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 as presented and discussed at the 2003 meetings of the CCAMLR Scientific Committee and its working groups. It 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(iii) scientific papers not intended for publication, which are listed as 'unpublished'; and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-XXII/BG/11 (background document number 11 submitted at the Twenty-second Meeting of the Scientific Committee); or WG-EMM-03/8 (document number 8 submitted at the 2003 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Unpublished papers must not be cited without written permission of the author(s).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.

CONTENTS

Scientific Committee

SC-CAMLR-XXII/BG/9
Fishing gear, marine debris and oil associated with seabirds at Bird Island, South Georgia, 2002/03. B. Phalan (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 23 pp. (English, unpublished).

This report describes and quantifies occurrences of fishing gear, marine debris and oil associated with seabirds at Bird Island, South Georgia, from 1 April 2002 to 31 March 2003. It is the 10th such annual report. As in most previous years, more items of fishing gear (mostly longlining gear) and debris (mostly plastics) were found in association with wandering albatrosses than with any other species, though numbers of both decreased slightly since last year. The quantity of fishing gear associated with giant petrels (northern and southern) was the second highest on record, and included five cases of entanglements with longline hooks and line. Eleven cases of contamination with oil were recorded, in wandering, black-browed and grey-headed albatrosses. In all cases, no more than about 1–2% of the birds' plumage was oiled, and breeding success was apparently not affected.

Continued evidence of the discarding of longline hooks in offal and by-catch is of concern. Based on items found in regurgitates, an estimated 630 longline hooks and/or snoods were ingested by wandering albatross chicks at South Georgia this year. Hooks were typical of those used in the demersal longline fishery around South Georgia and the Falklands.

SC-CAMLR-XXII/BG/10
Beach debris survey – Main Bay, Bird Island, South Georgia, 2001/02. C.J. Green and N.L. Warren (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 18 pp. (English, unpublished).

During the 12th year of standardised beach surveys of man-made debris at Bird Island, South Georgia, a total of 193 items was collected, 140 during summer and 53 during winter. This represents a 33% decrease on the total of 290 items recorded in 2000/01 and the lowest level of summer beach debris since 1994/95. Although only seven fewer items were collected during the summer (a 5% decrease from last season), 90 fewer items were collected throughout the winter, a 63% reduction compared with last year. The 2001/02 season was characterised by a dramatic decrease in the proportion of nylon line (braid) found, constituting only 3.6% of the annual total, a reduction of 93% in summer and 98.5% in winter compared to the previous year. Miscellaneous debris accounted for the greatest proportion (92%) of all debris. The large reduction in fishing gear found on the beach throughout this season, particularly during the winter months when the South Georgia longline fishery is most active, is encouraging. This would indicate that vessels are making efforts to comply with the correct waste disposal procedures for both domestic and fishing-related waste.

SC-CAMLR-XXII/BG/11
Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Bird Island, South Georgia, during the 2002 winter and 2002/03 breeding season. N.L. Warren (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 23 pp. (English, unpublished).

Results of the surveys of entanglement of Antarctic fur seals at Bird Island, South Georgia, for the 13th consecutive winter (2002) and 15th consecutive summer (2001/02) are reported here. The overall number of entanglements showed a decrease from last year of 55% in winter and 67% in summer. Severe injuries accounted for 33% of entanglements over winter and 25% during the summer. As in previous years, most individuals observed entangled in debris were juveniles (88% of winter and 81% of summer observations), the reasons for this are discussed. Of the entanglements where the animal could be sexed, males dominated the observations in both seasons. Plastic packaging bands and synthetic strings (nylon braid) accounted for the majority of all entanglements (81%); no entanglement in fishing nets was observed. This highlights the need for continued monitoring and increased

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effort to ensure correct disposal of debris with the potential to entangle wildlife at sea.

SC-CAMLR-XXII/BG/12
Beach debris survey Signy Island, South Orkney Islands, 2002/03. M.J. Dunn (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 12 pp. (English, unpublished).

During the 2002/03 austral summer the 13th annual beach debris survey was carried out at Signy Island, South Orkney Islands. Debris was cleared each month between December and March from the three study beaches. The debris was counted, measured and classified by type, material, mass and size categories. A total of 54 items weighing 27.36 kg was collected. The number of items found was the largest since 1999/2000 and the total mass of the waste recovered was the highest recorded since 1994/95 (an increase of 38% and 7% since 2001/02 respectively). There was an increase in the number of plastic packaging bands (23) from the total recorded the previous season (8), this increase continued the change in trend that began last season in what had otherwise been a declining trend since 1993/94. The continued increase in the number of packaging bands found indicates that the ban on their use on board fishing vessels brought into force by CCAMLR in 1995/96 has yet to prove entirely effective and should continue. Plastic waste was predominant, as in previous seasons, making up 67% of all items recorded, followed by wood at 11%. Classifying the waste by source revealed that most had originated from ships or fishing vessels, with four items being of British Antarctic Survey (BAS) origin. The results of this season's litter survey, with the continued increase in items found which began last season, clearly shows that the longevity of plastics, and other materials with a high resistance to degradation in the marine environment, remains a problem and highlights the need for continued monitoring to ensure that vessels are aware of, and comply with, regulations prohibiting the disposal of debris at sea.

SC-CAMLR-XXII/BG/13
Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Signy Island, South Orkney Islands, 2002/03. M.J. Dunn (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 8 pp. (English, unpublished).

The results of the seventh annual survey of entanglement of Antarctic fur seals at Signy Island, South Orkney Islands, are reported for the 2002/03 summer season. There was a single sighting of a seal wearing a neck collar of man-made debris. Data are compared with results from a parallel study undertaken at Bird Island, South Georgia, in 2002/03. In the case of Bird Island, data indicated that the number of entangled fur seals had decreased by 67% compared to the previous year, this being the lowest number recorded at Bird Island since 1999/2000. Although such a decrease is encouraging, the presence of the entangled seal at Signy Island, together with the considerable number of seals with neck collars at Bird Island, highlights the need for CCAMLR Members to continue their campaign to ensure that vessels are aware of, and comply with, regulations prohibiting the disposal of man-made debris at sea.

SC-CAMLR-XXII/BG/16
Summary of scientific observation programs during the 2002/03 season. CCAMLR Secretariat, 6 pp. (English, unpublished).

SC-CAMLR-XXII/BG/17
IMAF assessment of new and exploratory fisheries by statistical area. Ad Hoc Working Group on Incidental Mortality Arising from Fishing (WG-IMAF), 28 pp. (English, unpublished).

SC-CAMLR-XXII/BG/18
Summary of population data, conservation status and foraging range of seabird species at risk from longline fisheries in the Convention Area. Ad Hoc Working Group on Incidental Mortality Arising from Fishing (WG-IMAF), 9 pp. (English, unpublished).

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SC-CAMLR-XXII/BG/19
Incidental mortality of seabirds during unregulated longline fishing in the Convention Area. Ad Hoc Working Group on Incidental Mortality Arising from Fishing (WG-IMAF), 6 pp. (English, unpublished).

SC-CAMLR-XXII/BG/20
Beach debris survey at the northern coast of Antarctic Scientific Station Artigas (BCAA) on King George Island/ Isla 25 de Mayo during the 2002/03 season. Delegación de Uruguay, 10 pp. (Spanish, unpublished).

Uruguay has developed a Marine Debris Survey Program applicable to the coastal areas near the Antarctic Scientific Station Artigas (BCAA) situated on King George Island/Isla 25 de Mayo, in Subarea 48.1 and thus within the Antarctic Treaty Zone. The survey has been conducted in accordance with the standard method established by CCAMLR, on selected beaches in the northern area which can be reached from its Antarctic Base. The aim of the program is to collaborate fully with CCAMLR in the assessment of its conservation programs by monitoring factors that may have an influence on Antarctic marine living resources, thus providing guidance on how best to manage harvesting and related activities, including the rational use of these resources, in accordance with the provisions of the Convention and adopted measures thereof.

SC-CAMLR-XXII/BG/24
WG-FSA-03 assessment documents. Working Group on Fish Stock Assessment (WG-FSA), 15 pp. (English, unpublished).

SC-CAMLR-XXII/BG/25
Review of CCAMLR activities on monitoring marine debris in the Convention Area. CCAMLR Secretariat, 20 pp. (English, unpublished).

The current status of national surveys on monitoring of marine debris and its impact on marine mammals and seabirds in the Convention Area has been reviewed. The CCAMLR marine debris database contains data from 11 sites, all within Area 48, of which there are three sites that have data from more than three years. These are:
(i) beached marine debris: Chile (Cape Shirreff, Livingston Island, South Shetland Islands, 1993 to 1997), UK (Bird Island, South Georgia, 1989 to present and Signy Island, South Orkney Islands, 1991 to present) and Uruguay (King George Island, South Shetland Islands, 2001 to present);
(ii) debris associated with seabird colonies: UK (Bird Island 1993 to present);
(iii) marine mammal entanglement: UK (Bird Island 1991 to present and Signy Island 1997 to present);
(iv) hydrocarbon soiling: UK (Bird Island 1993 to present).

Marine debris, principally packaging items and fishing gear, reached a peak in the period 1994–1996 at Bird Island and Signy Island and has declined thereafter. The level of marine debris found in seabird colonies at Bird Island has continually increased, with fishing gear such as lines and hooks forming the major part of the debris. Marine mammal (Antarctic fur seal) entanglement at Bird Island reached a peak in 1993 and showed a decline until 2000, since when there has been a slight increase with packaging bands, synthetic string and longline fragments being the main entanglement material. The number of seabirds contaminated with hydrocarbons remains low.

SC-CAMLR-XXII/BG/26
Information on the biology, ecology and demography of Antarctic fish species contained in papers tabled at WG-FSA-2003. Working Group on Fish Stock Assessment, 18 pp. (English, unpublished).

SC-CAMLR-XXII/BG/27
Background information supporting the report of the meeting of WG-FSA, 13 to 23 October 2003 (SC-CAMLR-XXII, Annex 5). Working Group on Fish Stock Assessment, 46 pp. (English, unpublished).

SC-CAMLR-XXII/BG/28
Trawling operations on vessels fishing for icefish in Subarea 48.3. Working Group on Fish Stock Assessment, 4 pp. (English, unpublished).

SC-CAMLR-XXII/BG/31
Minimisation of accidental mortality in longline fisheries outside the CCAMLR Convention Area. Prepared by E. Fanta

(Brazil), based on data provided by T. Neves (Instituto Albatroz, Brazil), 2 pp. (English, unpublished).

SC-CAMLR-XXII/BG/32
Report on the activities of the Life Sciences Standing Scientific Group – LSSSG of the Scientific Committee on Antarctic Research – SCAR. E. Fanta (CCAMLR Observer at SCAR, SCAR Observer at CCAMLR) (Brazil) 4 pp. (English, unpublished).

Working Group on Ecosystem Monitoring and Management

WG-EMM-03/4
Shedding new light on the life cycle of mackerel icefish in the Southern Ocean. K.-H. Kock and I. Everson (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany). 38 pp. *J. Fish Biol.*, in press (English).

Mackerel icefish (*Champsocephalus gunnari*) has a widespread distribution in the Atlantic and Indian Ocean sectors of the low-Antarctic region. Biological characteristics differ considerably between populations in the southern Scotia Arc and those living further to the north. Fish living in the north mature one year earlier than in the south. They have a much shorter life span and die after they have spawned for 2–3 times. The number of eggs produced per gram of body weight is higher in the north. Stocks have declined in most parts of the distributional range due to the impact of fishing and due to natural causes. Increases in populations of Antarctic fur seals at South Georgia and parts of the Indian Ocean appear to have led to increased predation on stocks of icefish. Shifts in hydrological regimes in the northern part of the distributional range have either started to lead or will lead to deteriorating living conditions for *C. gunnari* in the near future. Fish stock assessment under CCAMLR needs to take these constraints into consideration when providing advice on total allowable catches for fisheries management.

WG-EMM-03/5
The use of Antarctic shags to monitor coastal fish populations: evaluation and proposals after five years of test of a standard method. R. Casaux and E. Barrera-Oro (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina, pipocasaux@infovia.com.ar), 18 pp. *CCAMLR Science*, submitted (English).

This overview reflects the main points of the feasibility of using the Antarctic shag as a monitor of inshore demersal fish populations, including species of commercial importance. Likewise, the history of the development of this theme in relation to CCAMLR's WG-EMM and WG-FSA since the onset of the 1990s until the recent five-year testing period of the standard method, is described. Among other conclusions, the analysis of pellets is an adequate method to estimate qualitatively and quantitatively the diet of shags and can reflect differences in fish availability between seasons and areas. Considering the similarities in foraging strategies and reproductive behaviour between Antarctic and sub-Antarctic shags, the methodology proposed could readily be used with other shag species in Antarctica.

WG-EMM-03/6
An 8-year cycle in krill biomass density inferred from acoustic surveys conducted in the vicinity of the South Shetland Islands during the austral summers of 1991/92 through 2001/02. R.P. Hewitt, D.A. Demer and J.H. Emery (US AMLR Program, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, rhewitt@ucsd.edu). *Aquatic Living Resources,* in press (English).

Data from single and multi-frequency active acoustic surveys conducted annually in the vicinity of the South Shetland Islands, Antarctica, were re-analysed using updated procedures for delineating volume backscattering due to Antarctic krill, adjusting for signal contamination due to noise, and compensating for diel vertical migration of krill outside of the acoustic observation window. Intra-and inter-seasonal variations in krill biomass density and dispersion were derived from the reprocessed dataset for surveys conducted in the austral summers of 1991/92 through 2001/02. Estimated biomass density ranged

from 1 to 60 g m^{-2}, decreasing from mid-range levels in 1991/92 to a minimum in 1992/93–1993/94, increasing to a peak in 1996/97–1997/98, and decreasing again through 2000/01–2001/02. Although this variability may be attributed to changes in the spatial distribution of krill relative to the survey area, comparisons with the proportion of juvenile krill in simultaneous net samples suggest that the changes in biomass density are consistent with apparent changes in reproductive success. A truncated Fourier series fit to the biomass density time series is dominated by an 8-year cycle and predicts an increase in krill biomass density in 2002/03 and 2003/04. This prediction is supported by an apparent association between cycles in the extent of sea-ice cover and per-capita krill recruitment over the last 23 years and indications that ice cover in the winter of 2002 is seasonally early and extensive.

WG-EMM-03/7
Mackerel icefish size and age at South Georgia and Shag Rocks. A.W. North (British Antarctic Survey, Natural Environmental Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, awno@bas.ac.uk), 46 pp. (English, unpublished).

Mackerel icefish (*Champsocephalus gunnari* Lönnberg), at South Georgia and Shag Rocks in the Southern Ocean have supported a fishery since the 1970s. This study has analysed the length-frequency distribution of *C. gunnari* from 10 bottom trawl surveys at South Georgia and nine at Shag Rocks between 1987 and 2002. Most surveys were between December and February (summer), with one in September (spring). Mean total lengths (TL) of age-classes were determined for each year by examining length-frequency plots and tables, and by using CCAMLR's Mixture Analysis Program (CMIX). These methods were only applied where there was distinct modality in the length-frequency distributions. Lengths of age classes derived by these two methods were not statistically different. Age-class 1 was found for all surveys at South Georgia but was absent for three years at Shag Rocks, potentially indicating greater recruitment variability at Shag Rocks. Age-class 4 was found for eight surveys at South Georgia but for only one survey at Shag Rocks, indicating likely

differences in mortality between localities. To compensate for variation in the time of surveys, the mean TL of age classes was standardised to a common day of the year (16 January) based on the von Bertalanffy growth curve. The CMIX estimated mean TL of age-classes 1, 2 and 3 was 14.5, 23.8 and 30.2 cm respectively at South Georgia, and 18.6, 26.8 and 33.6 cm at Shag Rocks. The mean TL of each age class of *C. gunnari* at Shag Rocks was significantly larger than at South Georgia, although the annual growth increment at each locality was similar. This is further evidence that *C. gunnari* probably hatch earlier at Shag Rocks. A difference in hatching period between the two localities and differences in recruitment and mortality indicates that the *C. gunnari* populations at South Georgia and Shag Rocks should be managed as two different stocks. At South Georgia, the mean TL of age-class 1 decreased significantly between 1987 and 1994, and this change was negatively correlated with summer sea-surface temperatures during the previous year. Summer maximum sea-surface temperatures at South Georgia have increased significantly between 1950 and 2000, and this shift in temperature is likely to have changed the seasonal timing and level of primary production. The decreased size of *C. gunnari* may be the result of reduced nearshore food availability linked to climate variability.

WG-EMM-03/8
Populations of surface-nesting seabirds at Marion Island, 1994/95–2002/03. R.J.M. Crawford, J. Cooper, B.M. Dyer, M.D. Greyling, N.T.W. Klages, P.G. Ryan, S.L. Petersen, L.G. Underhill, L. Upfold, W. Wilkinson, M.S. de Villiers, S. du Plessis, M. du Toit, T.M. Leshoro, A.B. Makhado, M.S. Mason, D. Merkle, D. Tshingana, V.L. Ward and P.A. Whittington. *African Journal of Marine Science*, 25 (2003). (English).

During the 1990s and early 2000s, populations of surface-nesting seabirds at Marion Island showed different trends, but for the majority of species numbers decreased. Reduced numbers of gentoo penguins *Pygoscelis papua*, rockhopper penguins *Eudyptes chrysocome*, Crozet shags *Phalacrocorax melanogenis* and probably macaroni penguins *E. chrysolophus* are most plausibly attributed to an

altered availability of food for these species. Decreases in numbers of dark-mantled sooty albatrosses *Phoebetria fusca*, light-mantled sooty albatrosses *P. palpebrata*, southern giant petrels *Macronectes giganteus* and possibly northern giant petrels *M. halli* may have resulted from mortality of birds in longline fisheries. However, populations of wandering albatrosses *Diomedea exulans* and grey-headed albatrosses *Thalassarche chrysostoma* fluctuated around a stable level in this period. Numbers of sub-Antarctic skuas *Catharacta antarctica* and kelp gulls *Larus dominicanus* breeding at Marion Island also decreased after the 1980s. Kerguelen terns *Sterna virgata* and Antarctic terns *S. vittata* remain scarce at the island. Trends for king penguins *Aptenodytes patagonicus* were not reliably gauged but numbers probably remained stable or increased. There were large fluctuations in numbers of king penguin chicks surviving to the end of winter.

WG-EMM-03/9
Counts of surface-nesting seabirds breeding at Prince Edward Island, summer 2001/02. P.G. Ryan, J. Cooper, B.M. Dyer, L.G. Underhill, R.J.M. Crawford and M.N. Bester. *African Journal of Marine Science*, 25 (2003). (English).

The first midsummer survey of surface-nesting seabirds at Prince Edward Island was conducted during December 2001. It was also the first census for most species since the early 1980s. Despite concerns about the impacts of longline fishing mortality on various albatrosses and giant petrels, there was no evidence that populations of these species had decreased. Indeed, the estimate of wandering albatross *Diomedea exulans* (Vulnerable) has increased significantly, making Prince Edward Island equal with Marion Island as supporting the largest single-island population of this species. Species that underwent significant decreases were macaroni penguins *Eudyptes chrysolophus* (Vulnerable), Crozet shags *Phalacrocorax [atriceps] melanogenis* and Kerguelen terns *Sterna virgata* (Near-Threatened). The reasons for these decreases are unclear, but for macaroni penguins may be partly a consequence of competition for space with the burgeoning population of fur seals *Arctocephalus* spp. The 2001 survey increased the population estimates for sub-Antarctic skuas *Catharacta antarctica*, light-mantled sooty albatrosses *Phoebetria palpebrata* (Vulnerable) and southern giant petrels *Macronectes giganteus* (Vulnerable), mostly as a result of greater coverage than for previous counts. The 2001 survey confirms that Prince Edward Island remains a globally important breeding site for seabirds.

WG-EMM-03/10
Decrease in numbers of the eastern rockhopper penguins *Eudyptes chrysocome filholi* at Marion Island, 1994/95–2002/03. R.J.M. Crawford, J. Cooper, B.M. Dyer, M.D. Greyling, N.T.W. Klages, D.C. Nel, J.L. Nel, S.L. Petersen and A.C. Wolfaardt. *African Journal of Marine Science*, 25 (2003). (English).

Numbers of rockhopper penguins *Eudyptes chrysocome* breeding at Marion Island decreased from about 173 000 pairs in 1994/95 to about 67 000 pairs in 2001/02. During 1994/95–2002/03 pairs fledged on average 0.40 chicks per annum, an amount thought insufficient to balance mortality of breeding adults, and there was a decrease in the mass at arrival at breeding colonies of both males and females. Except in 1997/98, the mass of chicks at fledging was less than that recorded at two other localities. These factors suggest an inadequate supply of food for rockhopper penguins at Marion Island. Decreases of rockhopper penguins at several other localities also have been attributed to inadequate food. Rockhopper penguins at Marion Island continued to feed mainly on crustaceans during chick rearing. There was a marked increase in the contribution of fish to the diet in 1999/00 that coincided with an increase in mass at arrival at colonies of both males and females. Trends in numbers of pairs breeding in different sections of Marion Island were not always consistent, indicating the need of wide-scale monitoring to establish the overall trend.

