the current FSR catch limit of 100 tonnes is appropriate for this fishery. Antarctic toothfish contributed to 86% of the catch in 2001. They were caught in almost 95% of all sets and in all five SSRUs. They were the dominant catch in most sets except for those made in the northern SSRU (SSRU A). Antarctic toothfish were recorded at depths from 300 to 1 900 m, but were most abundant from about 600 to 1 300 m. In 2001, an additional 30 tonnes

of Patagonian toothfish (*Dissostichus eleginoides*) were taken from SSRU A. This is the largest catch of Patagonian toothfish in Subarea 88.1 to date.

The main by-catch species continues to be rattails, which contributed to about 7% of the 2001 catch. Following identification by New Zealand rattail specialists, it is now believed that the dominant species in Subarea 88.1 is the ridge-scaled rattail (*Macrourus whitsoni*). A second rattail species (*Coryphaenoides armatus*), identified from five specimens, was caught in deep water in SSRU A in 2001. There is still some confusion over rattail identification in the area and it is recommended that rattail specimens are retained in the coming season so that their identity and distribution throughout Subarea 88.1 can be determined. The by-catch of the two skate species was only 1%. This is considerably lower than previous years mainly because of the depths fished, but also partly because of the tag and release experiments carried out. Other by-catch species (including icefish, notothenids and moray cods) each contributed less than 1% of the catch overall. The main non-fish by-catch reported was starfish.

Length-frequency data for Antarctic toothfish were scaled up to the catch by SSRU, and then combined for the year. About 500 otoliths were read from each year and the scaled length frequency converted to catch at age. The catch was dominated by fish aged 5 to 20, although the proportions varied between years. New growth parameters have been estimated using all available data, but they differ only slightly from those calculated previously. Fish of both sexes appear to be fully selected in the longline fishery by age 8, with 50% selectivity at about age 7. As in previous years, there appeared to be inconsistencies in staging the maturity of fish, and it is again recommended that the current length at maturity is retained.

Length-frequency data for Patagonian toothfish were scaled up to the catch by SSRU, and then combined for the year. There was a strongly skewed sex ratio of 4:1 in favour of females. About 500 otoliths were read from 2001 and the scaled length frequency converted to catch at age. The catch was dominated by fish aged 5 to 20.

WG-FSA-01/64

A short note on the tagging of Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 88.1. N.W.McL. Smith and A. Bond (Ministry of Fisheries, Wellington, New Zealand), 8 pp. (English, unpublished).

A tagging program for Antarctic toothfish (*Dissostichus mawsoni*) and Patagonian toothfish (*D. eleginoides*) has begun in the Ross Sea (Subarea 88.1). The program has the initial aim of studying the movement and growth rates of toothfish species in the Ross Sea. Details of the program to date, and of future plans, are given.

In the 2000/01 fishing season, 259 *D. mawsoni* and 67 *D. eleginoides* were tagged by New Zealand vessels participating in the Subarea 88.1 exploratory fishery. All three New Zealand vessels were involved in the tagging program and had copies of recapture sheets on board. New Zealand is particularly keen to see this program expanded to all vessels participating in the Subareas 88.1 and 88.2 exploratory fisheries for *Dissostichus* spp. in the 2001/02 season.

WG-FSA-01/65

A short note on the tagging of skates in Subarea 88.1. N.W.McL. Smith (Ministry of Fisheries, Wellington, New Zealand), 3pp. (English, unpublished).

New Zealand has undertaken a tag–recapture study of skates (family Rajidae) in Subarea 88.1. The objective of the program is to determine the probability of released skates surviving. Skates have been tagged in the 1999/2000 and 2000/01 seasons. Results from 1999/2000 were presented in WG-FSA-00/55. This paper provides a brief update on the 2000/01 results and the tagging protocol in use.

WG-FSA-01/66

A short note on conversion factors for toothfish in Subarea 88.1. J.M. Fenaughty and N.W.McL. Smith (Silvifish Resources Ltd, Wellington, New Zealand), 5 pp. (English, unpublished).