WG-EMM-03/11
Population dynamics of the wandering albatross *Diomedea exulans* at Marion Island: long-line fishing and environmental influences. D.C. Nel, F. Taylor, P.G. Ryan and J. Cooper. *African Journal of Marine Science*, 25 (2003). (English).

The Prince Edward Islands support the largest breeding population of the vulnerable wandering albatross *Diomedea exulans*. The number of birds breeding in this population has fluctuated over the past three decades and appears to be the result of both real changes in the size of the population and changes in the proportion of the population that attempts to breed in a given year. We describe changes in several demographic parameters that appear to be influenced by both environmental and anthropogenic effects. The proportion of first-time breeders in the population was positively correlated with the maximum ENSO index, while the annual survival rates of breeding adults was negatively correlated with Japanese pelagic longline fishing effort in the Southern Indian Ocean. Adult survival rates were significantly correlated with those recorded on neighbouring Possesion Island (Crozet Islands) but differed from those at South Georgia, suggesting common factors operating at ocean-basin scale. The average survival rate of adult females was lower than that of males. Males who lost partners took 40% longer than females to find a new mate, suggesting a male-biased population. Survival rates of juvenile males and females did not differ. The age distribution of first-time breeders has shifted progressively towards younger birds during the 1990s. Higher than expected survival rates of breeding adults during the late 1990s may be linked to large amounts of supplementary food being made available by the initiation of a longline fishery for Patagonian toothfish *Dissostichus eleginoides* close to the islands during this time. Overall, breeding success was better than recorded at other localities, indicating that breeding conditions at Marion Island were favorable. The implementation of international conservation initiatives to reduce the impact of longline fishing on this species and improve its conservation status, is recommended.

WG-EMM-03/12
The oldest known banded wandering albatross Diomedea exulans at the Prince Edward Islands. J. Cooper, H. Battam, C. Loves, P.J. Milburn and L.E. Smith. *African Journal of Marine Science*, 25 (2003). (English).

The oldest known wandering albatross *Diomedea exulans* at the Prince Edward Islands is estimated to have been approximately half a century old when last recaptured in 2001. Demographic studies need to continue for several more decades before the true maximum longevity for the species becomes evident.

WG-EMM-03/13
Unusual breeding by seabirds at Marion Island during 1997/98. R.J.M. Crawford, C.M. Duncombe Rae, D.C. Nel and J. Cooper. *African Journal of Marine Science*, 25 (2003). (English).

In 1997/98, breeding at sub-Antarctic Marion Island was exceptionally good for five species of seabirds capable of foraging over wide areas and a tern. The number of king penguin *Aptenodytes patagonicus* chicks surviving to the start of spring in 1997 was considerably more than previously recorded. Greater numbers of wandering *Diomedea exulans* and grey-headed *Thalassarche chrysostoma* albatrosses, northern giant petrel *Macronectes halli* and Kerguelen tern *Sterna virgata* bred than previously recorded and more southern giant petrels *M. giganteus* did so than in any other year since 1994. For southern giant petrels, reproductive success was higher than in any other year, as was survival of chicks of northern giant petrels. Conversely, for two seabirds that feed close to the island, gentoo penguin *Pygoscelis papua* and Crozet shag *Phalacrocorax [atriceps] melanogenis*, 1997/98 was a particularly poor breeding season. Gentoo penguins initiated breeding later than usual and fledged few chicks. The number of Crozet shags that bred decreased; probably about 25% of the adult population did not breed. For two species with an intermediate foraging range that eat mainly crustaceans, macaroni *Eudyptes chrysolophus* and rockhopper *E. chrysocome* penguins, breeding was not noticeably different from normal except that chicks of rockhopper penguins fledged with a slightly heavier mass than in other years. However, for both these penguins mass of adults on arrival at colonies decreased substantially in the following (1998/99) breeding season. The unusual breeding by most of the seabirds coincided with the El Niño Southern Oscillation (ENSO) event of 1997/98. This synchrony

contrasts with lagged responses to ENSO events of seabirds that breed farther south in the Southern Ocean. Continued monitoring of seabirds over well-separated sites in the Southern Ocean may elucidate how climatic perturbations operating at a global scale impact seabirds in the region.

WG-EMM-03/14
Conserving surface-nesting seabirds at the Prince Edward Islands: the roles of research, monitoring and legislation. R.J.M. Crawford and J. Cooper. *African Journal of Marine Science*, 25 (2003). (English).

South Africa's sub-Antarctic Prince Edward Islands support substantial proportions of the global populations of a number of surface-nesting seabirds. Populations of most of these have decreased at the islands since the 1980s and 12 of 16 species are regarded as Threatened or Near Threatened regionally or internationally. The main causes of population decreases are thought to be by-catch mortality of albatrosses and giant petrels in longline fisheries, and environmental change influencing availability of prey to penguins and the Crozet shag *Phalacrocorax [atriceps] melanogenis*. It is proposed that the Prince Edward Islands Special Nature Reserve be expanded to include surrounding territorial waters so as to afford additional protection for seabirds breeding there, especially those species feeding near to the islands. Consideration needs also to be given to listing species as threatened or protected in terms of planned new legislation in South Africa and then developing management plans for them, preferably linked closely with the Agreement on the Conservation of Albatrosses and Petrels and the National Plan of Action (NPOA) – Seabirds. The islands should also be nominated as a Ramsar Wetland of International Importance in recognition of their importance to seabirds, with 13 of the 16 species exceeding the 1% of the global population criterion. A combination of research, monitoring and legislation will help conserve the surface-nesting seabirds of the Prince Edward Islands into the 21st century, but only providing the effects of climate change can somehow be addressed.

WG-EMM-03/15
Population of macaroni penguins *Eudyptes chrysolophus* at Marion Island, 1994/95–2002/03, with information on breeding and diet. R.J.M. Crawford, J. Cooper and B.M. Dyer. *African Journal of Marine Science*, 25 (2003). (English).

There is indication that numbers of macaroni penguins *Eudyptes chrysolophus* at sub-Antarctic Marion Island have decreased since the early 1980s. Estimates of the population at the island fell from about 405 000 pairs in 1983/84 and 434 000 pairs in 1994/95 to about 356 000 pairs in 2002/03. Two large colonies, at Bullard Beach and Kildalkey Bay, account for about 85% of the overall population. At both these colonies the area occupied by breeders showed no trend between 1983/84 and 2002/03 but the mean density of nests decreased. However, error on estimates of abundance at these colonies precludes demonstration of a significant decrease in the overall population. Numbers of occupied nests at other colonies decreased from 79 000 in 1994/95 to 31 000 in 2002/03. At three small colonies there was a significant decrease of 88% between 1979/80 and 2002/03, most of the decrease occurring after 1983/84. At Marion Island, macaroni penguins usually breed for the first time when aged about three years. From 1994/95–2002/03, pairs fledged on average 0.46 chicks per annum, an amount thought insufficient to maintain the population. However, during this period there was a significant increase in reproductive success with time. In the same period, the masses of males and females on arrival at breeding colonies were significantly correlated. Both showed a marked decrease in 1998/99, after the El Niño of 1997/98. In most seasons from 1994/95–2001/02 crustaceans dominated the food, but the mass of chicks at fledging was significantly related to the contribution of fish to the diet.

WG-EMM-03/16
Population and breeding of the gentoo penguin *Pygoscelis papua* at Marion Island, 1994/95–2002/03. R.J.M. Crawford, J. Cooper, M. du Toit, M.D. Greyling, B. Hanise, C.L. Holness, D.G. Keith, J.L. Nel, S.L. Petersen, K. Spencer, D. Tshingana and A.C. Wolfaardt. *African Journal of Marine Science*, 25 (2003). (English).

The numbers of gentoo penguins *Pygoscelis papua* breeding at sub-Antarctic Marion Island fell by 40% from 1 352 pairs in 1994/95 to 806 pairs in 2002/03. Apart from a slight increase in 1998/99, there was a steady decrease in numbers breeding between 1995/96 and 2000/01, when the population stabilised. There is indication that in some years not all breeders nested and that some birds relocated to another colony after disturbance. From first clutches, pairs on average fledged between 0.01 chicks in 1997/98 and 0.58 chicks in 2002/03 (mean 0.38 ± 0.21). In 1994/95, replacement clutches increased the overall production of fledged chicks by 11%. Based on demographic parameters measured at other localities, the production of chicks at Marion Island was inadequate to maintain the population during 1995/96–2000/01. Consistency in trends in breeding success at five colonies suggests that factors operating at a meso scale, rather than those specific to particular colonies, often influenced breeding success. Laying was later than normal in 1997/98, when there was almost total breeding failure with large losses of eggs and small chicks to returning sub-Antarctic skuas *Catharacta antarctica*. Future research on this Near Threatened species at Marion Island must take full account of its susceptibility to human disturbance.

WG-EMM-03/17
Population, breeding, diet and conservation of Crozet shag *Phalacrocorax [atriceps] melanogenis* at Marion Island, 1994/95–2002/03. R.J.M. Crawford, J. Cooper, B.M. Dyer, A.C. Wolfaardt, D. Tshingana, K. Spencer, S.L. Petersen, J.L. Nel, D.G. Keith, C.L. Holness, B. Hanise, M.D. Greyling and M. du Toit. *African Journal of Marine Science,* 25 (2003). (English).

The numbers of Crozet shags or cormorants *Phalacrocorax [atriceps] melanogenis* breeding at sub-Antarctic Marion Island decreased by 68% from 841 pairs in 1994/95 to 272 pairs in 2002/03. The mean number of pairs at colonies also decreased and was significantly related to the overall number of birds breeding in any given season. The decreases coincided with a period of warming and reduced precipitation at Marion Island and with a decrease in numbers of gentoo penguins *Pygoscelis papua* breeding there. Both these seabird species forage inshore and there is considerable overlap in their diets. Nototheniid fish and the decapod *Nauticaris marionis* continued to be important in the diet of Crozet shags but a change in dominance amongst nototheniid prey suggests availability of prey to shags changed after the mid 1980s. Crozet shags breed for the first time when aged three years. It is probable that about 25% of the mature population did not breed in 1997/98, coincident with a strong El Niño Southern Oscillation event. In four seasons, breeding pairs on average fledged 0.30 chicks from first clutches, an amount thought inadequate to sustain the population. Crozet shags at the Prince Edward Islands should now be regarded as Endangered. Placing breeding colonies in the most highly protected zone on Marion Island, considering the establishment of an *ex situ* population and undertaking a genetic study of the specific status of the Crozet shag are recommended conservation activities.

WG-EMM-03/18
Population numbers of fur seals at Prince Edward Island, Southern Ocean. M.N. Bester, P.G. Ryan and B.M. Dyer. *African Journal of Marine Science*, 25 (2003). (English).

During the period 17–22 December 2001, the onshore distribution and abundance of Antarctic fur seals *Arctocephalus gazella* and sub-Antarctic fur seals *A. tropicalis* were determined for Prince Edward Island (46°38'S 37°57'E). Two breeding colonies of Antarctic fur seals were located on the southeast coast of the island; the first a mixed (with sub-Antarctic fur seals) breeding colony with an estimated 24 pups on a vegetated promontory on the northern section of Boggel Beach, and the second, a presumably pure Antarctic fur seal breeding colony with an estimated 380 pups, at Penguin Beach. At a mean intrinsic rate of natural increase of 13.7% per year, Antarctic fur seals appear to be in the rapid recolonisation phase of population growth. Breeding colonies of sub-Antarctic fur seals, largely found on the entire east coast, produced an estimated 15 000 pups, and the population had maintained a mean intrinsic rate of natural increase of some 9.5% per year since 1987/88.

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WG-EMM-03/19
Absence of haematozoa in breeding macaroni *Eudyptes chrysolophus* and rockhopper *E. chrysocome* penguins at Marion Island. A. Schultz and S.L. Petersen. *African Journal of Marine Science*, 25 (2003). (English).

Haematozoan infections cause the death of penguins in captivity, but seldom in the wild. No haematozoa were found in 89 blood smears taken from macaroni penguins *Eudyptes chrysolophus* or 80 smears from eastern rockhopper penguins *E. chrysocome filholi* at sub-Antarctic Marion Island between October and November 2001. Discussion centres on the possibility of vector introduction and establishment under conditions of climatic and/or anthropogenic change.

WG-EMM-03/20
Modern mean monthly SST and SST anomalies off South Georgia during recent years (based on satellite data). G.P. Vanyushin (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia, sst.ocean@g23.relcom.ru), 8 pp. (English, unpublished).

VNIRO continues to monitor sea-surface temperatures (SSTs) in Subarea 48.3 (South Georgia). Current satellite surveys provide continuous information for an up-to-date assessment of changes in both mean monthly SST and SST anomalies during recent years. Daily satellite data from GOES-E and real-time data from vessels and buoy stations are processed to produce the initial weekly SST maps. For a quantitative analysis of variations in temperature distribution in the waters around South Georgia, two grid cells (cell 1 and cell 2) on the SST map were randomly selected, each having a resolution of 2° x 2° and centred at 54°S 41°W and 53°S 37°W respectively. This work is continuing.

WG-EMM-03/21
Differential catchability of trawls as a method for providing a more precise estimate of the density of krill swarms and krill biomass. V. Akishin (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia), 10 pp. (English, unpublished).

Krill escapement in different parts of krill trawls and their differential catchability have been studied. It is shown that krill

exhibits behavioural peculiarities which significantly affect catches. It is proved that the estimation of density and size structure of fished krill swarms should be carried out taking into account the differential catchability of krill trawls. A mathematical model of krill trawling has been developed to estimate the above values.

WG-EMM-03/22
WG-EMM Subgroup on Protected Sites: Terms of Reference – summary of CCAMLR decisions. CCAMLR Secretariat, 10 pp. (English, unpublished).

WG-EMM-03/23
History of development and completion of tasks put forward by WG-EMM (2001–2002). CCAMLR Secretariat, 5 pp. (English, unpublished).

WG-EMM-03/24
CEMP indices 2003: analysis of anomalies and trends. CCAMLR Secretariat, 151 pp. (English, unpublished).

WG-EMM-03/25
General information about CEMP. CCAMLR Secretariat, 15 pp. (English, unpublished).

WG-EMM-03/26
Preliminary analyses in support of the CEMP Review Workshop: power analyses. CCAMLR Secretariat, 196 pp. (English, unpublished).

WG-EMM-03/27
Preliminary analyses in support of the CEMP Review Workshop: serial correlations. CCAMLR Secretariat, 195 pp. (English, unpublished).

WG-EMM-03/28
Krill fishery information. CCAMLR Secretariat, 35 pp. (English, unpublished).

WG-EMM-03/29
Diets of sympatrically breeding Adélie, gentoo and chinstrap penguins from Admiralty Bay, South Shetland Islands, Antarctica, 1981 to 2000. W.Z. Trivelpiece, K. Salwicka and S.G. Trivelpiece (US AMLR Program, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA,

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wayne.trivelpiece@noaa.gov), 28 pp. *Marine Ecology Progress Series*, submitted (English).

Given the importance and interdependence of diet studies to monitoring work, data on the stomach contents and food load masses were compared among three species of *Pygoscelis* penguins during chick rearing over the 20-year period from 1981 to 2000. All three penguin species were largely dependent on Antarctic krill (*Euphausia superba*), which accounted for over 93% of each species' diet by frequency of occurrence and mass. Gentoo penguins ate significantly more fish than either congener, specifically the benthic nototheniid species, while Adélie and chinstrap penguins largely ate two species of pelagic fishes, *Pleuragramma antarcticum* and *Electrona antarctica*. All species exhibited significant interannual variability in mean food load sizes during chick rearing and there was a high degree of coherence among the three species in the years of high versus low food loads. Adélie and chinstrap penguin adults experienced significant declines in body weight during the chick provisioning period in several of the latter years of the study, suggesting food availability may have declined significantly between the earlier 1980s and the more recent 1990s periods. This conclusion is supported by annual US Antarctic Marine Living Resources (AMLR) marine surveys in the area. Finally, the digested portion of the stomach contents was examined and a significant increase in the proportion of digested versus fresh stomach contents was noted as the season progressed and as chick food demands increased. It is proposed that the digested contents of a penguin's food load has more than twice the caloric value of a comparable mass of fresh krill in the same bird's stomach. This allows *Pygoscelis* penguins to significantly increase the caloric value of food brought to their chick per foraging trip. The energetic consequences of this hypothesis to the energy balance of the birds provisioning chicks are discussed and the implications of this finding for past and future studies of penguin energetics using the Doubly-labelled water technique are pointed out.

WG-EMM-03/30

Krill biomass and density distribution in February–March 2002 in Subarea 48.3. S.M. Kasatkina and A.P. Malyshko (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, atlant@baltnet.ru) 11 pp. (English, unpublished).

This paper presents the results of an acoustic krill survey carried out by the Russian RV *Atlantida* on the South Georgia shelf within the 500 m isobath, from 14 February to 5 March 2002. The average krill density in the survey area was estimated to be 45.45 g/m^2 and total biomass, 1 898 492 tonnes.

Krill aggregation distribution was analysed to identify potential fishing grounds. Also presented are the results of a density assessment of potential fishing grounds and a map of their location. Location of potential fishing areas is further evidence that no sustainable commercial aggregations are formed during the critical period for animals feeding on krill in the western extremity of South Georgia where the main feeding grounds serving their needs for food exist.

WG-EMM-03/31

The commercial significance of krill aggregations. S.M. Kasatkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, atlant@baltnet.ru), 10 pp. *CCAMLR Science*, submitted (English).

In this paper an attempt is made to estimate commercial krill biomass density within the fleet operation areas and to compare this with critical density values for marine animals feeding on krill, using the results of acoustic investigations obtained by Soviet trawler operations in Subareas 48.1 to 48.4. Also analysed were the commercial statistical data, including haul-by-haul data from Soviet trawlers totalling 22 000 hauls from 1986 to 1990 and 2 380 hauls from Ukrainian trawlers from 2001 to 2002.

Over the last 20 years, krill has been fished in areas with a biomass density of at least 100 g/m^2. This threshold value of commercial krill biomass considerably exceeds the critical value of krill density for marine animals feeding on krill and has been estimated at 24 g/m^2 (Boyd, 2001). As is evident from a comparison of the

above density values, the fleet and dependent predators will have different density niches.

WG-EMM-03/32
Disease outbreak threatens Southern Ocean albatrosses. H. Weimerskirch (Centre d'Etudes Biologiques de Chizé, UPR 1934 Centre National de la Recherche Scientifique, 79360 Villiers en Bois, France, henriw@cebc.cnrs.fr), 20 pp. *Biological Conservation*, submitted (English).

Infectious diseases have the potential to cause rapid decline and extinction in vertebrate population and are likely to be spreading with increased globalisation and climate warming. In the Southern Ocean and in Antarctica no major outbreaks of infectious diseases have been reported, perhaps because of isolation and cold climate, although recent evidence suggests their presence. The major threat for the Southern Ocean environment is today considered to be fishing activities, and especially controversial longlining that is assumed to be the cause for the major decline of albatrosses and petrels observed recently. Here it is shown that two highly pathogenic diseases (worldwide spreading avian cholera, Erysipelas bacteria) are the major cause of the decline on Amsterdam Island of the large yellow-nosed albatross population that was previously attributed to longline fishing. The diseases are affecting mainly chicks during their first weeks of life with a cyclic pattern between years, but also adult birds that can be found dead on the colonies. The outbreak of the disease occurred probably in the mid-1980s when the population started to crash at the same time that chick mortality increased and adult survival declined. The diseases could today cause the complete extinction of the very rare Amsterdam albatross, and are probably also affecting sooty albatrosses. The spread of diseases in the remotest areas of the world raises major concern for the conservation of the Southern Ocean environment.

WG-EMM-03/33
Ecological games in space and time: the distribution and abundance of Antarctic krill and penguins. S.H. Alonzo, P.V. Switzer and M. Mangel. *Ecology*, 84 (6): 1598–1607 (2003). (English).

The distribution and abundance of organisms are affected by behaviours, such as habitat selection, foraging and reproduction. These behaviours are driven by interactions within and between species, environmental conditions, and the biology of the species involved. Although extensive theoretical work has explored predator–prey dynamics, these models have not considered the impact of behavioural plasticity and life-history trade-offs on predicted patterns. We apply a modelling method that allows the consideration of a spatial, dynamic ecological game between predators and prey using a life-history perspective. As an illustrative example, we model the habitat selection of Antarctic krill and penguins during the time when penguins are land-based for reproduction. Although environmental conditions and the life-history constraints of each species have both direct and indirect effects on both species, the penguin's foraging rule (whether food-maximising or time-minimising) has the greatest effect on the qualitative distribution pattern of both species. Size-dependent diel vertical migration of krill also strongly affects penguin foraging patterns. This model generates suggestions for future research and qualitative predictions that can be tested in the field. The application of this method to a specific problem also demonstrates its ability to increase our understanding of important ecological interactions in general.

WG-EMM-03/34
An ecosystem-based approach to management: using individual behaviour to predict the indirect effects of Antarctic krill fisheries on penguin foraging. S.H. Alonzo, P.V. Switzer and M. Mangel. *Journal of Applied Ecology*, 40: 692–702 (2003). (English).

1. Changes in species' abundance and distributions caused by human disturbances can have indirect effects on other species in a community. Although ecosystem approaches to management are becoming increasingly prevalent, they require a fuller understanding of how individual behaviour determines interactions within and between species.

2. Ecological interactions involving krill are of major importance to many species within the Antarctic. Despite extensive knowledge of the ecosystem that

they occupy, there is still incomplete understanding of the links between species and the effect of environmental conditions on these interactions. In this study, we extended a behavioural model used previously to understand the interactions between penguins and krill to determine the indirect effect of krill fisheries on penguin foraging success and behaviour in adjacent breeding sites.

3. Increased fishing pressure offshore is predicted to reduce penguin food intake. Given the documented links between krill and penguins, this also leads to a prediction of decreased penguin survival and reproduction. Krill behaviour is predicted to cause stronger effects of krill fisheries than explained solely by the percentage of biomass removed. Environmental conditions that decrease krill growth rates or cause krill to spend time in deeper water are also predicted to increase the magnitude of the effect of fishing on penguin success. We show that changes in penguin foraging behaviour can be used to assess the impact of local fisheries on penguin reproductive success.

4. *Synthesis and applications*. These results demonstrate that an understanding of predator–prey interactions, indirect effects between species, and individual behaviour is imperative to our ability to manage populations. We describe a general method to use what is known about ecological and evolutionary processes with species-specific information to predict the response of organisms to novel situations. We further show how individual behaviour can be used to assess the impact of human disturbance on ecosystems.

WG-EMM-03/35
Different CPUE types in Soviet krill fishery statistics from 1977 to 1992. F.F. Litvinov, A.Z. Sundakov and V. Arkhipov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 19 pp. *CCAMLR Science*, submitted (English).

The various CPUE indices used in Soviet krill fishery statistics and their main sources and primary data for their calculations were examined. The main CPUE indices were catch per fishing day (CFD), catch per extended fishing day (CEFD) and catch per hour (CH). The primary data for all the calculations were catch per haul and haul duration. There is a fairly high

correlation between mean monthly values of CFD and CEFD, and CFD and CH. Conversely, correlation between daily values is rather low, due to high fluctuations in haul duration caused by the use of different fishing strategies to target different final products of the fishery: human consumption, krill meal and frozen krill. When considered separately with respect to different strategies and hence haul duration, mean daily CFD and CH are well correlated. Depending on the strategy, the number of hauls per day ranged from 1 to 15, generally 2–4, and hauls lasted from 0.1 to 16 hours, generally 3–8 hours. The higher the requirement for quality in the final product, the shorter the haul duration and thus the greater the number of hauls per day. Histograms of distribution of various CPUE, haul duration, number of hauls per day and linear regression equations allowing mutual conversion of the CPUE indices are presented.

WG-EMM-03/36
Options for allocating the precautionary catch limit of krill among small-scale management units in the Scotia Sea. R.P. Hewitt, G.M. Watters and P.N. Trathan (US AMLR Program, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, roger.hewitt@noaa.gov), 10 pp. *CCAMLR Science*, submitted (English).

With the intent of stimulating discussion, four options for subdividing the precautionary catch limit of krill for Area 48 into the small-scale management units (SSMUs) adopted at CCAMLR-XXI are presented. The first three are static allocations: the first is proportional to estimated predator demand in each SSMU; the second is proportional to the estimated standing stock of krill in each SSMU; and the third is proportional to the standing stock less predator demand in each SSMU. The fourth option is a dynamic allocation based on land-based predator monitoring conducted just prior to, or early in, the fishing season.

WG-EMM-03/37
Foraging strategies of chinstrap penguins at Signy Island, Antarctica: importance of benthic feeding on Antarctic krill. A. Takahashi, M.J. Dunn, P.N. Trathan,

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K. Sato, Y. Naito and J.P. Croxall. *Marine Ecology Progress Series*, 250: 279–289 (2003). (English).

Chinstrap penguins *Pygoscelis antarctica* are one of the major consumers of Antarctic krill *Euphausia superba* in the Southern Ocean. To examine their foraging strategy, we studied foraging trip patterns and diving behaviour of chinstrap penguins breeding at Signy Island, Antarctica, using time-depth recorders. Foraging trips of penguins could be divided into two groups, short diurnal (7.8 h) and longer overnight (19.9 h) trips, with diurnal trips (74%) being dominant in number (263 out of 355 trips). The diving depths of our study birds were much deeper (to 179 m) than previous studies on this species, with modal maximum dive depth at around 90 to 100 m. Diving patterns and profiles included typical pelagic dives, but also included series of consecutive square-wave shaped dives reaching similar maximum depth, the typical characteristics of benthic dives. These benthic-type dives were more abundant in diurnal foraging trips than overnight trips. Analysis of stomach contents showed that penguins on both types of trip fed almost exclusively on Antarctic krill. There was a positive relationship between indices of the proportion of benthic feeding and of foraging efficiency (stomach content mass divided by foraging trip duration). These results highlight the potential importance of benthic feeding on Antarctic krill, the first such recorded instance for chinstrap penguins. This previously undescribed foraging strategy by one of the major avian consumers of Antarctic krill provides a new insight into the predator–prey interactions of the Antarctic coastal marine ecosystem.

WG-EMM-03/38

Distribution of foraging by female Antarctic fur seals. I.L. Boyd, I.J. Staniland and A.R. Martin. *Marine Ecology Progress Series*, 242: 285–294 (2002). (English).

The study examined the distribution of critical habitat for foraging by female Antarctic fur seals breeding at the island of South Georgia. Bathymetric features of the continental shelf around the island of South Georgia were an important indicator for the localisation of foraging. This pattern was consistent among years of different prey availability. Lactating 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 dispersed to specific regions of the continental shelf east of Patagonia (>1 000 km) and to the northern edge of the Antarctic pack ice (500 km). The empirical distribution of foraging during the breeding season was used to develop a function that described the foraging distribution for the whole breeding population of females. The result was consistent with past observations from ship-based surveys and it allowed estimation of the spatial impact of breeding female fur seals on krill at South Georgia. 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-03/39

Energetics of diving in macaroni penguins. J.A. Green, P.J. Butler, A.J. Woakes and I.L. Boyd. *The Journal of Experimental Biology*, 206: 43–57 (2003). (English).

Heart rate (fH), abdominal temperature (T_{ab}) and diving depth were measured in 13 free-ranging breeding female macaroni penguins. Measurement of these variables allowed estimation of the mass-specific rate of oxygen consumption ($\dot{V}_{O_2}$) while diving and investigation of the physiological adjustments that might facilitate the diving behaviour observed in this species. In common with other diving birds, macaroni penguins showed significant changes in fH associated with diving, and these variables accounted for 36% of the variation in dive duration. When $\dot{V}_{O_2}$ was calculated for dives of different durations, 95.3% of dives measured were within the calculated aerobic dive limit (cADL) for this species. Mean fH for all complete dive cycles was 147±6 beats min^{-1}. When this fH is used to estimate $\dot{V}_{O_2}$ of 26.2 ± 1.4 ml min^{-1} kg^{-1} then only 92.8% of dives

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measured were within the cADL. Significant changes in abdominal temperature were not detected within individual dives, though the time constant of the measuring device used may not have been low enough to record these changes if they were present. Abdominal temperature did decline consistently during bouts of repeated diving of all durations and the mean decrease in T_{ab} during a diving bout was 2.32 ± 0.2°C. There was a linear relationship between bout duration and the magnitude of this temperature drop. There was no commensurate increase in dive duration during dive bouts as T_{ab} declined, suggesting that macaroni penguins are diving within their physiological limits and that factors other than T_{ab} are important in determining the duration of dives and dive bouts. Lowered T_{ab} will in turn facilitate lower metabolic rates during diving bouts, but it was not possible in the present study to determine the importance of this energy saving and whether it is occurs actively or passively.

WG-EMM-03/40
Krill length-frequency distribution in Subarea 48.3 from January to April 1988 in relation to sources of its origin. F.F. Litvinov, V.N. Shnar, A.V. Zimin and V.V. Lidvanov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, flit@atlant.baltnet.ru), 20 pp. (English, unpublished).

Krill length-frequency distribution in Subarea 48.3 from January to February 1988 is considered in the context of the hypothesis that krill resources originate from two sources: the Antarctic Circumpolar Current and the Weddell Scotia Sea water flow. It is shown that small krill with a mode of about 33 mm is distributed in the coastal zone of about 7–40 n miles wide, the boundary zone is situated further out, at a distance of about 30–60 n miles, while larger krill with a mode of about 49 mm is found beyond the boundary zone. Krill length-frequency distribution is unimodal in the coastal and off-shore zones and bimodal in the boundary zone. Krill distribution corresponds well to the water flows mentioned. Further analyses

revealed heterogeneity in the distribution of krill in the Weddell Sea: there are spots in which krill of increased length is found, where krill is retained for some time and has the opportunity to grow longer. Differences in krill length in such places and within the main water flow may be as much as 6 mm. Such spots may be considered as being the initial stage of krill aggregations forming inside quasi-stationary gyres, further development of this scenario leads to the creation of commercially significant krill aggregations.

WG-EMM-03/41
Exchange of wandering albatrosses *Diomedea exulans* between the Prince Edward and Crozet Islands: implications for conservation. J. Cooper and H. Weimerskirch. *African Journal of Marine Science*, 25 (2003). (English).

Exchange of 61 wandering albatrosses *Diomedea exulans* has been recorded between the French Crozet Islands and the South African Prince Edward Islands, 1 068 km apart in the Southern Ocean. Most movements of banded birds (57) have been westward, from the Crozets to the Prince Edwards. Eighteen fledglings banded at Possession Island, Crozets, have bred at Marion Island, Prince Edwards, but only one fledgling from Marion Island has been recorded breeding on Possession Island. The wandering albatrosses of the two island groups form a metapopulation that ideally should be conserved as a single unit. It is suggested that France and South Africa collaborate through the Agreement on the Conservation of Albatrosses and Petrels to effect an improved conservation status for the wandering albatrosses of the two island groups.

WG-EMM-03/42
Mackerel icefish ecological indices. I. Everson, K.-H. Kock and A.W. North (British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom), 15 pp. (English, unpublished).

Mackerel icefish have been harvested in the CCAMLR Convention Area for over 30 years. In the Atlantic sector of the Southern Ocean they feed preferentially on krill and are themselves preyed on by fur seals and several avian species. These attributes make them suitable for

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consideration within the CCAMLR Eco-system Monitoring Program (CEMP). With that in mind the following indices are outlined that might be incorporated in the program: standing stock, cohort strength and recruitment, natural mortality, length at age 1+ and 2+ years, condition, gonad maturity and diet.

WG-EMM-03/43
Ecosystem indicators: factors affecting the choice of predator performance indices for use in monitoring programs.
K. Reid (British Antarctic Survey, National Environment Research Council, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom, k.reid@bas.ac.uk), 25 pp. (English, unpublished).

The ability to use upper-trophic level species as ecosystem indicators is determined by the ability to relate changes in indices of their performance to changes at lower trophic levels. Using indices of predator performance from four species of krill-eating predators together with independent ship-based acoustic estimates of krill abundance from South Georgia, the relationship between a range of indices of predator performance and krill abundance was examined. There was a distinct relationship between the variability of indices and the biological processes that they measured: body mass parameters had the lowest variability (CV < 10%), whereas parameters measuring breeding success showed the greatest variability (CVs > 50%). Predator parameters that reflected processes occurring during the summer showed the closest relationship with krill abundance, especially those for species with foraging ranges similar to spatial scales at which krill surveys were undertaken. Population size parameters showed no functional response relationship with annual krill abundance estimates. Combining the summer parameters into a single combined index provided a better fit with the krill data than any of the individual parameters.

WG-EMM-03/44
Adélie penguin foraging behaviour and breeding success in seasons of contrasting krill availability (Mawson Coast, Antarctica). J.R. Clarke, M. Tierney, S.G. Candy, S. Nicol, L. Irvine and K.R. Kerry (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, judy.clarke@aad.gov.au), 25 pp. (English, unpublished).

Parameters measured under the CCAMLR Ecosystem Monitoring Program (CEMP) for Adélie penguins at the Béchervaise Island CEMP site were compared between seasons of contrasting krill availability. Krill biomass estimates were derived from shipboard surveys carried out within the penguins' normal foraging range during the 2001 and 2003 breeding seasons. More than three times as much krill was present during the two-week survey period in 2001 than in 2003. Penguin parameters that showed significant differences between the two seasons included A5 (foraging trip duration), A6 (breeding success) and A8 (meal mass and dietary composition). Penguins travelled further to forage in 2003 than 2001, stayed away longer and brought back smaller meals. Fish (mostly *Pleuragramma antarcticum*) contributed significantly to the diet in 2003 but was only a minor component in 2001. Differences between years were particularly apparent during the late guard to early crèche stages of chick rearing, coinciding with the timing of the krill survey. Chick mortality also peaked during this period. The findings illustrate the sensitivity of parameters A5 and A8 to prey availability during the short time scale of the chick-rearing period. Data on meal mass and foraging trip duration were combined to provide an index of provisioning rate, analogous to the functional response referred to in the predator–prey theory. This showed the expected concave monotonic relationship to krill biomass over the investigation period. These results are discussed in relation to aspects of foraging behaviour, monitoring programs and management issues.

WG-EMM-03/45
Demographic studies for CEMP. K.R. Kerry, J.R. Clarke and L.M. Emmerson (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, knowles.kerry@aad.gov.au), 9 pp. (English, unpublished).

This paper responds to a request (SC-CAMLR-XXI, Annex 4, paragraphs 3.46 to 3.47) for standard methods for determining demographic parameters. It is noted the methods (CEMP A4) as published in

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CEMP Standard Methods (2003) appear adequate. Revision may be required in the future following consideration of how aspects of predator demographics may be used for management in the CCAMLR context. The considerable tagging and search effort required to obtain demographic data and the period over which such effort needs to be sustained is described.

WG-EMM-03/46
Short note: time series of Drake Passage Oscillation Index (DPOI) from 1952 to 2003, Antarctica. M. Naganobu and K. Kutsuwada (National Research Institute of Far Seas Fisheries, Shimizu, 424-8633 Japan, naganobu@affrc.go.jp), 3 pp. (English, unpublished).

An assessment of the environmental processes influencing variability in the recruitment and density of Antarctic krill (*Euphausia superba* Dana) is important as variability in krill stocks affects the Antarctic marine ecosystem as a whole. Naganobu et al. (1999) had assessed variability in krill recruitment and density in the Antarctic Peninsula area with an environmental factor; strength of westerly winds (westerlies) determined from sea-level pressure differences across the Drake Passage, between Rio Gallegos (51°32'S 69°17'W), Argentina, and Base Esperanza (63°24'S 56°59'W), at the tip of the Antarctic Peninsula from 1982 to 1998. Fluctuations in the westerlies across the Drake Passage were referred to as the Drake Passage Oscillation Index (DPOI). Significant correlations between krill recruitment and DPOI were found. Additionally, a new time series of DPOI from January 1952 to May 2003 is calculated.

WG-EMM-03/47
Spatial variability and power to detect regional-scale trends. C. Southwell and L.M. Emmerson (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, colin.southwell@aad.gov.au), 20 pp. (English, unpublished).

An important issue in regional-scale trend detection is the degree of concordance in trend between sites in relation to an average regional trend. If there is much or more variability between sites than within sites over time, inter-site variance can overwhelm the effects of other sources of variation in a system, resulting in low power in trend detection across that scale, despite precise methods of measurement and long time series of data. Published data from repeated regional-scale surveys of Adélie penguin breeding population size in east Antarctica is used to assess the degree of spatial concordance in population trends within the scale of notional small-scale management units, and given these estimates of trend concordance, then used the power analysis program MONITOR to predict power for various multiple-site monitoring scenarios. Under the conservative hypothetical scenarios examined, monitoring at only two or three sites provided insufficient power to detect a trend. At the other extreme, monitoring at all sites in a region (a census) may be an unnecessary use of resources because the gains in power over a design using a sample of sites were very marginal. Reasonable power was achieved by monitoring around six sites in a region under conservative criteria of a two-tailed test and $\alpha = 0.10$. However, fewer sites were required for less conservative criteria; using a one-tailed test instead of a two-tailed test meant that a few less sites were able to achieve the same power for a fixed duration for detection, and increasing the significance or Type I error level from 0.10 to 0.20 improved power such that a few less years or sites were required to detect a trend. Monitoring every three years instead of annually reduced power only very marginally.

WG-EMM-03/48
Sources of variability associated with Adélie penguin CEMP parameters measured at Béchervaise Island, East Antarctica. L.M. Emmerson, C. Southwell, J.R. Clarke and K.R. Kerry (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, louise.emmerson@aad.gov.au), 24 pp. (English, unpublished).

This paper examines the magnitude of a variety of sources of variability associated with CEMP parameters. The CEMP parameters considered include A1 (arrival weights), A3 (breeding population size), A5 (duration of foraging trips) and A7 (fledgling weights). Sources of variability can generally be considered as either

sampling variance or process-related vari-
ance, although sometimes the two can be
confounded. Temporal variability, that is
the between-season variability, was consis-
tent across parameters at around 5–7% CV.
The smallest source of variability was
associated with measurement error al-
though this source of variability is difficult
to assess. The largest source of variability
was related to the timing of data collection,
which we term as the within-season
variability. This ranged between 4.6% for
population size up to 19.8% for fledgling
weights. It would be useful to explore
ways of reducing the magnitude of within-
season variability because of the potential
influence it has on detecting between-
season changes in these parameters. This
could potentially be achieved by either
pooling several five-day CEMP periods to
reduce the time span over which the data
are collected, while simultaneously main-
taining a sufficient sample size or by
standardising summary statistics against
some chronologically relevant event and
reassessing temporal variability. Partition-
ing the sources of variability further than
we were able to for this paper may be
useful because our estimates of temporal
variability incorporate within-season vari-
ability and measurement error. However,
any refined estimates of variability would
only affect the ability to detect long-term
changes in a parameter if sampling vari-
ance can also be reduced.

WG-EMM-03/49
**The effect of temporal variability on
power analysis predictions for Adélie
penguin CEMP parameters at Bécher-
vaise Island.** L.M. Emmerson and
C. Southwell (Australian Antarctic Divi-
sion, Channel Highway, Kingston 7050,
Tasmania, Australia, louise.emmerson@
aad.gov.au), 13 pp. (English, unpublished).

There are unresolved issues surround-
ing the use of power analyses for
examining the ability of CEMP data to
detect change. The effect size that should
prompt a response if observed in a
parameter and the likely response of
parameters such as arrival or fledgling
weights are two of these issues. Under-
standing the source of the variability
required to generate 'noise' for the power
analysis simulations is another and it has
major ramifications on power estimates.

Increasing the variability associated with
power analysis estimates results in a
decreased level of power to detect a trend.
Similar power analysis results are obtained
for a fixed coefficient of variation (CV) of
the temporal variability standard deviation
(SD) in relation to the initial value
irrespective of the magnitude of the initial
size. This means that power analysis
results based on occupied nest counts with
increasing levels of temporal variability
(% CV) are applicable to other parameters
that are suitable for trend detection. The
four CEMP parameters considered in this
paper have similar power estimates because
their estimates of temporal variability are
comparable (5.2–6.7%). For example, with
a 10-year monitoring program it is possible
to detect fixed increases or decreases larger
than 2% each year with more than 80%
power. Increasing the duration of the
monitoring program has a positive impact
on power estimates. There is very little
difference between results generated using
an exponential model compared with a
linear model for short-term monitoring
programs of up to 10 years duration.

WG-EMM-03/50
**An unmanned aerial vehicle as a plat-
form for aerial photography of land-
based predator populations in Antarc-
tica: specifications and suitability of the
Aerosonde Mark III.** L. Irvine and
C. Southwell (Australian Antarctic Divi-
sion, Channel Highway, Kingston 7050,
Tasmania, Australia, lyn.irvine@aad.gov.au),
12 pp. (English, unpublished).

WG-EMM is currently investigating the
feasibility of undertaking broad-scale
surveys of land-based predators in Antarc-
tica. Such surveys are likely to rely
heavily on recent technological develop-
ments, such as satellites and unmanned
aerial vehicles (UAVs), which may allow
cost-effective surveys in large and remote
regions. Some specifications are described
and the advantages and disadvantages of
one such UAV, the 'Aerosonde', which is
manufactured by Aerosonde™ in Mel-
bourne, Australia, is assessed. The Aero-
sonde is designed largely for long-distance
high-speed flights with data collection and
real-time transmission back to a flight
control centre, but could also serve as a
platform for aerial photography. Its advan-
tages in this role would be long-distance

capability and low noise levels. Its disadvantages include cost, the need for a launching and landing runway, difficulty in operating around mountainous terrain, and likely instability in strong winds.

WG-EMM-03/51
The utility of satellite remote sensing for identifying the location and size of penguin breeding sites in Antarctica: a review of previous work and specifications of some current satellite sensors.
C. Southwell and L. Meyer (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, colin.southwell@aad.gov.au), 18 pp. (English, unpublished).