WG-FSA-01/67

National research programs into the status and foraging ecology of albatrosses, giant petrels and white-chinned petrels. Delegation of the United Kingdom, 8 pp. (English, unpublished).

WG-FSA-01/68
Using hierarchical methods for subsampling hauls taken by trawl during fisheries surveys. J.R. Ashford and C.D. Jones (Center for Quantitative Fisheries Ecology, Old Dominion University, Technology Building Room 102, 4608 Hampton Boulevard, Norfolk, Va. 23529, USA), 10 pp. (English, unpublished), (abstract not available).

WG-FSA-01/69
Genetic variation among populations of the Antarctic toothfish: evolutionary insights and implications for conservation. R.W. Parker, K.N. Paige* and A.L. DeVries (*Department of Animal Biology, University of Illinois, 515 Morrill Hall, 505 S. Goodwin Avenue, Urbana, Il. 61801, USA), 23 pp. (English, unpublished).

Commercial fishing is having an increasingly negative impact on marine biodiversity with over 70% of the world's fish stocks being fully exploited and in many cases overexploited. On top of this, CCAMLR has granted commercial fishing permits in the most remote marine environment on earth, the high latitude Southern Ocean. The primary target of these new commercial fishing ventures is the large pelagic piscivorous predator, the Antarctic toothfish (*Dissostichus mawsoni*). Unfortunately little information is available on the demography, genetics or life history of this large fish. Without such information we have little idea as to the effects of commercial fishing on the population structure and survival of this species. In this study we focus on patterns of genetic diversity within and between geographically disparate populations of the Antarctic toothfish using randomly amplified polymorphic DNA (RAPD) markers. Results of our study showed high levels of genetic similarity within and between populations. Despite high levels of genetic similarity, genetic analyses detected a significant population structure including fixed differences among populations, a significant fixation index (Fst) and between population differentiation via a Mantel test. From a conservation perspective, low levels of genetic diversity may be indicative of relatively small populations that would not be able to withstand heavy commercial fishing pressures. Given that there is evidence for significant genetic structure, it will be important to manage these fisheries in a manner that will help prevent the loss of unique genetic variation from regional overfishing.

WG-FSA-01/70
In support of a rationally managed fishery: age and growth in Patagonian toothfish (*Dissostichus eleginoides*) – dissertation summary. J.R. Ashford (Center for Quantitative Fisheries Ecology, Old Dominion University, Technology Building Room 102, 4608 Hampton Boulevard, Norfolk, Va. 23529, USA), 8 pp. (English, unpublished).

WG-FSA-01/72
Trawl survey of the Patagonian toothfish (*Dissostichus eleginoides*) resource off the Prince Edwards Islands. R.W. Leslie and B.P. Watkins (Marine and Coastal Management, Private Bag X2, Rogge Bay 8012, South Africa), 15 pp. (English, unpublished).

A bottom trawl survey was conducted in the northern half of the South African EEZ around the Prince Edward Islands in April 2001. Due to the paucity of bathymetric data, it was not possible to design a statistically rigid survey, consequently this first survey is regarded as a pilot study to ascertain the feasibility of conducting future trawl surveys, and to collect relevant data to aid in the design of such surveys, should they be deemed practical.

The maximum operating depth for the survey vessel was 1 500 m. Over 90% of the survey area is deeper than 1 500 m and, therefore, cannot be surveyed by bottom trawl. The small area above the 1 500 m isobath is scattered over 28 hills and seamounts (of various sizes and heights). This combination of factors makes the design and execution of bottom trawl surveys extremely difficult.

A total of 55 trawls was completed and these show a relationship between Patagonian toothfish density and latitude and/or depth. Although this pilot survey was not designed to yield a biomass estimate, a first, crude estimate for Patagonian toothfish is presented. Fifty-one Patagonian toothfish were tagged and released.