Broad-scale survey of the abundance of colonial breeding penguins requires locating all, or the great majority of, colonies as the first of several survey stages. Given the remoteness of Antarctica and the sub-Antarctic islands, satellites offer obvious potential for such a task in this region. Past evaluations of the utility of satellites for the detection of penguin breeding sites are reviewed. Despite the obvious potential for such use, very few evaluation studies have been undertaken. The studies indicate great potential, but also caution on, or allude to, the need for further evaluation or consideration with respect to the following issues: spectral response of surrounding material, variability in the spectral response of guano due to environmental features, inadequate or ambiguous signal from guano and spatial resolution of the technology and penguin breeding sites. Developments in satellite technology since the time of the studies will have alleviated some issues such as spatial resolution. Some directions for further evaluation work, and possible survey design options for addressing deficiencies in current satellite technology, are discussed. Some specifications of current satellite sensors that may be useful for this purpose are given.

WG-EMM-03/52
Power analyses of CEMP indices for penguins at Admiralty Bay and fur seals at Cape Shirreff and Seal Island.
G.M. Watters, R.P. Hewitt, W.Z. Trivelpiece and M.E. Goebel (US AMLR Program, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, gwatters@upwell.pfeg.noaa.gov), 25 pp. (English, unpublished).

The program MONITOR was used to conduct a set of power analyses for CEMP indices developed by the US AMLR Program. CEMP Indices A2, A3, A5, A6, A7 and A8 for penguins at Admiralty Bay, and Indices C1 and C2 for fur seals at Cape Shirreff and Seal Island were considered. These power analyses describe the likelihood of rejecting null hypotheses stating that the slopes of linear models relating the values of transformed CEMP indices to breeding year are equal to zero when, in fact, these trends actually exist. The power of rejecting these null hypotheses at three levels of α (the probability of rejecting the null hypotheses when they were, in fact, true), three periods of monitoring, and 21 levels of annual percentage change in the CEMP indices was estimated. A number of 'combined analyses' were conducted in which observations for different species, sexes, colonies/rookeries, and periods during the breeding chronology were treated as separate 'plots' that might be monitored in an attempt to detect some type of overall trend. The results of these analyses are displayed in a tabular format designed to identify general patterns rather than specific outcomes. In general, power to detect change was increased when α levels, periods of monitoring and levels of change were increased. It was found that many of the CEMP indices considered here are contaminated by so much observation error that there would often be less than a 50:50 chance of detecting an actual trend over a period of five years. Nevertheless, detecting trends over a period of 20 years may be feasible for most indices. Detecting trends in Indices A8 and C2 may be extremely difficult under any combination of α, observation period and level of change, but detecting trends in log-abundance of breeding penguins (one possible transformation of Index A3) will, apparently, be relatively easy. Treating observations for different species, sexes, colonies/rookeries and periods of the breeding chronology as separate plots both degraded (e.g. combining species for Index A2 and periods of the breeding chronology for Index A5) and enhanced (e.g. combining species for Index A6 and chinstrap penguin colonies

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for Index A3) the ability to detect real trends. It is difficult, however, to know whether the 'combined' approach is warranted because of the uncertainty of the degrees to which different species, sexes, colonies, etc. are jointly affected by some overall trend. The authors caution that their analyses should, at this point, still be considered exploratory since there are underlying questions regarding the appropriate use of MONITOR that they have not been able to resolve.

WG-EMM-03/53
Trends in bird and seal populations as indicators of a system shift in the Southern Ocean. H. Weimerskirch, P. Inchausti, C. Guinet and C. Barbraud. *Antarctic Science*, 15 (2): 249–256 (2003). (English).

Although world oceans have been warming over the past 50 years, the impact on biotic components is poorly understood because of the difficulty of obtaining long-term datasets on marine organisms. The Southern Ocean plays a critical role on global climate and there is growing evidence of climate warming. We show that air temperatures measured by meteorological stations have steadily increased over the past 50 years in the southern Indian Ocean, the increase starting in the mid-1960s and stabilising in the mid-1980s, being particularly important in the in the sub-Antarctic sector. At the same time with a time lag of 2–9 years with temperatures, the population size of most seabirds and seals monitored on several breeding sites has decreased severely, whilst two species have increased at the same time. These changes, together with the indications of a simultaneous decrease in secondary production in sub-Antarctic waters and the reduction of sea-ice extent further south, indicate that a major system shift has occurred in the Indian Ocean part of the Southern Ocean. This shift illustrates the high sensitivity of marine ecosystems, and especially upper trophic level predators, to climate changes.

WG-EMM-03/54
Antarctic fur seal predator performance indices for the South Shetland Islands 1987/88–2002/03. M.E. Goebel (US AMLR Program, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, mike.goebel@ noaa.gov), 13 pp. (English, unpublished).

Fifteen predator performance indices for Antarctic fur seals breeding at two sites in the South Shetland Islands are presented. Five indices were derived from CEMP Standard Methods C1 (female foraging trip duration) and C2b (pup growth rates). Measures of female foraging trip duration, pup growth rates, adult female survival and natality were made at Seal Island from 1986/87 to 1994/95. Studies at Cape Shirreff, Livingston Island, measured female foraging trip duration, foraging range, diet (3), pup growth rates (3), pup mortality, timing of reproduction, adult female survival and natality, cohort success, pup production, and the change in pup production from 1997/98 to 2002/03. Pup growth rate (C2b) data were recalculated for 1997/98–2001/02 to facilitate comparisons between sites. Long foraging trip durations (7.09 d ± 0.19), below-average frequency of krill in fur seal diet (79.6% ± 7.7), above-average pup mortality (9.0%), decreased pup production (–12.1%), and below-average adult female survival (85.8%) and natality (74.3%) all indicated that 2002/03 was a season of poor reproductive performance for fur seals at Cape Shirreff.

WG-EMM-03/55
Suggestions on revision of the *CCAMLR Scientific Observers Manual.* S. Kawaguchi, R. Williams and E. Appleyard (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, so.kawaguchi@aad.gov.au), 9 pp. (English, unpublished).

The *CCAMLR Observers Manual* details scientific observation guidelines and contains a set of logbook forms with instructions for recording observations. This document proposes some revised versions of the logbook forms (fish by-catch, krill biological data, conversion factors) and guides in the *Observers Manual* which may maximise the opportunity to collect data, and also streamline/ prioritise the work/sampling to be completed by the observers.

WG-EMM-03/56
Report of the International Workshop on Understanding Living Krill for Improved Management and Stock

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Assessment. S. Kawaguchi and M. Naganobu (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, so.kawaguchi@aad.gov.au), 9 pp. (English, unpublished).

The International Workshop on Understanding Living Krill for Improved Management and Stock Assessment was held at Port of Nagoya Public Aquarium, Nagoya, Japan, from 1 to 4 October 2002. Thirty-five participants from six nations (Australia, Germany, Japan, Republic of Korea, Mexico and the USA) attended the meeting.

Following a series of presentations, an extensive discussion took place regarding the future research on live krill. A special volume of contributions to this workshop will be published in December 2003.

WG-EMM-03/57
Developing a non-lethal approach for assessing endocrine disruptors in Antarctic seabirds. S. Corsolini, W.Z. Trivelpiece and S. Focardi (Dipartimento di Scienze Ambientali G. Sarfatti, University of Siena, I-53100 Siena, Italy, corsolini@unisi.it), 8 pp. (English, unpublished).

The *CEMP Standard Methods* Manual includes a 'Protocol for collecting samples for toxicological analyses' (Part IV, Section 5: 1–3), dated August 1997. This procedure describes the methods used to collect samples of organisms to be analysed for ecotoxicology. The aim is to detect toxic persistent organic pollutants (POPs, such as organochlorine compounds), heavy metals and biomarkers in Antarctic organisms. Results can be used both for POP global transport studies and for biomagnification and risk assessment. However, the procedures currently used to gather samples for analysis involve either sacrificing animals or collecting tissues from dead specimens.

The use of blood as an alternative (or additional) technique for residue analyses is suggested here. This methodology is particularly useful where protected/endangered organisms and/or protected/ecological relevant areas have to be investigated. This paper reports the preliminary results obtained by this new sampling and analytical technique and outlines future work proposals.

WG-EMM-03/58
Persistent organic pollutants in stomach contents of Adélie penguins from Edmonson Point (Victoria Land, Antarctica). S. Corsolini, S. Olmastroni, N. Ademollo, G. Minucci and S. Focardi. *Antarctic Biology in a Global Context*: 296–300 (2003) (English).

Stomach contents (n = 43) of Adélie penguin (*Pygoscelis adeliae*) nesting at Edmonson Point (Ross Sea) (74°20'56.7"S 165°08'10.03"E) were analysed. Gas chromatography revealed concentrations of polychlorinated biphenyls (PCBs), including coplanar congeners, at 1.01 ng/g wet wt, *pp*'DDE at 5.80 ng/g wet wt and and hexachlorobenzene (HCB) at 4.70 ng/g wet wt. Average input of these persistent organic pollutants (POPs) through diet also was evaluated. The following concentration gradient of PCB isomer-specific classes was revealed: hepta-CB > hexa-CB > penta-CB. The most abundant congeners were PCB189, PCB134 and PCB151, while PCB126 was the most abundant among coplanar PCBs. Toxic Equivalency Factors (TEFs) were also used to evaluate toxicity. Correlation was found between contamination and penguins diet in relation to sex during the mating season, when observations took place. Foraging sites were identified by satellite trackers in two study periods.

WG-EMM-03/59
Observations of Adélie penguins in two seasons with contrasting weather and sea-ice conditions – a brief report. S. Olmastroni, F. Pezzo, V. Volpi and S. Focardi (Dipartimento di Scienze Ambientali, Università degli Studi di Siena, Italy, olmastroni@unisi.it), 12 pp. *CCAMLR Science*, submitted (English).

The 2002/03 breeding season in comparison with 2000/01 at Edmondson Point was characterised by unusual sea-ice and weather conditions. Strong southerly winds and snow were experienced at the colony during December coinciding with hatching and the guard stage. The sea-ice in the Ross Sea was held in by the presence of large icebergs. This resulted in extensive sea-ice adjacent to the Edmonson Point colony lasting into February. These environmental effects were accompanied by changes in CEMP parameters A2, A6 and A9. Breeding success was reduced to 0.3 chicks

crèched per nest with eggs. The mean crèche date was extended by four days, the first incubation shift was significantly longer compared to 2000/01 (19 days compared with 13). It is suggested that a combination of environmental factors operating at different times throughout the breeding season was responsible for the poor breeding success. These findings highlight the need for collecting environmental data as part of CEMP.

WG-EMM-03/60
Growth of mackerel icefish (*Champso-cephalus gunnari*) and age–size composition of populations in the South Georgia subarea. K.V. Shust and E.N. Kuznetsova (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia, antarctica@vniro.ru), 18 pp. (English, unpublished).

Age, growth rate and age composition of icefish catches in Subareas 48.1, 48.2 and 48.3 were studied for different periods. The analysis of icefish age composition in Subarea 48.3 showed that catches consisted mainly of individuals of the 2–4 age groups, where more than 60% were represented by fish of two contiguous age groups. It is shown that over a number of years in the 1980s catches were based on fish of two contiguous year classes, the strong 1984 year class and the average 1983 year class. These year classes appeared against a background of intensive fishing for icefish, and krill biomass, judging from the catches, was rather low. It is possible that the abundance of one or other of the icefish year classes in Subarea 48.3 depends on a number of factors, of which it is currently difficult to determine the most important. A comparative analysis of icefish growth in Subarea 48.3 based on data collected at different times in the course of the fishery revealed a substantial interannual variability. A comparison of the growth rate of fish caught in 1978 in Subareas 48.2 and 48.3 with that of fish caught in 1986 in Subareas 48.1 and 48.3 did not reveal any significant differences. The relatively high growth rate of icefish in Subareas 48.2 and 48.3 in 1978 compared with 1985 may indicate the common factors affecting icefish growth in different regions of the South Atlantic at that time.

WG-EMM-03/61
Synopsis of CEMP and non-CEMP predator parameters from Admiralty Bay and Cape Shirreff, South Shetland Islands, Antarctica: their relationships to krill abundance and ice cover, 1978–2003. W.Z. Trivelpiece, K. Salwicka and S.G. Trivelpiece (US AMLR Program, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, wayne.trivelpiece@noaa.gov), 16 pp. (English, unpublished).

A suite of CEMP and non-CEMP parameters collected at Admiralty Bay and Cape Shirreff, South Shetland Islands, Antarctica, was analysed to assess the characteristics of the individual parameters, and their relationships to krill abundance and ice cover indices for the period 1978–2003. Results of the analyses are presented in a series of six tables, following the outline of a draft paper by Dr K. Reid (UK) for similar analyses at South Georgia. The tabular data include:

Table 1: A list of the penguin performance indices collected at the two sites.
Table 2: Data on annual variability in krill biomass density, annual sea-ice cover and the relationship between these two measures for the period 1992–2002.
Table 3: Characteristics of the predator performance indices.
Table 4: A linear regression of the relationships between predator indices and ice cover.
Table 5: The relationships between predator indices and krill biomass presented as a linear regression for both Admiralty Bay and Cape Shirreff and as an exponential regression for the longer Admiralty Bay time-series data.
Table 6: A summary of the R2 values for all indices by seasons and species.

**Working Group on
Fish Stock Assessment
Subgroup on Assessment Methods**

WG-FSA-SAM-03/4
WG-FSA Subgroup on Assessment Methods: summary of current CCAMLR assessments to the end of 2002. A.J. Constable (Subgroup Coordinator), 12 pp. (English, unpublished).

WG-FSA-SAM-03/5
Verification of the CMIX procedure on species with known age–length keys. P.S. Gasiukov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, pg@atlant.baltnet.ru), 9 pp. (English, unpublished).

Calculation of age composition from density-at-length data collected during inventory surveys using the method of de la Mare (1994) is a conventional procedure used by WG-EMM and WG-FSA. Verification of the method was made using data on Baltic cod collected in ICES Subarea 26. Age–length keys for 1995–2001 and length-frequency data obtained during the surveys carried out by research vessels of Russia and other countries were used. It has been shown that divergence in the estimates of age composition calculated using the CMIX method from those determined from age–length keys derived from direct age readings may be significant, reaching 100% or more. Individually, recruitment estimates also differ considerably from estimates based on age–length keys.

WG-FSA-SAM-03/6
Methical problems of trawl and acoustic surveys in mackerel icefish stock assessment. S.M. Kasatkina, P.S. Gasiukov and Zh.A. Frolkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, ks@atlant.baltnet.ru), 24 pp. (English, unpublished), (abstract not available).

WG-FSA-SAM-03/7
Growth of mackerel icefish (*Champsocephalus gunnari*) and age–size composition of the population in the South Georgia subarea. K.V. Shust and E.N. Kuznetsova (VNIRO, 17 V. Krasnoselskaya, Moscow 107140, Russia, antarctica@vniro.ru), 19 pp. (English, unpublished).

Age, growth rate and age composition of icefish catches in Subareas 48.1, 48.2 and 48.3 were studied for different periods. The analysis of icefish age composition in Subarea 48.3 showed that catches consisted mainly of individuals of age groups 2–4, where more than 60% were represented by fish of two contiguous age groups. It was shown that over a number of years in the 1980s catches were based on fish of two contiguous year classes, the strong 1984 year class and average 1983 year class. These year classes appeared against a background of intensive fishing for icefish, and krill biomass, judging from the catches, was rather low. It is possible that the abundance of one or other of the icefish year classes in Subarea 48.3 depends on a number of factors, of which it is at present difficult to determine the most important. A comparative analysis of icefish growth in Subarea 48.3 based on data collected at different times in the course of the fishery revealed a substantial interannual variability. A comparison of the growth rate of fish caught in 1978 in Subareas 48.2 and 48.3 with that of fish caught in 1986 in Subareas 48.1 and 48.3 did not reveal any significant differences. The relatively high growth rate of icefish in Subareas 48.2 and 48.3 in 1978 compared with 1985 may indicate the common factors affecting the icefish growth in different regions of the South Atlantic at that time.

WG-FSA-SAM-03/8
Review of management boundaries (SSRUs) used for the assessment of *D. mawsoni* in Subarea 88.1. P.L. Horn and S.M. Hanchet (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, p.horn@niwa.co.nz), 7 pp. (English, unpublished).

This paper provides a review of the boundaries of the small-scale research units (SSRUs) used to manage the exploratory fishery for *Dissostichus mawsoni* in Subarea 88.1. In determining appropriate SSRU boundaries, the physical and geographical features of the subarea, including the impact of sea-ice on fishing practices, were considered, as well as the distribution and abundance of target and by-catch species

(rattails and skates). It is recommended that the northern SSRU boundary (at 65°S) remain in place, but that the other boundaries of the other four SSRUs are changed to reflect the underlying bathymetry, species distributions and ice conditions.

WG-FSA-SAM-03/9
Descriptive analysis of acoustic data collected during the 2003 exploratory fishery for toothfish in the Ross Sea. R.L. O'Driscoll and G.J. Macaulay (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, r.odriscoll@ niwa.co.nz), 24 pp. (English, unpublished).

This report presents results from a pilot study to determine the feasibility of conducting acoustic surveys for toothfish and rattails in the Ross Sea. Acoustic data were collected using a Simrad ES60 38 kHz echosounder on the New Zealand commercial longliner FV *Janas* during the 2002/03 exploratory fishery. Data were recorded continuously from 28 December to 2 February 2003, then during line setting only from 5 to 22 February 2003. Analyses were carried out to assess data quality, describe different mark types, and quantify acoustic backscatter by echo integration and echo counting. These analyses focused on the subset of acoustic data collected when setting longlines so acoustic recordings could be compared with longline catches. Each 'line' recording was between 20 and 50 min long, corresponding to 2–4 n miles.

Data quality was generally good. Of the 84 line recordings, 68 were considered suitable for acoustic analysis. The other 16 files were rejected because data quality was too poor (11 files), the file was corrupted (1 file), or the longline was lost so there were no corresponding catch data (4 files). Poor data quality was associated with strong winds (greater than Beaufort 5) and/or high seas (swell heights greater than 2 m): conditions that led to bubble interference on the hull-mounted transducer. Other issues with data quality were interference from another echosounder before 11 January 2003, and the occurrence of a double bottom echo caused by too high a ping rate from 23 to 30 January.

All line recordings were in water over 1 000 m deep. Because of the spreading of the acoustic beam, the acoustic deadzone at these depths is relatively large, especially if the bottom is rough or sloped. Simulations indicated that at 1 500 m depth, the acoustic deadzone would be over 50 m high for a seabed with a slope of 20°. The problem of the acoustic deadzone was worsened by the occurrence of side-lobe echoes, produced as longlines were set on steep slopes parallel to the depth contours. Measurements indicated that side-lobe could create a deadzone of 50–100 m on apparently flat ground. Because both toothfish and rattails are considered to be demersal species, the inability of the acoustics to 'see' close to the bottom is a major limitation that could only be avoided with the use of an acoustic system deployed at depth.

Two types of pelagic layers were present in most acoustic recordings: a dense shallow layer between 30 and 200 m; and a more diffuse deep scattering layer between 300 and 800 m. Pelagic schools were also present in some recordings and these tended to occur at 150–400 m depth, between the layer marks. The most common demersal mark was single targets, which were present in 84% of line recordings. Most single targets occurred in a surface-referenced band between 800 and 1 100 m depth, and were up to 500 m off the bottom. There was a significant positive correlation between the number of single targets counted from the echogram and the catch of rattails in the accompanying long-line set. Bottom-referenced layers were present in 18% of line recordings and were also associated with higher catches of rattails. Demersal schools were present in 16% of recordings and were associated with higher catches of toothfish. Despite these associations, no acoustic marks could be reliably identified as being rattails or toothfish. It seems unlikely that the schools were toothfish or the single targets were rattails, as these were often more than 300 m off the bottom.

At this point, it is not practical to estimate toothfish or rattail abundance in the Ross Sea using hull-mounted acoustic systems. The acoustic deadzone was large, meaning it was not possible to detect demersal species close to the bottom. Echo integration was unreliable because there was a very low signal-to-noise ratio deeper than 1 000 m. Echo counting showed more promise, but only relatively

strong targets well separated from the bottom could be enumerated. As toothfish do not have a swimbladder, their acoustic target strength may be too weak to allow them to be counted at the ranges required.

WG-FSA-SAM-03/10
A feasibility study for stock assessment of *D. mawsoni* in the Ross Sea (Subareas 88.1 and 88.2) using a tag and recapture experiment. K.J. Sullivan, N.W.McL. Smith, J. McKenzie and S.M. Hanchet (Ministry of Fisheries, PO Box 1020, Wellington, New Zealand, sullivank@ fish.govt.nz), 22 pp. (English, unpublished).

This paper reports on a feasibility study into a tag and recapture experiment for the purpose of stock assessment of the Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea. An exploratory fishery for *D. mawsoni* has been operating since 1997/98. Catches have increased from ~40 tonnes in 1997/98 to nearly 1 800 tonnes in 2002/03. Although some Patagonian toothfish (*D. eleginoides)* are taken in the more northern areas, catches have been predominantly *D. mawsoni.*

To date nearly 2 000 toothfish (about 90% *D. mawsoni*) have been tagged and released in the area, from vessels operating in the exploratory fishery during the last three seasons. A good number of tag recoveries has been reported, mainly within the same season but also between successive seasons, which indicates that fish are surviving the tagging event.

It is proposed to continue tag releases each season as part of the exploratory fishery for the purpose of determining the stock size of *D. mawsoni* and sustainable yields for the fishery. Ongoing annual tagging will provide data suitable for estimating natural survival, abundance and recruitment using the Jolly–Seber or variant estimators. The utility of this approach is investigated here by applying a Jolly–Seber estimator to simulated tagging data generated by an operating model over a range of assumed population sizes and tagging strategies. The study indicates the number of releases required to achieve various levels of precision of the population estimate based on:
- assumed survival rates of released fish;
- current exploitation rates in the fishery;
- known growth and natural mortality parameters.

Although this initial attempt considers the simplest population structure (a homogeneous stock and fishery), further complexity can be added to the model to explore the heterogeneity in the population using length and spatial strata.

WG-FSA-SAM-03/11
Preliminary results of simulations looking at the optimal use of research sets in Subarea 88.1. S.M. Hanchet and I.R. Ball (National Institute of Water and Atmospheric Research (NIWA), Ltd, PO Box 893, Nelson, New Zealand, s.hanchet@ niwa.co.nz), 16 pp. (English, unpublished).

As a condition on their permit, all vessels fishing in a new or exploratory fishery must carry out 20 research sets in each small-scale research unit (SSRU) before commercial fishing can take place. Each research set must have a minimum number of hooks and be separated from its neighbours by at least 5 n miles. Using simulation studies, Ball and Constable (2001) showed that there were certain advantages to be gained by carrying out surveys (research sets) in a consistent manner between years. This simulation study has been continued by making it more applicable to the Ross Sea area by basing it on known fishing grounds and recruitment areas.

At this stage it would be premature to make any conclusions from this work regarding the placement of research sets. There are a number of extra simulations, which should be examined before any decisions on this are made. This includes carrying out separate simulations for the northern and southern parts of the subarea, examining the effect of having variable closed areas (as would happen when ice closes areas in some years), and examining the sensitivity of the results to other parameters such as movement rates and natural mortality. However, this preliminary work supports the findings of Ball and Constable (2001) that there are advantages in placing the research sets in areas with similar habitat qualities each year. It appears that there may also be advantages in placing the research sets in the same locations each year, although this does need further work. It should also be noted that even if simulations showed that

placing research sets in the same locations each year was optimal, that at least for Subarea 88.1 it would be impractical. This is because large areas of the Ross Sea are covered by ice each year, and therefore returning to the same sites year after year would be extremely difficult.

WG-FSA-SAM-03/12 Rev. 1
Modelling catch and effort data using generalised linear models, the Tweedie distribution, and random vessel effects: longline fishery for *Dissostichus eleginoides* in CAMLR Subarea 48.3.
S.G. Candy (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, steve.candy@aad.gov.au), 45 pp. *CCAMLR Science*, submitted (English).

The current standard method for modelling catch and effort data for *Dissostichus eleginoides* in Subarea 48.3 of the CAMLR Convention Area is to model the ratio of catch (kg) to effort (hooks) calculated by haul as the response variable in a generalised linear model (GLM) with a square root link function and a unit variance function. A standardised time series of CPUE estimates along with their precision can be obtained from the 'season' and baseline parameter estimates, their variance–covariance matrix, and the inverse link function. An alternative model with a more rigorous theoretical basis is introduced here. The catch is modelled as the response variable using a GLM with a power variance function, with the power parameter, λ, estimated using a profile extended quasi-likelihood, and a log link function with offset the log of effort. For $1 < \lambda < 2$ this model is equivalent to assuming a compound Poisson-gamma distribution (i.e. Tweedie distribution) for catch that, unlike lognormal or gamma distributions, admits zero values.

Using the Subarea 48.3 data, the log link function gave a superior fit in terms of residual deviance and fit diagnostics compared to the square root link function while the power variance function with $\lambda = 1.3$ was superior to the assumed variance model used by the standard method. In addition, random vessel effects were introduced into the GLM, specified as a generalised linear mixed model (GLMM), in order to provide more efficient estimates of the standardised CPUE time series.

Extra efficiency is gained by recovery of intervessel information as a result of the imbalance in the number of hauls in the season by vessel cross-classification. Also more realistic estimates of precision of the CPUE series are obtained using the GLMM. Estimated random vessel effects adjusted the marginal predictions of CPUE by as much as ±40%.

The major difference between the GLMM(log link) and the GLM(square root) in terms of the standardised CPUE series was that for fishing seasons 1987, 1988, 1991 and 1994 the former gave substantially higher estimates of CPUE and gave much wider confidence bounds for the estimates, particularly so for seasons prior to 1992.

WG-FSA-SAM-03/13
Predicting average weight-at-age from weight-at-length and length-at-age models with and without density dependence for *Dissostichus eleginoides* from the Heard Island Plateau.
S.G. Candy and A.J. Constable (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, steve.candy@aad.gov.au), 27 pp. *CCAMLR Science*, submitted (English).

Length-at-age and weight-at-length relationships required for stock assessment are fitted as von Bertalanffy and loglinear models respectively to fishery data for *Dissostichus eleginoides* from the Heard Island Plateau. Cruise-level random effects were incorporated in each model and their estimated values were then regressed on the average fish density for each cruise to determine if length-at-age or weight-at-length relationships are affected by density. These regressions were not significant, indicating that density does not need to be taken into account when predicting weight-at-age from the combined length-at-age and weight-at-length models. The models of these relationships employed in simulation software such as the generalised yield model (GYM), are not spatially (i.e. within the large-scale management area) or year specific and therefore cannot incorporate temporal or spatial variations in density in the weight-at-age relationship if this relationship was found to be density dependent. However, it was shown that given the form of random-effects models employed here, models that do not include density

give unbiased predictions of population-average weight-at-age even if either or both of the length-at-age or weight-at-length relationships are density dependent if hauls randomly sample the fish density distribution.

WG-FSA-SAM-03/14
The Generalised Yield Model Version 5: structure, specifications and examples for validation. A.J. Constable (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@aad.gov.au), 94 pp. (English).

WG-FSA-SAM-03/15
Fish Heaven 2.0: summary of modifications and additions to earlier versions and illustrations of its application as a tool for evaluating fisheries management systems. I.R. Ball (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, ian.ball@ aad.gov.au), 26 pp. (English, unpublished).

WG-FSA-SAM-03/16
JGYM – a Java version of the generalised yield model. (Power Point presentation) R.N. Vilhelm (MRAG Americas Inc., runi.vilhelm@mragamericas.com).

As part of a wider research project aimed at developing management strategies based on the current toothfish assessment methodology using the generalised yield model (GYM), a Java version of the GYM has been developed. The new version has been developed directly from the specifications kindly provided by Dr A. Constable (Australia). Some routines have been translated from the GYM FORTRAN code into Java. As such, if sufficiently similar results can be obtained from the JGYM and the current GYM given identical input, then this would be a major step towards a verification of the GYM. This paper, given in the form of a Power Point presentation, discusses how the JGYM was developed, indicates differences from the GYM where they exist, and compares results from the two programs with identical inputs.

Working Group on Fish Stock Assessment

WG-FSA-03/4
Species profile: mackerel icefish. I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, i.everson@bas.ac.uk), 90 pp. (English, unpublished).

Information on mackerel icefish that has been presented at WG-FSA is summarised and the information augmented by reference to published papers.

WG-FSA-03/5
Bibliography on mackerel icefish. K.-H. Kock and I. Everson (British Antarctic Survey, Madingley Road, Cambridge CB3 0ET, United Kingdom, i.everson@ bas.ac.uk), 11 pp. (English, unpublished).

Published references to work on mackerel icefish are listed in alphabetical order of author. This listing was originally tabled at the Workshop on Approaches to the Management of Icefish (WAMI) associated with WG-FSA-2001 and has been updated since that time.

WG-FSA-03/6
Fishery information for WG-FSA-03. CCAMLR Secretariat, 4 pp. (English, unpublished).

WG-FSA-03/7
Survey database. CCAMLR Secretariat, 16 pp. (English, unpublished).

WG-FSA-03/9
The diet of black-browed albatrosses at the Diego Ramírez Islands, Chile. J.A. Arata and J.C. Xavier (Instituto de Ecología y Evolución, Campus Isla Teja, Casilla 567, Universidad Austral de Chile, Valdivia, Chile, javierarata@entelchile.net), 22 pp. (English, unpublished).

The diet of black-browed albatrosses was studied at Gonzalo Island, Diego Ramírez Islands, Chile, during the early chick-rearing period of 2000, 2001 and 2002. Diet composition was determined by sampling chick stomach contents during January and February of each year. Reconstituted meal mass was similar throughout the study, with diet being dominated by fish in all three years. Overall, the main items taken were the fishes *Macruronus*

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magellanicus (66–89% by mass) and *Micromesistius australis* (2.6–3.7% by mass), which are both fisheries-related species, and the squid *Martialia hyadesi* (8–20% by mass). The distribution of the prey species indicates that black-browed albatrosses obtained the bulk of their food over the South American continental shelf, but also foraged at the Antarctic Polar Front. The prevalence in the diet of fish species discarded from fishing operations, and the presence of fish hooks and fish bait species, indicates a strong association with fisheries in southern Chile.

WG-FSA-03/10
The Evangelistas Islets, Chile: a new breeding site for black-browed albatrosses. J.A. Arata, G. Robertson, J. Valencia and K. Lawton (Instituto de Ecología y Evolución, Casilla 567, Universidad Austral de Chile, Valdivia, Chile, javierarata@entelchile.net), 10 pp. (English, unpublished).

A previously undescribed population of black-browed albatrosses (*Thalassarche melanophrys*) is reported at the Evangelistas Islets, Straits of Magellan, Chile. The population was censused from aerial photographs taken on 13 October 2002 which yielded an estimate of the number of breeding pairs. A combined total of 4 670 pairs of black-browed albatrosses were found nesting at Elcano and Lobos Islets, two of the four islets in the Evangelistas group. This new record raises to four the number of breeding islands of this albatross species in Chile.

WG-FSA-03/11
Summary report on the status of black-browed and grey-headed albatrosses breeding in Chile. G. Robertson, J. Valencia and J.A. Arata (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, graham.robertson@ aad.gov.au), 11 pp. (English, unpublished).

In October 2001 and October 2002 censuses were conducted of albatrosses at all known breeding locations in Chile. The breeding locations are Diego de Almagro Islands, Evangelistas Islets, Ildefonso and Diego Ramírez Islands. Population sizes were determined using yacht-based, aerial and ground-based photography and ground counts. Total population sizes for the four

known breeding locations are about 123 000 pairs of black-browed albatrosses and about 16 400 pairs of grey-headed albatrosses. These estimates are far greater than reported in the published scientific literature. Chile holds the second largest (after the Falkland Islands) population of black-browed albatrosses and the second largest (after South Georgia) population of grey-headed albatrosses in the world.

WG-FSA-03/12
Is our attempt to estimate biomass of Antarctic fish from a multi-species survey appropriate for all targeted species? *Notothenia rossii* **in the Atlantic Ocean sector – revisited.** K.-H. Kock, M. Belchier and C.D. Jones (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany, karl-hermann.kock@ish.bfa-fisch.de), 22 pp. *CCAMLR Science*, submitted (English).

Notothenia rossii was the first target species of the fishery in the Southern Ocean. The species was heavily fished at the beginning of the 1970s. The closure of the fishery for this species was one of the first conservation measures CCAMLR adopted in 1985. Fish biomass within a CCAMLR subarea or part of a subarea is commonly estimated targeting a number of species including *N. rossii* at the same time. These surveys are conducted under the assumption that the target fish species are more or less evenly distributed over the area at the time of the survey. This assumption is violated in the case of *N. rossii* which shows an abundance which is extremely skewed in that a large proportion of the population tends to aggregate in small areas, while most of the area of distribution is only thinly populated. In order to provide more accurate estimates of the species, it is suggested that an acoustic survey combined with a number of identification hauls might be the most promising approach to estimate biomass of *N. rossii* more adequately.

WG-FSA-03/13
Analysis of dietary overlap in Antarctic fish (Nototheniodei) from the South Shetland Islands: no evidence of food competition. E. Barrera-Oro. *Polar Biology*, 26 (10): 631–637 (2003). (English).

A dietary overlap analysis between notothenioid species was carried out

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among three fish assemblages at the South Shetland Island area. Using Tyler's (1972) method, the reoccurrence of main and secondary prey among fish predators was 33% in summer and 37% over the year at Potter Cove, 25% in summer and 7% in winter at Admiralty Bay, and 20% in autumn/winter around Elephant Island. Likewise, using the 'S' index of Linton et al. (1981), the diet similarity between most species pairs is <50%. This relatively low dietary overlap may be explained by the about equally divided occurrence of gener-alised feeders and specialized feeders, with no evidence of competition among them. The fishes' trophic niches seem to be separated by depth and prey taxa. These findings are compared with other Antarctic fish communities and those in similar non-Antarctic cold marine ecosystems.

WG-FSA-03/14
Report of the Subgroup on Fisheries Acoustics (British Antarctic Survey, Cambridge, 18 to 22 August 2003), 36 pp. (English, unpublished).

WG-FSA-03/15
Toothfish, skate and longline by-catch survey in Subarea 48.3. M. Belchier, M.A. Collins, M. Endicott, I. Everson, S. Hawkins, T.R. Marlow, T. Mulvey and R. Patterson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, markb@ bas.ac.uk), 19 pp. (English, unpublished).

This was the first deep-water trawl survey of the South Georgia maritime zone funded by the Government of South Georgia and the South Sandwich Islands as part of the South Georgia Project. The survey was focused primarily at providing new information on the distribution, biology and ecology of Patagonian tooth-fish (*Dissostichus eleginoides*) at South Georgia as well as providing information on by-catch species of the longline fishery, particularly grenadiers (macrourids) and skates (rajids). A further key aim of the survey was to employ the AUDOS baited-camera system to provide new information on the distribution and behaviour of toothfish and other species found over the shelf edge at South Georgia.

The primary objectives of the survey were to:

- determine toothfish distribution and population structure in the South Geor-gia and Shag Rocks regions;
- provide further information on the biology and ecology of toothfish;
- commence tagging studies on rajids to contribute to our understanding of their stock structure, migrations and growth;
- investigate the biological characteristics of potential relevance to stock dynamics for all fish species in the area including by-catch species of the longline fishery i.e. macrourids;
- deploy AUDOS to investigate the distribution of toothfish at depths beyond which fishing is undertaken.

WG-FSA-03/16
Aspects of the ecology of the bigeye grenadier at South Georgia. S.A. Morley, T. Mulvey, J. Dickson and *M. Belchier (British Antarctic Survey, Natural Envi-ronment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, *markb@bas.ac.uk), 31 pp. (English, unpublished).

Aspects of the ecology of the bigeye grenadier (*Macrourus holotrachys*) caught as by-catch in the Patagonian toothfish longline fishery conducted around South Georgia were investigated. Age estimates suggest that *M. holotrachys* is a long-lived and moderately slow-growing species, reaching ages of over 30 years and attain-ing lengths in excess of 80 cm (L_t). Von Bertalanffy growth parameters were esti-mated for females and closely matched those of the congeneic species *M. berglax* from the Northern Hemisphere. The size at which 50% of females had started to mature (L_{int50}) for *M. holotrachys* was 21cm (L_{pa}) and occurred at around 9 years old. Estimates of natural mortality and Pauly's growth performance index were found to be low (M = 0.09 and ϕ = 2.82 respectively). Gonad maturity stage was described from macroscopic and histo-logical investigation. Mature ovaries had oocytes at all developmental stages with between 22 and 55% likely to be spawned each year. Absolute fecundity ranged from 22 000 to 260 000 eggs, an average num-ber for a macrourid of this size. A highly skewed sex ratio of 33:1 females:males was found for specimens caught by

longlines but not for shallower trawl-caught specimens (1:1). It is suggested that females are far more susceptible to long-line capture than males. *M. holotrachys* is a bentho-pelagic predator/scavenger that feeds on a wide range of fish and invertebrates.

WG-FSA-03/17
Request to conduct an integrated weight longline trial on autoline vessels in Subareas 88.1 and 88.2 in 2003/04. G. Robertson and N.W.McL. Smith (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, graham_rob@antdiv.gov.au), 8 pp. (English, unpublished).

This document seeks the approval of CCAMLR to conduct an integrated weight (IW) longline trial on autoline vessels in Subareas 88.1 and 88.2 in the 2003/04 season. The purpose of the trial is to determine the effect of IW longlines on the catch rates of Antarctic toothfish and non-target fishes. In the trial, half the lines set will be IW lines and half will be normal (unweighted) lines. Lines will be set in pairs to minimise confounding effects and so the data can be analysed by paired *t*-test. Execution of the trial will be contingent on deviation from the minimum sink rate of 0.3 m/s required by Conservation Measure 41-09 to 0.25 m/s, which is the sink rate of IW longlines. The trial will also require that the unweighted longlines sink at their normal speed, which is 0.1 m/s. The potential for seabird mortality will be mitigated by use of two streamer lines (not one, as required by Conservation Measure 25-02) and an additional bird scaring cannon. The cannon is not required by Conservation Measure 25-02, but has been shown to be effective in the New Zealand ling fishery in scaring seabirds away from longlines. With these measures additional to the Conservation Measure 25-02 requirement, the deviation to Conservation Measure 41-09 is not expected to cause any seabird mortality during line-setting operations.

WG-FSA-03/18
Streamer lines to reduce seabird by-catch in longline fisheries. E.F. Melvin (Washington Sea Grant Program, University of Washington, Fishery Sciences Building, Box 355020, Seattle, WA 98195, USA, emelvin@u.washington.edu). Washington Sea Grant Program, WSG-AS 00-03. (English).

This two-page flyer targets commercial longline fishermen in Alaska. Aspects of the streamer line developed in the course of research in Alaskan demersal longline fisheries are described including materials and performance standards.

WG-FSA-03/19
Off the hook: an informational video for Alaska longliners. E.F. Melvin and D. Mercy (Washington Sea Grant Program, University of Washington, Fishery Sciences Building, Box 355020, Seattle, WA 98195, USA, emelvin@u.washington.edu). Washington Sea Grant Program, WSG-AV 00-01. (English).

The video portrays a variety of seabird species in flight and interacting with longline gear. It also demonstrates how to rig and deploy streamer lines – a seabird by-catch deterrent required on most Alaska longlines beginning in 2004.

WG-FSA-03/20
Focusing and testing fisher know-how to solve conservation problems: a common sense approach. E.F. Melvin and J.K. Parrish (USA). In: Haggan, N., C. Brignall and L. Woods (Eds). *Putting Fishers' Knowledge to Work. Fisheries Centre Research Report*s, 11: 224–226. (English).

Worldwide, the incidental capture or by-catch of marine organisms, especially mammals, turtles and seabirds, can pose serious threats to specific animal populations causing public outcry and regulatory attention. When such issues arise, especially in US fisheries, they can threaten fisheries and necessitate immediate solutions. Unfortunately, no standard mechanisms exist within stewardship and regulatory authorities to go beyond problem identification to crafting solutions. We have worked to devise solutions to seabird mortality in two fisheries: the Puget Sound drift gillnet fishery for sockeye salmon and the longline fisheries in Alaska for sablefish and Pacific cod. Although these fisheries are very different, the cooperative research model we have developed is the same and is proving successful in both. At the most basic level, this model includes communication and cooperation with all stakeholders, strict scientific protocols and

development of effective and practical regulations. Although this model was developed with specific reference to seabird by-catch reductions, it is readily applicable to a wide range of conservation issues. There are three key elements: 1) Working with industry leaders through relevant industry associations to identify possible new technologies and/or operational practices that are practical and likely to solve the problem; 2) Testing the proposed solutions in a collaborative study on active fishing vessels using strict scientific protocols, and developing incentives for individual participants to: a) host scientists, who collect the necessary data, and b) adhere to a specific scientific protocol within their standard operation is key; 3) Crafting new regulations based on the results of the research program in cooperation with the industry, resource management agencies and conservation organisations. Our model results in proof at two levels. At the practical level, fishers' ideas are tested in the context of an active fishery. At the scientific level, peer review and publication certify results for the regulatory, academic, and conservation communities.

WG-FSA-03/21
Main points in WG-EMM-03/05 (fish monitoring using Antarctic shags) and additional comments, on the recommendation from WG-EMM to WG-FSA to be considered at its 2003 meeting. R. Casaux, E. Barrera-Oro and E. Marschoff (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina, pipocasaux@infovia.com.ar), 5 pp. (English, unpublished).

WG-FSA-03/22
CCAMLR streamer line requirements revisited. E.F. Melvin (Washington Sea Grant Program, University of Washington, Box 355020, Seattle, WA 98195, USA), 14 pp. *CCAMLR Science*, submitted (English).