WG-FSA-01/73
Reassessment of important population parameters for *Dissostichus eleginoides* on the Heard Island Plateau (Division 58.5.2) based on time series of surveys and fishery data. A.J. Constable, R. Williams, T. Lamb, I.R. Ball and E. van Wijk (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 41 pp. *CCAMLR Science*, submitted (English).

A large body of data and techniques are available for reassessing the biological parameters and recruitment of Patagonian toothfish (*Dissostichus eleginoides*) in the Heard Island region. A new survey of the Heard Island Plateau was undertaken in May/June 2001, providing the sixth survey over 11 years on this stock with other surveys including part of this stock. This paper describes the results of that survey, the time series of abundances and assessments of growth, recruitment, mortality and selectivity of this species. The results indicate that *D. eleginoides* is faster growing that originally thought with growth rates similar to South Georgia. The new estimates of growth parameters enabled a more accurate reassessment of the recruitment time series, which was likely to have been overestimated in the past. An estimate of natural mortality indicates that mortality of young fish, ages 3 to 8, may be much greater than older fish. This may need to be taken account of in the assessment process. An approach is proposed to estimate age selectivity to the trawl fishery in the region. In conclusion, the overall analysis shows a promising way forward in understanding the dynamics of *D. eleginoides* in the Heard Island region. Clearly, a longer time series of data will be useful to better estimate recruits and natural mortality. A question to be addressed is the extent to which these stocks are connected to the wider Kerguelen plateau as evidenced by some of the movement patterns and interannual variation in distribution.

WG-FSA-01/74
Modifications to the Generalised Yield Model: updated input of recruitment time-series data and annual fishing selectivity functions. A.J. Constable (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 6 pp. (English, unpublished).

Revisions to the Generalised Yield Model (GYM) provide for re-estimating the recruitment series from survey data for each value of natural mortality used in the assessments, whenever it is altered over the range of uncertainty in *M* factored into the assessment process. Data from outputs from mixture analyses from surveys are input to the GYM in raw form. An example file is provided. Consequently, endeavouring to predetermine the recruitment series with an average value of *M* is no longer necessary for inputting to the GYM.

In addition, provision is now made for inputting different fishing selectivity functions for different years in the assessment model. This is done in the usual way but with repeated input sections for each year at which the selectivity is altered.

WG-FSA-01/75
Ideal survey patterns: an example of using a simulated world. I.R. Ball and A.J. Constable (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 31 pp. (English, unpublished).

This paper considers a class of survey patterns for a toothfish longline fishery. These survey patterns are characterised by a minimum mutual separation distance and a shot selection criteria. The shot selection criteria can be either that locations of known good quality are preferentially selected or that locations are selected at random. The landscape and fishery are simulated in a spatially explicit Monte Carlo model and the use of such models to study these issues is considered along with their ability to answer such questions as: How well do different survey restrictions capture information of interest about the fished population? If and when can the catch/effort data be used as a measure of the relative abundance of the population? How well can this method detect changes in the abundance of the population? How sensitive are the results to the number of research shots used?

This paper shall show the strength of the simulation method in answering these questions and in exploring the efficacy of survey strategies in general as well as a generator of ideas for survey design.

WG-FSA-01/76
Toothfish tagging at Heard Island: a summary of principal results. R. Williams, T. Lamb and A.J. Constable (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 8 pp. *CCAMLR Science*, submitted (English), (abstract not available).

WG-FSA-01/77
Summary of research on New Zealand seabirds vulnerable to fisheries interactions. Delegation of New Zealand, 10 pp. (English, unpublished).

WG-FSA-01/78
Seabird and longline interactions: effects of a bird-scaring streamer line and line shooter on the incidental capture of northern fulmars (*Fulmarus glacialis*). S. Løkkeborg and G. Robertson (Institute of Marine Research, Fish Capture Division, PO Box 1870, Nordnes, N-5817 Bergen), 16 pp. (English, unpublished).