The streamer line has become the primary seabird mitigation device prescribed and used in most longline fisheries throughout the world, based to a large degree on the precedent set by CCAMLR in 1991. This discussion paper responds to the interest of ad hoc WG-IMAF to consider possible revisions to the CCAMLR streamer line requirement. Existing literature on the effectiveness of single and paired (or multiple) streamer lines is reviewed and CCAMLR streamer line performance and material standards are discussed and contrasted with recent Alaskan requirements.

WG-FSA-03/23
The effectiveness of integrated weight (fast sinking) longlines in reducing white-chinned petrel mortality in the New Zealand ling longline fishery. G. Robertson, M. McNeill, B. Wienecke, N.W.McL. Smith and M. Bravington (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, graham_rob@antdiv.gov.au), 15 pp. (English, unpublished).

An experiment was conducted on the effectiveness of longlines with integrated weights in reducing white-chinned petrel mortality in the New Zealand ling longline fishery. Longlines with integrated weights sank to 20 m depth 2.5 times faster than unweighted longlines. Integrated weight longlines sank instantly, whereas unweighted lines took about 15 seconds to clear surface waters. Unweighted longlines caught 81 white-chinned petrels and one sooty shearwater, compared to one white-chinned petrel caught by integrated weight longlines (combined capture ratio: 82:1 in favour of integrated weight lines). Catch rates of ling and non-target fish species by both types of longline were similar, though sample sizes were small. Work on the effectiveness of integrated weight longlines in reducing seabird mortality, and effects on the economics of fishing, is ongoing.

WG-FSA-03/24
Beached birds: a guide used by North Pacific groundfish observers to identify seabirds incidentally caught in fisheries. T. Hass and S. Davis (School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, WA 98103, USA), 3 pp. This summary document describes the published book *Beached Birds: A COASST Field Guide*, by T. Hass and J.K. Parrish, 2nd Edition. Wavefall Press, Seattle, WA, ISBN 0-9704157-1-0. (English, unpublished).

In the fall of 2002, the US National Marine Fisheries Service (NMFS) purchased 300 copies of *Beached Birds* for use by North Pacific groundfish observers

deployed on commercial fishing vessels in the Bering Sea and Gulf of Alaska. This new guide replaces a dichotomous key on looseleaf paper with black and white drawings. The purpose of using this new educational tool is to enhance the ability of fishery observers to accurately identify seabirds as they come up in the sampled fishing gear, typically wet and bedraggled birds – appearances much different than living specimens. A description of *Beached Birds* is provided as well as how this guide has been incorporated into observer training and data collection at the NMFS North Pacific Groundfish Observer Program. A copy of *Beached Birds* is available in the CCAMLR library.

WG-FSA-03/26

The area north of Joinville–D'Urville Islands (Subarea 48.1) – a former fishing ground at the tip of the Antarctic Peninsula – revisited. K.-H. Kock, L. Pshenichnov, K. Skora, Zh.A. Frolkina and C.D. Jones (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany, karl-hermann.kock@ish.bfa-fisch.de), 34 pp. *CCAMLR Science*, submitted (English).

The former fishing ground off Joinville–D'Urville Islands was revisited in the course of the Antarctic expedition ANT XIX/3 with the RV *Polarstern* in February 2002. Five hauls were conducted north of Joinville–D'Urville Islands at 149–282 m depth on 21 February 2002. Published and unpublished reports by the Fischkombinat in Rostock (ex-German Democratic Republic), Sea Fisheries Institute in Gdynia (Poland) and material available in YugNIRO, Kerch (Ukraine) from ex-Soviet fishing operations in the 1970s and 1980s were analysed in order to provide a comprehensive review of fishing activities in that area hitherto unavailable to CCAMLR.

WG-FSA-03/27

Killer whale *Orcinus orca* and sperm whale *Physeter macrocephalus* interactions with longline vessels in the Patagonian toothfish fishery at South Georgia, South Atlantic. M.G. Purves, D.J. Agnew, E. Balguerías, C.A. Moreno and B. Watkins (Marine Resources Assessment Group Ltd, 47 Prince's Gate, London SW7 2QA, United Kingdom, m.purves@mrag.co.uk), 20 pp. *CCAMLR Science*, submitted (English).

Killer whale (*Orcinus orca*) and sperm whale (*Physeter macrocephalus*) interactions with longline fishing operations were recorded by CCAMLR observers between 2000 and 2002 at South Georgia (Subarea 48.3) in the southeast Atlantic Ocean. Demersal longlines, targeting Patagonian toothfish (*Dissostichus eleginoides*), were deployed in depths of 300 to 2 000 m, concentrated along the 1 000 m contour. Sperm whales were the most abundant marine mammals observed in the vicinity of vessels when lines were being hauled, occurring during 24% of hauling observations. Killer whales, the second most sighted, occurred during 5% of haul observations. A high inter-vessel variation was noted for interactions with both species. Geographic plots of cetacean sightings during hauls were compared to fishing positions. Both killer whale and sperm whale interactions occurred over a wide geographic range and were mostly dependent on the extent of fishing effort on the different grounds, although some 'hotspots' for interactions seem to occur. Killer whale pods were generally small, (2–8 animals, 57% of observations), while solitary animals (13%) and larger pods (>15 animals, 8%) occurred less frequently. Sperm whales were most often solitary (43% of observations) when interacting with fishing vessels, although smaller groups (2–3) were also relatively common. Larger groups were not often sighted. Interactions with killer whales were most often observed in the day, mostly in the afternoon, while night-time interactions were relatively few and usually occurred before midnight. Interactions with sperm whales followed a similar pattern occurring most often in the afternoon, while very few interactions were observed at night. Catch rates were significantly lower ($P > 0.05$) when killer whales were present (0.15 kg/hook; 21.5 fish/1 000 hooks), when compared to hauls with no cetacean present (0.29 kg/hook; 48.5 fish/1 000 hooks). The same trend was, however, not observed for catch rates when sperm whales were present during hauling (0.32 kg/hook; 51.9 fish/1 000 hooks). Catch rates were in fact slightly higher in the presence of sperm

whales when compared to lines with no cetacean presence. It is likely that sperm whales were attracted to areas with high catch rates, but in areas with lower catch rates indications are that depredation by sperm whales can lead to a drop-off in catches. During hook-line observations on a longliner in the 2001 season it was noted that toothfish lips on hooks were more prevalent when sperm whales were in the vicinity of the vessel, suggesting that whole fish might be 'stripped' off the line, leaving only the lips. This would further complicate the quantification of levels of depredation. In contrast, depredation by killer whales was often characterised by the occurrence of damaged fish, with often only the heads on returning hooks, although lips were also sometimes observed when killer whales were in the vicinity. Some mitigation measures have been tried by vessels to reduce interactions with cetaceans, although no quantitative studies were done to measure their effectiveness. Further investigations are needed to determine the extent of longline-cetacean interactions, to address the problems of longline-cetacean depredation, to standardise observer protocols to ensure the collection of valuable data, and to assess and implement mitigation strategies under controlled experimental conditions.

WG-FSA-03/28
Descriptive analysis of acoustic data collected during the 2003 exploratory fishery for toothfish in the Ross Sea.
R.L. O'Driscoll and G.J. Macaulay (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, r.odriscoll@ niwa.co.nz), 21 pp. (English, unpublished).

This report presents results from a pilot study to determine the feasibility of conducting acoustic surveys for toothfish and rattails in the Ross Sea. Acoustic data were collected during the 2002/03 exploratory fishery. Data were recorded continuously from 28 December to 2 February 2003, then during line setting only from 5 to 22 February 2003. Analyses were carried out to assess data quality, describe different mark types, and quantify acoustic backscatter by echo integration and echo counting. These analyses focused on the subset of acoustic data collected when

setting longlines so acoustic recordings could be compared with longline catches.

Data quality was generally good. Of the 84 line recordings, 68 were considered suitable for acoustic analysis. Poor data quality was associated with strong winds and/or high seas: conditions that led to bubble interference on the hull-mounted transducer. Other issues with data quality were interference from another echo-sounder, and the occurrence of a double bottom echo caused by too high a ping rate.

All line recordings were in water over 1 000 m deep. Because of the spreading of the acoustic beam, the acoustic deadzone at these depths is relatively large, especially if the bottom is rough or sloped. Simulations indicated that at 1 500 m depth, the acoustic deadzone would be over 50 m high for a seabed with a slope of 20°. The problem of the acoustic deadzone was worsened by the occurrence of side-lobe echoes, produced as longlines were set on steep slopes parallel to the depth contours. Measurements indicated that side-lobe could create a deadzone of 50–100 m on apparently flat ground. Because both toothfish and rattails are considered to be demersal species, the inability of the acoustics to 'see' close to the bottom is a major limitation that could only be avoided with the use of a towed acoustic system.

Two types of pelagic layers were present in most acoustic recordings: a dense shallow layer between 30 and 200 m; and a more diffuse deep scattering layer between 300 and 800 m. Pelagic schools were also present in some recordings and these tended to occur at 150–400 m depth, between the layer marks. The most common demersal mark was single targets, which were present in 84% of line recordings. Most single targets occurred in a surface-referenced band between 800 and 1 100 m depth, and were up to 500 m off the bottom. There was a significant positive correlation between the number of single targets counted from the echogram and the catch of rattails in the accompanying longline set. Bottom-referenced layers were present in 18% of line recordings and were also associated with higher catches of rattails. Demersal schools were present in 16% of recordings and were associated with higher catches of toothfish. Despite these associations, no acoustic marks could be reliably identified as being rattails or

toothfish. It seems unlikely that the schools were toothfish or the single targets were rattails, as these were often more than 300 m off the bottom.

At this point, it is not practical to estimate toothfish or rattail abundance in the Ross Sea using hull-mounted acoustic systems. The acoustic deadzone was large, meaning it was impossible to detect demersal species close to the bottom. Echo integration was unreliable because there was a very low signal-to-noise ratio deeper than 1 000 m. Echo counting showed more promise, but only relatively strong targets well separated from the bottom could be enumerated. As toothfish do not have a swimbladder, their acoustic target strength may be too weak to allow them to be counted.

WG-FSA-03/29
Review of small-scale research unit boundaries used for the assessment and management of _Dissostichus mawsoni_ in Subarea 88.1. S.M. Hanchet (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, s.hanchet@niwa.co.nz), 7 pp. (English, unpublished).

This paper provides a review of the boundaries of the small-scale research units (SSRUs) used to manage the exploratory fishery for _Dissostichus mawsoni_ in Subarea 88.1. In determining appropriate SSRU boundaries, the physical and geographical features of the subarea, including the impact of sea-ice on fishing practices, were considered, as well as the distribution and abundance of target and by-catch species (rattails and skates). It is recommended that the northern SSRU boundary (at 65°S) remain in place, but that the other boundaries of the other four SSRUs are changed to reflect the underlying bathymetry, species distributions and ice conditions.

WG-FSA-03/30
An examination of latitudinal variation in the growth rates of Antarctic toothfish (_Dissostichus mawsoni_) in the Ross Sea. P.L. Horn (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, p.horn@niwa.co.nz), 12 pp. (English, unpublished).

Following a finding that a small sample of aged _Dissostichus mawsoni_ from

McMurdo Sound (76°S) fell consistently below the von Bertalanffy curves calculated predominantly from data collected between 67° and 74°S, an investigation to test for latitudinal differences in growth rates was conducted. Length-at-age of _D. mawsoni_ was compared across five zones in a 15.5° latitudinal range (62.5°–78.0°S). Between-zone comparisons were confounded by marked differences in the age structure of catches from the northern and southern sections of the range, and by the relatively high level of variance in the length-at-age data. There is no statistically significant difference in mean growth rates of _D. mawsoni_ between 62.5° and 75°S. However, fish between the ages of 6 and 15 years in the southernmost zone (75°–78°S) are, on average, significantly smaller at age than those in the more northern zones. There were insufficient older fish in the southernmost zone to enable a comparison with other areas. Any real latitudinal differences in growth rates for relatively sedentary fish are likely to be blurred by migration between latitudes.

WG-FSA-03/32
Preliminary assessment of mackerel icefish (_Champsocephalus gunnari_) on the Heard Island Plateau (Division 58.5.2) based on a survey in April–May 2003. A.J. Constable, C.R. Davies, R. Williams and T. Lamb (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@ aad.gov.au), 16 pp. (English, unpublished).

A preliminary assessment of yield of _Champsocephalus gunnari_ for the Heard Island Plateau (Division 58.5.2) was undertaken using the standard CCAMLR methods, based on the result of a randomly stratified trawl survey completed between 16 April and 10 May 2003. The 2003 estimate of abundance was approximately 20% of the 2002 estimate. This decline in abundance is consistent with the passage of the strong 1997 cohort through the population and relatively weak recruitment in 1999 and 2000. The 1+ fish evident in the survey were not fully sampled and as such are not included in the assessment. Estimates of the strength of this cohort will not be possible until the May 2004 survey is complete. The estimates of short-term yield for 2004 and 2005 using the MathCad implementation were 259 tonnes

and 196 tonnes respectively. Consideration is given to the potential use of alternative technical measures to control harvest of unassessed cohorts and provide for more stable catches between fishing years, while meeting the objectives of Article II. Comparison of yield estimates between MathCad and Generalised Yield Model (GYM) implementations indicated that the GYM version provided slightly higher estimates of short-term yield. These differences will need to be considered by WG-FSA. The implications of the interannual variability in recruitment, natural mortality and growth of these fish, combined with the need to maintain a steady yield if possible need to be explored further in the development of a management procedure that fulfils the objectives of Article II and is robust against the uncertainties inherent in the stock dynamics of this species.

WG-FSA-03/33
Preliminary assessment of *Dissostichus eleginoides* on the Heard Island Plateau (Division 58.5.2) based on a survey in April–May 2003. A.J. Constable, C.R. Davies, R. Williams and T. Lamb (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@aad.gov.au), 18 pp. (English, unpublished).

A preliminary assessment of yield of Patagonian toothfish (*Dissostichus eleginoides*) for the Heard Island Plateau (Division 58.5.2) was done, using the standard CCAMLR methods, based on the result of a randomly stratified trawl survey completed between 16 April and 10 May 2003. The 2003 estimate of abundance of recruits indicates a continuation of a period of relatively low recruitment since 1999. A minor revision to the recruitment series resulted in a relatively small reduction in the preliminary estimate of sustainable long-term yield assessed using the standard method. The preliminary estimate for 2004 was 2 680 tonnes. Initial tests of length-at-age assumptions indicated that using a specified length-at-age vector that did not include growth beyond 15 years had only small effects on projected long-term yields. Further work is required to evaluate the implications of current uncertainty in the rate of growth beyond this age in Division 58.5.2. Preliminary

examinations of the effect of refinements to the design of the annual survey indicated some variability in survey catchability between years and suggest that it may be appropriate to adjust estimates of cohort strength for catchability where possible. The 2003 season saw the operation of the first commercial longline vessel in Division 58.5.2. An initial comparison of the length distribution of the catches suggests that the two gears sample a similar range of sizes. This initial comparison was somewhat confounded by the depth of the grounds fished by the trawl and longline operations. Very few large (>1 200 mm) fish were observed in the longline catch. Further structured work is planned in conjunction with the commercial operators for the 2004 season to provide data for a more comprehensive comparison, and to sample greater depths than fished by the longline operator in the 2003 season.

WG-FSA-03/34
Modelling catch and effort data using generalised linear models with random cruise and stratum-by-year effects: trawl fishery for *Dissostichus eleginoides* in CAMLR Division 58.5.2. S.G. Candy (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, steve.candy@aad.gov.au), 17 pp. *CCAMLR Science*, submitted (English).

A set of procedures for modelling catch and effort data using generalised linear mixed models (GLMMs), including data analytic methods for examining the appropriateness of model structure and parameter values, was presented in WG-FSA-SAM/03-12 using *Dissostichus eleginoides* in Subarea 48.3 of the CAMLR Convention Area as an example dataset. Further development of these procedures is presented in this report using trawl catches for *D. eleginoides* in Division 58.5.2. The extension described here deals with calculating an overall standardised CPUE series when the subarea has been divided into sampling strata by incorporating 'stratum' as a fixed-effect term and the stratum-by-year interaction (S x Y) as a random-effect term in the GLMM. Statistical methods are presented for examining the validity of considering the S x Y term as random. A random S x Y term avoids the difficulty in calculating an overall standardised time series of CPUE estimates of weighting by

the areal extent of each stratum which is necessary when the S x Y term is included in the GLMM as a fixed effect. Defining an areal extent of each stratum that is valid for use in calculating a weighted mean over all strata using the formula based on stratified random sampling is problematic given that hauls are not a spatially random sample within each stratum. Including the stratum term as fixed simply results in uniform scaling of the CPUE series, as is the case with other additive fixed terms in the GLMM.

It was concluded that there was an increase in CPUE in the second year of the fishery with a sharp decline in the following year followed by a relatively stable series of CPUEs. It was also shown that the influence on the series of the random effects estimates for stratum-by-year is small.

For the trawl catch and effort data it was found that considering the S x Y term as random was valid. The precision of the standardised CPUE estimates was considerably poorer than that of the longline data for Subarea 48.3. A weak trend of decreasing CPUE values with entry into the winter months was detected using a cubic smoothing spline.

WG-FSA-03/35
Modelling catch and effort data using generalised linear models with random cruise effects: trawl fishery for mackerel icefish (*Champsocephalus gunnari*) in CAMLR Division 58.5.2. S.G. Candy (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, steve.candy@aad.gov.au), 10 pp. (English, unpublished).

A set of procedures for modelling catch and effort data using generalised linear mixed models (GLMMs), including data analytic methods for examining the appropriateness of model structure and parameter values, was presented in WG-FSA-SAM-03/12 using *Dissostichus eleginoides* in Subarea 48.3 of the CAMLR Convention Area as an example dataset. The application of these procedures to trawl catches of *Champsocephalus gunnari* in Division 58.5.2 is described. For the trawl catch and effort data it was found the precision of the standardised CPUE estimates was considerably poorer than that of the longline data for Subarea 48.3.

It is concluded that CPUE was relatively stable from the start of the fishery until 2000, after which time there was a sharp increase in 2001 with a steady decline thereafter. The sharp increase in 2001 is most likely the result of the large abundance of 3-and 4-year-old fish in that year, which has since diminished through a combination of natural mortality and fishing.

WG-FSA-03/36
Performance assessment of underwater setting chutes, side setting and blue-dyed bait to minimise seabird mortality in Hawaii longline tuna and swordfish fisheries. Final report August 2003. E. Gilman, N. Brothers, D. Kobayashi, S. Martin, J. Cook, J. Ray, G. Ching and B. Woods (National Audubon Society, 2718 Napua`a Place, Honolulu, Hawaii 96822 USA, ericgilman@earthlink.net), 42 pp. (English, unpublished).

Mortality in longline fisheries is a critical global threat to some seabird species. Identifying and mainstreaming seabird avoidance methods that not only have the capacity to minimise bird interactions, but are also practical and convenient, providing crew with incentives to employ them consistently and effectively, will help resolve this global problem. Cooperative research and a commercial demonstration were conducted to assess three methods' effectiveness at avoiding incidental seabird capture, commercial viability, and practicality in the Hawaii pelagic longline fisheries. A seabird avoidance method called side setting, which entails setting gear from the side of the vessel, with other gear design the same as conventional approaches when setting from the stern, had the lowest mean seabird contact and capture rates of treatments tested. Because side setting promises to provide a large operational benefit for longline vessels, the incentive for broad industry uptake and voluntary compliance is realistic. After making the initial conversion to side setting, there is no additional effort required to employ the method. A seabird avoidance method called an underwater setting chute also holds high promise, but requires additional research and evaluation to correct design problems, after which it can be considered being made commercially available. Two

chutes, one 9 m long and one 6.5 m long, which deployed baited hooks 5.4 m and 2.9 m underwater respectively, were used in this trial. The 9 m chute had the second lowest mean seabird interaction rates when used with swordfish gear, and the 6.5 m chute had the second lowest mean seabird interaction rates when used with tuna gear. A third seabird avoidance method, which entails thawing and dying bait dark blue to attempt to reduce seabirds' ability to see the baits by reducing the bait's contrast with the sea surface, was found to be less effective than the other two methods and was found to be relatively impractical and inconvenient. If pre-dyed bait were commercially available, use of blue-dyed bait in combination with other methods, such as side setting and adequate line weighting, has high promise.

WG-FSA-03/37
Demography and population trends of the Atlantic yellow-nosed albatross. R. Cuthbert, P.G. Ryan, J. Cooper and G. Hilton. *The Condor,* 105: 439–452 (2003). (English).

The Atlantic yellow-nosed albatross (*Thalassarche chlororhynchos*) breeds only at the Tristan da Cunha archipelago and Gough Island in the central South Atlantic Ocean, and is threatened by mortality from longline fisheries operating in the South Atlantic. Demographic data have been collected from two study colonies on Gough Island and Tristan da Cunha for 20 years. Annual variation in the number of breeding birds was strongly correlated between the two islands, and over the whole study period both study populations have trended downward at around 1.2% per year. The number of established breeders on Gough Island has declined more rapidly, and significantly, at an annual rate of 2.3%. Monitoring established breeders may be a sensitive means of detecting population trends. Average breeding success (67–69%) and breeding frequency (66–65%) were very similar on the two islands. On Gough Island immature and adult annual apparent survival averaged 88 ± 3% and 92 ± 1% respectively, and apparent survival from fledging to age 5 has averaged 31 ± 8%. Apparent adult survival on Tristan da Cunha averaged only 84 ± 2%. Annual

survival of Tristan birds was negatively correlated with longline fishing effort in the South Atlantic Ocean. Population modelling predicts annual rates of decrease of 1.5–2.8% on Gough Island and 5.5% on Tristan da Cunha. Comparison with congeners suggests that the observed and predicted decreases are most likely to be caused by low adult and immature survival. The conservation status of Atlantic yellow-nosed albatrosses should be changed from Near Threatened to Endangered.

WG-FSA-03/38
Standing stock, biology, diet and spatial distribution of demersal finfish from the 2003 US AMLR bottom trawl survey of the South Shetland Islands (Subarea 48.1). C.D. Jones, K.-H. Kock, J.R. Ashford, A. DeVries, K. Dietrich, S.M. Hanchet, T. Near, T. Turk and S. Wilhelms (US AMLR Program, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, cdjones@ucsd.edu), 31 pp. (English, unpublished).

The US Antarctic Marine Living Resources (US AMLR) Program has conducted bottom trawl surveys of the South Shetland Islands (Subarea 48.1) during the 1998, 2001 and 2003 austral summers. Information on species and size composition, abundance, spatial distribution and dietary patterns from the 2003 survey is presented. The spatial distributions and standardised densities for demersal finfish species have remained relatively consistent across all surveys. Shelf regions of importance for krill, fish and benthic feeding guilds, based on stomach content analysis, demonstrate the most important feeding areas lie to the west and north of Elephant Island and to the north of King George Island at depths greater than 200 m. Estimates of total stock biomass from these surveys were computed for eight species: *Champsocephalus gunnari, Chaenocephalus aceratus, Chionodraco rastrospinosus, Gobionotothen gibberifrons, Lepidonotothen larseni, L. squamifrons, Notothenia coriiceps* and *N. rossii*. The standing stock for most species has fluctuated, with no signal of substantial year classes or significant recruitment for any species. Although standing stocks of *G. gibberifrons* remain the largest relative to all other species, there appears to be a

decline in biomass. The overall abundance of finfish in the South Shetland Islands has yet to reach a level at which commercial exploitation would be advisable.

WG-FSA-03/39
Information on incidental mortality of seabirds and other protected species in the US West Coast pelagic longline fishery. D. Petersen, L. Enriquez and S. Fougner (National Marine Fisheries Service, Southwest Region, 501 W. Ocean Boulevard, Long Beach, CA 90802-4213, USA), 10 pp. (English, unpublished).

Although the IATTC does not have an established observer program in its longline fisheries, one does exist for a US-based pelagic longline fishery for tuna and swordfish. These vessels are subject to pertinent US regulations as well as under the purview of IATTC. In response to a CCAMLR query in 2002, IATTC informed CCAMLR of this US observer program. Information about seabird by-catch observed in the US West Coast pelagic longline fishery was reported by the USA in WG-FSA-02/39. As per a standing request from CCAMLR for information on incidental seabird mortality in fisheries adjacent to the Convention Area, information is provided about the US West Coast pelagic longline fishery.

Pelagic longline vessels operating in the North Central-Eastern Pacific targeting broadbill swordfish (*Xiphias gladius*) and tuna (*Thunnus* spp.), inadvertently hook and kill black-footed (*Phoebastria nigripes*) and Laysan albatrosses (*P. immutabilis*) that nest in the northwestern Hawaiian islands. The US-based pelagic longline fishery does not interact with albatross or petrel species that breed in the CCAMLR Convention Area. Although procellarids demonstrate broad and far-ranging foraging distributions, it is doubtful that Southern Hemisphere albatrosses and petrels forage this far north.

WG-FSA-03/40
Report of the Subgroup on Assessment Methods (London, United Kingdom, 12 to 15 August 2003), 39 pp. (English, unpublished).

WG-FSA-03/41
New Zealand Draft National Plan of Action – Seabirds. J. Nicolson and D. Randall (Department of Conservation, PO Box 10 420, Wellington, New Zealand and Ministry of Fisheries, PO Box 1020, Wellington, New Zealand), 8 pp. (English).

WG-FSA-03/42
Length-at-maturity of the Antarctic skates *Amblyraja georgiana* and *Bathyraja eatonii* in the Ross Sea. M.P. Francis (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 14-901, Kilbirnie, Wellington, New Zealand, m.francis@niwa.co.nz), 8 pp. (English, unpublished).

Scientific observers collected maturity data from skates caught by New Zealand longline vessels targeting toothfish in the Ross Sea during 2002/03. Sample sizes were small, making it difficult to obtain accurate estimates of the length at 50% maturity. Results were compared with data collected in the previous season.

The length at 50% maturity for male *Amblyraja georgiana* is about 92 cm TL. Females appear to mature at a slightly greater length of 95–100 cm TL, but further data are required to confirm this. The length at 50% maturity of male and female *Bathyraja eatonii* could not be accurately determined, but may be around 85–90 cm and 100–120 cm respectively.

WG-FSA-03/43
Preliminary standardised CPUE analysis of the New Zealand part of the toothfish fishery in CCAMLR Subarea 88.1, from 1988/89 to 2002/03. R.G. Blackwell and S.M. Hanchet (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, r.blackwell@niwa.co.nz), 14 pp. (English, unpublished).

The 2002 standardised analysis of Antarctic toothfish in Subarea 88.1 was updated by inclusion of data from New Zealand vessels during the 2002/03 fishing year. The CPUE indices over the six-year period essentially show no trend. Data adequacy, model fits, and evaluation of the CPUE index as an index of abundance are discussed. The CPUE work done so far forms an important baseline for future research into the long-term assessment of this fishery.

Continued monitoring of CPUE for the main grounds and main vessels is

recommended, and further research on other possible CPUE models, and inclusion of first-order interactions in the analysis, is suggested. Research into suitable methods for validating the relationship between CPUE seasonal indices and the relative abundance of toothfish is also recommended.

WG-FSA-03/44
The toothfish fishery in Subareas 88.1 and 88.2 from 1997/98 to 2002/03: New Zealand vessel summary. M.L. Stevenson, S.M. Hanchet and P.L. Horn (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, m.stevenson@niwa.co.nz), 20 pp. (English, unpublished).

An exploratory fishery for Antarctic toothfish (*Dissostichus mawsoni*) has been in operation for six seasons in Subarea 88.1 and for two seasons in Subarea 88.2. 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 toothfish fishery for the 2003 season (this is part of the 2002/03 CCAMLR split-year), and to compare these results with previous years. Note this report is confined to data for New Zealand vessels.

The heavy ice conditions caused by the presence of the huge C2 iceberg severely altered the fishers' behaviour in 2003. The vessels were unable to fish south of about 72°S, and so effort was mainly focused instead on SSRUs 881A–C. In addition, SSRU 882E was fished for the first time.

Ninety-two fine-scale rectangles, including 57 new ones, were fished during the 2003 season. New Zealand vessels have now fished a total of 228 fine-scale rectangles.

The catch of *D. mawsoni* was about 1 070 tonnes, and contributed 89% of the total catch in 2003. They were caught in over 90% of the sets in all five SSRUs fished. They were the dominant catch in all sets apart from some made in SSRU 881A. Antarctic toothfish were recorded at depths from 430 to 1 900 m, and were most abundant from about 1 000 to 1 800 m. In 2003, almost 25 tonnes of Patagonian toothfish (*D. eleginoides*) was taken, almost entirely from SSRU 881A. This is more than twice the catch from 2002 but not as great as the

catch from 2001. Patagonian toothfish dominated the catches from 60° to 62°30'S but Antarctic toothfish dominated catches further south.

The main by-catch species was *Macrourus whitsoni*, which contributed about 7% of the 2003 catch. Two other rattail species were identified from five sets. By-catch of the two skate species (*Amblyraja georgiana* and *Bathyraja eatonii*) was only 6.3 tonnes (less than 1% of total catch). Other by-catch species (including icefish and moray cods) each contributed less than 1% of the catch overall. The main non-fish by-catch reported was starfish.

Antarctic toothfish length-frequency data were scaled up to the catch. About 530 otoliths were read and the scaled length frequency converted to catch-at-age. Fish aged from 13 to 30 years dominated the catch. No progressions of any particularly strong or weak year classes were apparent throughout the time series. Length and age of Antarctic toothfish from the fishery have increased through the series, mainly because fishing has been directed more toward depths greater than 1 000 m in the later years.

Length-frequency data for *M. whitsoni* from 2002 and 2003 were scaled up to the catch for each year. Also age, growth and maturity data were reviewed.

WG-FSA-03/46
Information on the spawning season and gonadosomatic indices of *Dissostichus mawsoni* from Subarea 88.1 in the 2002/03 season. G.J. Patchell (Sealord Group Ltd, PO Box 11, Nelson, New Zealand, gjp@sealord.co.nz), 6 pp. (English, unpublished).

Data on maturity, gonadosomatic index (GSI) and length weight of Antarctic toothfish (*Dissostichus mawsoni*) were collected from Subarea 88.1 in the 2002/03 season by the New Zealand bottom longline vessels *Janas, Avro Chieftain* and *San Aotea II* operating in the exploratory fishery. The first spawning fish were found in April, a month earlier than in the previous season.

WG-FSA-03/47
Research under way in New Zealand on seabirds vulnerable to fisheries interactions. S. Waugh and S. Grayling (Science

Group, Ministry of Fisheries, Wellington, New Zealand, waughs@fish.govt.nz), 16 pp. (English, unpublished).

This paper provides an update on seabird research under way in New Zealand. Details of population research, including methods and relevant references, are provided. Foraging range tracking program details are also provided, along with details of recorded visits to the CCAMLR Convention Area (nil).

WG-FSA-03/48
On the problem of some fish ranges in Subarea 88.1. V.G. Prutko (YugNIRO, 2 Sverdlov Street, Kerch 98300, Crimea, Ukraine, vgprut@ker.post.crimea.ua), 4 pp. (English, unpublished).

Detailed material is presented collected by the author in Subarea 88.1 from December 2002–March 2003 on the appearance of the sub-Antarctic species *Dissostichus eleginoides*, *Lampris immaculatus* in polar latitudes (to 72°S). The hypothesis is raised that Ross Sea circulation affects the overlapping of Antarctic and Patagonian toothfish distribution areas and the appearance of opah in the polar Ross Sea.

WG-FSA-03/49
Some data on Antarctic toothfish (*Dissostichus mawsoni*) reproduction in the Ross Sea (Subarea 88.1) from December 2002 to March 2003. V.G. Prutko and L.A. Lisovenko (YugNIRO, 2 Sverdlov Street, Kerch 98300, Crimea, Ukraine, vgprut@ker.post.crimea.ua), 12 pp. (English, unpublished).

Based on an analysis of data collected by one of the authors (V.G. Prutko) in Subarea 88.1 in December 2002–March 2003, Antarctic toothfish body length at 50% maturity is calculated to be 128–130 cm for females, and 117–120 cm for males.

To estimate the maturity stages of postspawning individuals the authors suggest using double designation, and to check visual estimates of maturity stages, a number of different oocytes in Antarctic fish ovaries should be measured and calculated, in addition to histological investigations. Variations in the gonadosomatic index at different times and in different study areas are shown. The authors note the presence of Antarctic toothfish spawning concentrations in the northern part of the research area as well as the presence of 'exhausted' individuals. On the basis of the processed data and analysis of information in the literature, the authors came to the conclusion that strict limitation of Antarctic toothfish catch was necessary. Together with such a limitation, it is suggested that priority should be given to studies of the reproductive capacity of the species in question. A brief outline of such research is presented.

WG-FSA-03/50
On the problem of fish tagging. V.G. Prutko (YugNIRO, 2 Sverdlov Street, Kerch 98300, Crimea, Ukraine, vgprut@ker.post.crimea.ua), 3 pp. (English, unpublished), (abstract not available).

WG-FSA-03/51
Progress toward Australia's National Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries (NPOA-Seabirds). M. Drynan and L. Brown (Delegation of Australia), 4 pp. (English, unpublished).

WG-FSA-03/52
Research under way in Australia on seabirds vulnerable to fisheries interactions. B. Baker and R. Gales (Delegation of Australia), 9 pp. (English, unpublished).

WG-FSA-03/53
Progress toward an Agreement on the Conservation of Albatrosses and Petrels. B. Baker (Delegation of Australia), 4 pp. (English, unpublished).

WG-FSA-03/54
Features of the vertical distribution of mackerel icefish (*Champsocephalus gunnari*) in different habitats. Zh.A. Frolkina and V.V. Herasimchuk (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, atlant@baltnet.ru), 14 pp. *CCAMLR Science*, submitted (English).

Significant similarities between the population ecology of mackerel icefish (*Champsocephalus gunnari*) in the Kerguelen and South Georgia areas have been revealed. Fish of all lengths and ages are planktonophages. Fish of the first two age groups have been found regularly in the pelagic layer off South Georgia and Kerguelen and Heard Islands. Some immature fish are also found in the pelagic

layer both during daytime and at night. Mature fish are, as a rule, found on the bottom during daytime, but have, in some years, like immature fish, been caught with pelagic fishing gear in the water column during the daytime.

WG-FSA-03/55
Peculiarities of mackerel icefish (*Champsocephalus gunnari*) (Channich-thyidae) distribution in the South Georgia area during the surveys made by STM *Atlantida* in 2000 and 2002. Zh.A. Frolkina, S.M. Kasatkina and N.N. Zhigalova (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, atlant@ baltnet.ru), 19 pp. *CCAMLR Science*, submitted (English).

The reasons for differences in mackerel icefish (*Champsocephalus gunnari*) distribution and biomass assessment during two surveys made by STM *Atlantida* are revealed. The availability of large *C. gunnari* concentrations in the 10–100 m layer in the northwest shelf area in 2000 resulted in the formation of adult fish aggregations in the water column. The year 2002 was characterised by krill distribution in the near-bottom layer, resulting in *C. gunnari* being present near the bottom even in the dark hours of the day. During the two surveys, fry and immature fish occurred in numbers in the pelagic zone. At present, the population consists primarily of immature and fish at first maturity which remain in the water column for a considerable part of the day. In 2002 it was noted that the pre-spawning period began earlier in relation to the annual mean in the northeastern part of the area.

It is shown that the part of the stock which remains permanently in the pelagic layer during the day is not taken into account by bottom net surveys, and is consequently disregarded when estimating the catch limit. Diverse size groups, mainly juvenile and immature fish, form the pelagic and near-bottom components of the stock. Under certain oceanological conditions, the length-age composition of the pelagic component may include all size classes.

Results of the fishery and investigations in *C. gunnari* habitat show that the methodology followed in conducting census surveys is not suitable for fish with such a distribution pattern. A combined net and acoustic survey would enable a quantitative assessment of the bottom (bottom net survey) and pelagic (hydroacoustic survey) components of *C. gunnari* stock to be made. Taking the pelagic component of *C. gunnari* into account will make it possible to calculate recruitment to the fishery in the following year. There is a demonstrated need to change the survey season so as to avoid an underestimation of fish biomass resulting from its distribution.

WG-FSA-03/56
Estimates of bird by-catch by IUU vessels in Subarea 48.3, 1998–2001. D.J. Agnew (Renewable Resources Assessment Group, Imperial College, Royal School of Mines, Prince Consort Road, London SW7 2BP, United Kingdom, d.agnew@ic.ac.uk), 6 pp. (English, unpublished).

Estimates of bird catches by IUU fishing made using the new method presented by Agnew and Kirkwood last year (WG-FSA-02/4 and 02/5) are updated to take account of the comments of the working group. Last year we suggested that the *Isabel* data from 1997 were rather atypical of bird catch rates in the illegal fishery, and that these were more likely to be similar to the bird catch rates made by other vessels in 1997. Including the *Isabel* data and weighting the bootstrap estimates of bird catch rate by the number of hooks observed leads to revised estimates of total catch in 1999, 2000 and 2001 of 1 115, 4 898 and 1 236 birds respectively. The relevant rates per 1 000 hooks for this bootstrapping option, which should be used by WG-FSA/IMAF in future estimates of bird by-catch rates, are:

summer: median – 0.741 birds/thousand hooks; 95% confidence limits – lower 0.39, upper 11.641;

winter: median – 0.0 birds/thousand hooks; 95% confidence limits – lower 0.0, upper 0.99.

WG-FSA-03/57
The survivorship of rays discarded from the South Georgia longline fishery. M. Endicott and D.J. Agnew (Renewable Resources Assessment Group, Imperial College, Royal School of Mines, Prince Consort Road, London SW7 2BP, United Kingdom, michael.endicott@imperial.ac.uk), 10 pp. *CCAMLR Science*, submitted (English).

Skate post-haulage survival experiments were conducted by one Chilean fishing vessel throughout the months of May and June, during the 2003 toothfish fishing season in Subarea 48.3. From these results it is concluded that depth has a significant influence on the mortality of skates, with a predicted mortality of 0% for skates caught in waters of less than 1 100 m. A predicted mortality of 65% for skates caught in waters between 1 400 to 1 600 m and a mortality of 100% for skates caught at 2 000 m. It is recommended from these findings that a further survival experiment be conducted, particularly in more shallow waters where our sampling was restricted. Our findings support the suggestion of cutting rays from the line before landing (SC-CAMLR-XXI, Annex 5, paragraph 5.78), as this will help ensure that the survival chances of skates are maximised. Results from this experiment can also be used to calculate the expected skate mortality within the fishery, based on depth of capture.

WG-FSA-03/58
By-catch of rays in the 2002/03 toothfish fishery around South Georgia. D.J. Agnew, J. Pearce and M. Endicott (Marine Resources Assessment Group, 47 Prince's Gate, London SW7 2QA, United Kingdom, d.agnew@ic.ac.uk), 5 pp. (English, unpublished).

The 2002/03 fishing season was the first in which three new policies for rays were tried:

- it was the first in which vessels were asked to cut off all rays at water level to assist survival and conservation of rays;
- it was the first in which very good quality information was available from all observers' tally periods on the catch rates of rays cut off the line;
- in 2003 the UK, with the cooperation of Chile and one fishing company, undertook an experiment to determine the survivorship of cut-off rays. This is described elsewhere by Endicott and Agnew (WG-FSA-03/57).

The number of rays that were likely to have died as a result of being caught on longlines using a combination of the observer tally information and the survivorship experiments is estimated. The estimate, between 34 and 46 tonnes, is an order of magnitude lower than the precautionary catch limit for this fishery, 390 tonnes.

WG-FSA-03/59
Skate captures during the 2003 South Georgia research survey. M. Endicott (Renewable Resources Assessment Group, Imperial College, Royal School of Mines, Prince Consort Road, London SW7 2BP, United Kingdom, michael.endicott@ imperial.ac.uk), 6 pp. (English, unpublished), (abstract not available).

WG-FSA-03/60
The food and feeding of five species of icefish in the Elephant Island/South Shetland Islands region in March 2003. K.-H. Kock, H. Flores, C.D. Jones, S. Wilhelms and S. Schöling (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany, karl-hermann.kock@ ish.bfa-fisch.de), 23 pp. (English, unpublished).

The food and feeding of five species of icefish in the Elephant Island/South Shetland Islands region in March–early April 2003 is studied here. *Champsocephalus gunnari* took primarily krill. *Chaenocephalus aceratus* fed on krill and fish with some differences found between Elephant Island and the South Shetland Islands. The bulk of the diet of *Chionodraco rastrospinosus* consisted of krill and fish. Diet intensity, however, was low due to the progressing spawning season. *Cryodraco antarcticus* took almost entirely fish while *Pseudochaenichthys georgianus* was a fish feeder at Elephant Island and preyed on krill and fish further south. A large proportion of the stomachs in *C. aceratus* and *C. antarcticus* was found to be empty.

WG-FSA-03/61
Diet of two icefish species from the South Shetland Islands and Elephant Island (*Champsocephalus gunnari* and *Chaenocephalus aceratus*), 2001–2003. H. Flores, *K.-H. Kock, S. Wilhelms and C.D. Jones (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany, *karl-hermann.kock@ish.bfa-fisch.de), 33 pp. (English, unpublished).

The summer diet of two species of icefish (Channichthyidae) from the South Shetland Islands and Elephant Island (*Champsocephalus gunnari* and *Chaenocephalus aceratus*), was investigated from 2001 to 2003. *C. gunnari* fed almost exclusively on krill (*Euphausia superba*) in all years. The importance of other taxa (*Themisto gaudichaudii*, mysids, myctophids) in the diet was negligible. The average feeding rate of *C. gunnari,* inferred from an exponential gastric evacuation model, was between 1.0 and 1.5% of body weight per day. Most of the stomachs of *C. aceratus* were empty. Stomachs with food contained mainly krill, mysids and fish. Among the fish taken, locally abundant species formed the bulk of the diet. They were *Gobionotothen gibberifrons* in 2001, *Lepidonotothen larseni* and *C. gunnari* in 2002 and *L. larseni* in 2003. An ontogenetic shift in feeding preference of *C. aceratus* was observed: fish smaller than 30 cm fed on krill and mysids, while larger animals relied primarily on fish.