Interactions between seabirds and longline fishing can cause incidental bird mortality and reduced gear efficiency. The potential for solving these problems by using a bird-scaring streamer line and a line shooter was investigated in commercial longlining in the northern Atlantic off the coast of Norway. We compared the by-catch rate of northern fulmars (*Fulmarus glacialis*), the loss rate of baits to fulmars and the catch rates of fish target species among lines set with either of these mitigation measures, a combination of both and no mitigation measure. A total of 58 420 hooks was set in each of the four treatments. No birds were caught using the bird-scaring line alone and a single fulmar was caught when the bird-scaring line was used in combination with the line shooter. In contrast, 32 fulmars were caught in sets with no mitigation device and 13 in sets with the line shooter alone. Losses of mackerel bait were reduced when the bird-scaring line was used, but not by using the line shooter alone. Longlines set with the line shooter reached 3 m depth 15% faster then lines set without the line shooter; beyond this depth sinking rates were similar (about 15 cm s^{-1}). Fish catch did not vary significantly among setting methods. These results should also be applicable to the by-catch of *Fulmarus* spp. in demersal longline fisheries worldwide.

WG-FSA-01/79
Quantifying and mitigating seabird by-catch in the Falkland/Malvinas Islands. Delegation of the United Kingdom, 7 pp. (English, unpublished), (abstract not available).

WG-FSA-01/80
AFMA research fund – final report. Performance assessment and performance improvement of two underwater line setting devices for avoidance of seabird interactions in pelagic longline fisheries (ARF Project R2000/0469, September 2000). *Nature Conservation Report* 01/4, Appendix 2 (2001), Nature Conservation Branch (Marine), Tasmania. (ISSN 1441-0680). (English).

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

The chute was developed to a stage where it is now ready for more widespread testing in the industry. When in use, over 98% of baits were successfully set, irrespective of bait type, and there were no tangles.

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

WG-FSA-01/81
The effect of line weighting on the sink rate of pelagic tuna longline hooks, and its potential for minimising seabird mortalities. N. Brothers, R. Gales and T. Reid. *Nature Conservation Report* 01/4, Appendix 1 (2001), Nature Conservation Branch (Marine), Tasmania. (ISSN 1441-0680). (English).

WG-FSA-01/82
Seabird interactions with longline fishing in the AFZ: seabird mortality estimates and 1988–1999 trends. T. Reid, N. Brothers and R. Gales. *Nature Conservation Report* 01/4 (2001), Nature Conservation Branch (Marine), Tasmania. (ISSN 1441-0680). (English).

All pelagic longlining within the AFZ in 1999 was performed by domestic Australian vessels. The effort can be divided into vessels using Japanese-style methods, and local-style vessels that use more varied methods. The effort by the local-style vessels continued to rise, with almost 14 million hooks set, a rise of over 48% on the effort in 1998. Much of this effort was either off Western Australia, or from Mooloolaba. In addition, 445 000 hooks were set using Japanese methods.

Two cruises were observed off Western Australia, with over 13 000 hooks observed north of 30°S, and 3 400 observed south of 30°S. No seabird by-catch and few interactions were observed north of 30°S. One bird was observed caught south of 30°S (but north of Cape Leeuwin) off Western Australia. Discussions with the crew indicated that bird problems were worse south of Cape Leeuwin. These observations indicate that it will be important initially for the TAP observer program to have some observing conducted in these areas, and for methods to decrease or eliminate seabird by-catch.

During 1999, most observations in the AFZ were performed to look at mitigation measures in operation, therefore no effort was made to randomly sample catch rates or measure total catch were made. During one cruise, over 13 000 hooks were set using weighted lines. Two underwater setting devices were also used; a capsule on two cruises (3 550 hooks) and a chute (3 250 hooks). These methods were considered separately to this paper: a) Performance assessment and performance improvement of two underwater setting devices for avoidance of seabird interaction in pelagic longline fisheries (Appendix 2 – see WG-FSA-01/80); and b) The effect of line weighting on the sink rate of pelagic tuna longline hooks, and its potential for minimising bird by-catch (Appendix 1 – WG-FSA-01/81).