WG-FSA-03/62
Validation of sink rates of longlines measured by two different methods. B. Wienecke and G. Robertson (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 13 pp. *CCAMLR Science*, submitted (English).

We measured sink rates of longlines using two different methods: one was string wrapped around bottles and the other electronic time-depth recorders (TDRs). Bottles provided faster sink rates than TDRs. Results obtained from the bottle method were more variable, and hence less reliable, among individual deployments than TDRs requiring repeated deployments on a longline. Sink rates measured to 2 m with bottles averaged 0.13 ± 0.02 m·s^{-1} compared to 0.21 ± 0.07 m·s^{-1} recorded by TDRs. This difference was statistically significant ($t_5 = -2.720$, $P = 0.042$). Measuring sink rates to >10 m proved difficult and unreliable with bottles. Bottles had a higher failure rate than TDRs, for example, with string becoming entangled or bottles vanishing from sight. It is recommended that while bottles may be an appropriate means for measuring sink rates to shallow depths, they should not be used for estimating sink rates to greater depths.

WG-FSA-03/63 Rev. 1
A summary of observations on board longline vessels operating within the CCAMLR Convention Area. CCAMLR Secretariat, 12 pp. (English, unpublished).

WG-FSA-03/64 Rev. 1
Summary of observations on board trawlers operating in the Convention Area during the 2002/03 season. CCAMLR Secretariat, 9 pp. (English, unpublished).

WG-FSA-03/65 Rev. 1
A summary of scientific observations related to Conservation Measures 25-01 (1996), 25-02 (2002) and 25-03 (1999). CCAMLR Secretariat, 10 pp. (English, unpublished).

WG-FSA-03/66
Fine-scale genetic investigation into Patagonian toothfish structure within the west Indian Ocean sector of the Southern Ocean. S.A. Appleyard, R. Williams and R.D. Ward (CSIRO Marine Research, GPO Box 1538, Hobart 7001, Tasmania, Australia), 16 pp. *CCAMLR Science*, submitted (English).

Molecular markers were employed to investigate the fine-scale stock structure of Patagonian toothfish in the west Indian Ocean sector of the Southern Ocean. Four collections of toothfish from the Kerguelen ($n = 1$), Crozet ($n = 1$) and Prince Edward and Marion ($n = 2$) Islands were typed genetically using two fragments of mtDNA and seven nuclear microsatellite loci. MtDNA haplotype diversity was moderate, ranging from 0.331 to 0.343. Allelic variation at the seven microsatellite loci was widespread with observed heterozygosities per locus per collection ranging from 0.000 to 0.900 and allele counts from 1 to 21. There was no evidence for significant mtDNA heterogeneity among the four collections and only weak and inconsistent heterogeneity (based on minor allele frequency differences) at several microsatellite loci among the four collections. Both mtDNA and microsatellite F_{ST} values indicated no population sub-structuring among the collections. Genetic variance estimates of both mtDNA ($\sigma_{ST} = -0.016$) and microsatellites ($\sigma_{ST} = -0.005$) indicated all variation was seen within the toothfish collections. Comparisons with

previously collected genetic data collections from Heard and McDonald Islands (n = 4) also showed a lack of genetic differentiation among the geographic groups, indicating significant gene flow among west Indian Ocean sector fishing locations.

WG-FSA-03/67
Report of the Subgroup on By-catch.
4 pp. (English, unpublished).

WG-FSA-03/68
The Australian exploratory toothfish fishery in CCAMLR Division 58.4.2 in the 2002/03 season. R. Williams (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, dick.williams@antdiv.gov.au), 8 pp. (English, unpublished).

The Australian-flagged longliner *Eldfisk* was approved by CCAMLR to undertake an exploratory fishery for *Dissostichus mawsoni* in Division 58.4.2 in the 2002/03 season. The results of the fishery, involving 140 sets between 5 February and 25 March 2003, are summarised. Total catch from the three SSRUs fished was 111.8 tonnes, of which 88.7% overall was *D. mawsoni*. Principal by-catch species were macrourids (10.2% overall), skates (0.34%) and *Muraenolepis* spp. (0.27%). The length range of *D. mawsoni* caught was between 500 and 1 650 mm total length, and most fish were in gonad state 1 to 3. Length at first maturity is estimated at 1 000 mm for males and 1 300 mm for females. There were marked differences between the SSRUs in catch composition and *D. mawsoni* length frequency.

WG-FSA-03/69
A review of the *Somniousus* (sleeper shark) subgenus and a risk assessment of the sleeper shark by-catch caught in Australian sub-Antarctic fisheries. E.M. van Wijk, R. Williams and J.D. Stevens (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, esmee.vanwijk@aad.gov.au), 18 pp. (English, unpublished).

This review paper summarises available information on the Somniosus (sleeper shark) subgenus, comprising three species: *S. microcephalus, S. pacificus* and *S. antarcticus*. Taxonomy, distribution, life history, biological characteristics and

exploitation by fisheries is discussed. *S. antarcticus* is caught as by-catch in Australian sub-Antarctic fisheries at Heard and McDonald Islands (Division 58.5.2) and Macquarie Island. Based on present by-catch rates, a risk assessment for this species concluded that a serious risk to the stock is unlikely. A tagging program and continued monitoring of by-catch of this species is ongoing.

WG-FSA-03/70
Summary and update of tagging of Patagonian toothfish at Heard and Macquarie Islands. R. Williams (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, dick.williams@antdiv.gov.au), 3 pp. (English, unpublished).

WG-FSA-03/71
Coordinating approaches to incidental mortality arising from fisheries. A.J. Constable, C.R. Davies, A.T. Williamson, R. Williams and E.M. van Wijk (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@aad.gov.au), 10 pp. (English, unpublished).

Globally, by-catch is recognised as one of the most significant issues affecting fisheries management. CCAMLR has adopted an ecosystem approach to managing fisheries which takes into account the direct and indirect impacts of harvesting on non-target taxa. There are many approaches to reduce by-catch. Current approaches to managing by-catch focus on by-catch avoidance and mitigation measures, setting of precautionary catch limits and encouraging research programs that focus on non-target taxa.

Through summarising current approaches to by-catch management and activities across non-target taxa and examining the range of protection afforded to by-catch taxa (seabirds, marine mammals, elasmobranchs, bony fish and benthic invertebrates), it became evident that the application of these approaches is not consistent across by-catch taxa. CCAMLR has developed a comprehensive system for mitigation of incidental seabird mortality, but equivalent measures are not as well developed or implemented for bony fish, benthic invertebrates, and particularly the elasmobranch populations

that are particularly vulnerable to harvesting as they have low fecundity, potentially greater longevity and slow growth rates.

Within CCAMLR, the impetus for action and application of approaches to minimise by-catch needs to be consistent where possible across non-target taxa. A consistent, integrated approach to by-catch could assist the development of measures for vulnerable species such as skates and rays and some fish species. Such an approach would identify and prioritise the areas that need to be addressed based on a preliminary evaluation of risks. This would facilitate agreement on a program of work. Such an approach could provide the basis for a comprehensive and integrated approach by CCAMLR to managing by-catch issues.

WG-FSA-03/72
A possible model of metapopulation structure of *Dissostichus eleginoides* in the southern Indian Ocean. R. Williams, A.J. Constable, C.R. Davies and S.G. Candy (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, dick.williams@antdiv.gov.au), 5 pp. *CCAMLR Science*, submitted (English).

Based on data on movements of Patagonian toothfish derived from tagging experiments and analysis of toothfish DNA from Heard Island and McDonald Islands (HIMI), Kerguelen, Crozet and Marion and Prince Edward Islands regions, a possible metapopulation model for the region is postulated. In this model some or all of the subadult fish at HIMI migrate northwestwards to Kerguelen and Crozet. Larval fish spawned to the northwest of HIMI then return to HIMI in the Antarctic Circumpolar Current. If such a model is valid, this will have significant ramifications for management of fisheries around these islands, which are at present managed independently.

WG-FSA-03/73
Fish and invertebrate by-catch from Australian fisheries for *Dissostichus eleginoides* and *Champsocephalus gunnari* in Division 58.5.2. E.M. van Wijk and R. Williams (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, esmee.vanwijk@aad.gov.au), 25 pp. (English, unpublished).

Currently, three Australian commercial fisheries operate around Heard and McDonald Islands in CCAMLR Division 58.5.2. These comprise a trawl and a longline fishery for Patagonian toothfish (*Dissostichus eleginoides*) and a trawl fishery for mackerel icefish (*Champsocephalus gunnari*). This paper presents available by-catch information for the three fisheries including estimates of total removals by fishing season and ground, and length composition of rajids and macrourids. Preliminary results from a rajid tagging program are also presented. Total removals of by-catch in the trawl fisheries are estimated to be very low. From 1996/97 to 2002/03, a total of 115 tonnes of by-catch was caught in the *D. eleginoides* trawl fishery and 107 tonnes in the *C. gunnari* trawl fishery. These values represent less than 1 and 2% respectively, of the total catch weight (target and non-target species) in each fishery. During the 2002/03 season of the longline fishery for *D. eleginoides*, 23 tonnes of by-catch was caught representing 8% of the total catch. The length range of macrourids and rajids caught in the trawl and longline fisheries is discussed and compared to the length range of the population sampled by research surveys. Eight *Bathyraja eatonii* have been recaptured to date, resulting in a recapture rate of 1.9% for this species. Tagged rajids exhibit little movement between release and recapture with distances travelled ranging between 1 and 7 n miles. The time at liberty varied between 208 and 823 days, with most skates at liberty for approximately one year. Estimates of growth were very low, with average increments of 12 mm per year in total length, 17 mm per year in disk width and 0.1 kg per year in weight. The results presented here indicate that this species is likely to be very slow growing and/or that the trauma of capture results in at least one year of very slow growth. Growth estimates were lower than those estimated for similar-sized species from the Northern Hemisphere.

WG-FSA-03/74
Mackerel icefish (*Champsocephalus gunnari*) in the diet of upper trophic level predators at South Georgia: implications for fisheries management. K. Reid, S. Hill and T. Diniz (British Antarctic

Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET United Kingdom, k.reid@bas.ac.uk), 33 pp. (English, unpublished).

Mackerel icefish (*Champsocephalus gunnari* Lönnberg) is an important component of the ecosystem at South Georgia where its diet is dominated by Antarctic krill (*Euphausia superba*). It is an important prey species for a number of upper trophic level predators and is the target of commercial fisheries. Data on the frequency and size structure of *C. gunnari* in the diet of Antarctic fur seals (*Arctocephalus gazella*) and gentoo penguins (*Pygoscelis papua*) at Bird Island, South Georgia, from 1991 to 2002, were used to examine the trophic interactions and evaluate the potential impact of predators on the *C. gunnari* population. *C. gunnari* occurred in 20–40% of scats from Antarctic fur seals and comprised 48% of the diet by mass of gentoo penguins. The length-frequency distributions of *C. gunnari* indicated a dominant mode at 180–200 mm total length (1+ age class), with strong cohorts entering the population in 1993, 1996, 1999 and 2001. A recruitment index based on the contribution by mass of the 1+ age-class in the diet of gentoo penguins indicated a higher degree of variability in recruitment than was considered previously. Estimates of consumption of *C. gunnari* by Antarctic fur seals and gentoo penguins (c. 138 000 tonnes per annum) exceed standing stock estimates (17–67 000 tonnes). A deterministic population model of *C. gunnari* from 1991 to 2002, using a variable mortality rate scaled by the inverse of krill abundance, replicated the fluctuations in *C. gunnari* shown by trawl surveys. Changes in the South Georgia ecosystem over the past two decades may have increased the level of predator consumption of *C. gunnari* providing a potential ecosystem-based explanation for the lack of a recovery of pre-exploitation population size.

WG-FSA-03/75 Rev. 1
Otolith microstructure of juvenile fish, the first annulus radius and duration of the pelagic stage in mackerel icefish (*Champsocephalus gunnari*) (Channichthyidae) in the South Georgia area. L.V. Shcherbich (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, atlant@baltnet.ru), 11 pp. *CCAMLR Science*, submitted (English).

On the basis of the results of the acoustic trawl survey in February–March 2002, an analysis of the microstructure of otoliths of juvenile icefish 5.5–13.3 cm in length was carried out. The fish studied represent a mixture of two year classes, namely 1999/2000 and 2000/01. The mean width of the daily growth zone in the first 100 days of fish life was 6 μk at a fish length of 4 cm. By the 200th day the daily growth zone was 4.2 μk at fish length 7.2 cm, by the 300th day, 3.5μk at fish length 11 cm, by the 400th day, 3.1 μk at fish length of up to 11.8 cm, by the 500th day, 2.8 μk at fish length of up to 12.5 cm. The resulting age–length ratio can be used to separate adjacent year classes during juvenile fish surveys. The length of the young-of-the-year varies within a broad range as a result of the prolonged spawning period and by the end of the first summer of fish life approaches 5.5–10.4 cm. This corresponds to an age of 120–250 days. The length of 1-year-old fish (1+) by the end of the second summer of fish life is 12.5–13.3 cm, at an age of 477–533 days, and the radius of the first annulus is 0.7–1.3 mm. It was revealed that the period of egg incubation and larvae hatching of the year class 2000/01 was about four months.

WG-FSA-03/76
***In situ* observations of the scavenging fauna of the South Georgia slope.** M.A. Collins, I. Everson, R. Patterson, P.M. Bagley, C. Yau, M. Belchier and S. Hawkins (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 17 pp. (English, unpublished).

The scavenging fauna of the South Georgia slope was investigated from 41 baited camera deployments at depths of 471–2 235 m during research cruises in September 1997 and January 2000 and 2003. The scavenging fauna was dominated by lithodid crabs, with Patagonian toothfish seen at most deployments. Other scavenging fauna included grenadiers (*Macrourus* spp.), morids and skates. The data indicate toothfish are absent from depths greater than 1 800 m and

temperatures less than 1.3°C. The arrival rate of crabs at the bait can be used to estimate density, but the behaviour of toothfish precludes this approach to estimating their density.

WG-FSA-03/77
Assessment of stone crab (Lithodidae) density on the South Georgia slope using baited video cameras. M.A. Collins, C. Yau, F. Guillfoyle, P.M. Bagley, I. Everson, I.G. Priede and D.J. Agnew. *ICES J. Mar. Sci.*, 59: 370–379. (English).

During January 2000 a baited video camera system was deployed 15 times at depths of 719–1 518 m around the sub-Antarctic island of South Georgia. Four species of lithodid (Anomura: Lithodidae) crab (*Paralomis formosa, P. spinosissima, Lithodes* sp. and *Neolithodes diomedeae)* were attracted to the baits of which *Paralomis formosa* was the most abundant. Using arrival rate at baits, predictions of odour plume size and observations of walking speed, the abundance of the stone crab *Paralomis formosa* was estimated. Numbers of crabs increased rapidly following bait emplacement, with total numbers observed in the 4.9 m^2 field of view exceeding 50 within 200 minutes on three occasions. Current speed was used to predict the area of the odour plume, and by integrating the area to account for scavenger speed the effective area of the odour plume was obtained. The density of crabs, estimated from the increase in crab numbers per unit area of odour plume, averaged 8 313 individuals km^{-2} (range 1 100–25 600). Density was not significantly correlated with depth, temperature or current speed and variability was attributed to substrate form.

WG-FSA-03/78
Data and parameter values from the previous year that might be used for assessments at WG-FSA-2003. I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, i.everson@bas.ac.uk), 7 pp. (English, unpublished).

WG-FSA-03/79
Incidental mortality of birds on trawl vessels fishing for icefish in Subarea 48.3. J. Hooper, D.J. Agnew and I. Everson (Marine Resources Assessment Group,

47 Prince's Gate, London SW7 2QA, United Kingdom, j.hooper@imperial.ac.uk), 19 pp. (English, unpublished), (abstract not available).

WG-FSA-03/80
Determining toothfish otolith structure using oxytetracycline at South Georgia – a preliminary report. M.G. Purves, M. Belchier, D.J. Agnew, G. Moreno and T.R. Marlow (Marine Resources Assessment Group, 47 Prince's Gate, London SW7 2QA, United Kingdom, m.purves@ mrag.co.uk), 12 pp. (English, unpublished).

A tagging program for Patagonian toothfish (*Dissostichus eleginoides*) was initiated at South Georgia and Shag Rocks early in 2000. A total of 2 486 fish have been tagged and released during trawl surveys, experimental pot fishing and longline fishing. Some of the fish tagged on longliners in 2002 were injected with oxytetracycline (OTC) to mark the otoliths for age-validation purposes. The otoliths of some of these chemically marked recaptures of the 2003 season were examined and the preliminary results are presented here. Two fish marked with strontiumchloride (SrCl$_2$) during the 2002 trawl survey were also recaptured. From recaptures of chemically marked fish our study seems to indicate that the dosages used for the injection of both OTC and SrCl$_2$ did not impact negatively on their survival rate.

WG-FSA-03/81
Brief report on the sink rates of Spanish system longlines with special reference to the line-weighting regimes of Agnew et al. (2000). G. Robertson, T.A. Reid and B.J. Sullivan (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, graham.robertson@ aad.gov.au), 6 pp. (English, unpublished).

A line sink rate trial was conducted on a Spanish-system vessel to estimate the sink rates of the line-weighting regimes of Agnew et al. (2000) so that Agnew's seabird mortality levels could be interpreted in the context of line sink rates. Lines with 4.25 kg/40 m, 8.5 kg/40 m and 12.75 kg/40 m sank to 20 m depth at 0.4 m/s, 0.54 m/s and 0.68 m/s respectively. Juxtaposing those rates on Agnew's seabird mortality estimates for the three weighting regimes suggests that even sink rates as high as

0.4 and 0.5 m/s might still have potential to kill seabirds. Methodological nuances aside, the results suggest there is still much to be learnt about the relationship between longline sink rate and seabird mortality in demersal longline fisheries.

WG-FSA-03/82
The use of genetic markers to identify the species and provenance of albatrosses among seabird by-catch. M.C. Double, C. Abbott and R. Alderman (School of Botany and Zoology, Australian National University, Canberra ACT 0200, Australia, mike.double@anu.edu.au), 10 pp. (English, unpublished).

This paper draws attention to a suite of recently developed genetic tests for the accurate identification of albatross species. At present, genetic tests are available for 18 of the 24 albatross species. The tests are simple, can be completed with minimal cost and laboratory infrastructure, and have recently been employed to examine the species composition of albatross by-catch from South Georgia, New Zealand, Australian and South African fisheries. In this paper the current tests available are summarised, those species that cannot yet be distinguished are highlighted, the recent application of these genetic tests is discussed, and the feasibility of developing genetic tests that can identify the island of origin for albatross specimens is reviewed.

WG-FSA-03/83
Proposal for a workshop to examine the influence of Southern Ocean physical dynamics on the population structure and movement of *Dissostichus eleginoides* and *D. mawsoni.* J.R. Ashford, E. Hofmann, P. Smith and P. Gaffney (Center for Quantitative Fisheries Ecology, Old Dominion University, Room 102, Technology Building, 4608 Hampton Boulevard, Norfolk, VA 23529, USA, jashford@odu.edu), 9 pp. (English, unpublished).

WG-FSA-03/84
Is population structure of Patagonian toothfish (*Dissostichus eleginoides*) determined by the Antarctic Circumpolar Current? J.R. Ashford, C.M. Jones, E. Hofmann, I. Everson and G. Duhamel (Center for Quantitative Fisheries Ecology, Old Dominion University, Room 102,

Technology Building, 4608 Hampton Boulevard, Norfolk, VA 23529, USA, jashford@odu.edu), 38 pp. (English, unpublished).

Water transported by the Antarctic Circumpolar Current (ACC) in the Southern Ocean may provide opportunities for Patagonian toothfish (*Dissostichus eleginoides*) to move downstream between island groups with little energetic cost, and may constrain movement in other directions, influencing population structure and richness. To test whether toothfish stocks were connected or segregated, we used an integrated experimental design to compare age-at-length data sampled at similar times from longline fisheries off the southern South American continent around the Falkland Islands north of the sub-Antarctic Front of the ACC, and off Kerguelen and South Georgia Islands, situated respectively in the southern Indian and Atlantic Oceans to the south of the Polar Front. Von Bertalanffy models representing segregation and coupling between management areas to the data were fitted and tested between the models using a likelihood method. Toothfish showed significant differences in von Bertalanffy parameters between the Falkland Islands and both South Georgia and Kerguelen, but no differences between South Georgia and Kerguelen. This evidence suggests that, consistent with the dynamic physical structure of the ACC, toothfish off the Falkland Islands are segregated from toothfish caught in the other two management areas, but that toothfish stocks at South Georgia and Kerguelen may be connected. Taken with the published genetic data, this evidence strongly suggests that toothfish population structure is related to the physical structure of the ACC and its fronts; that some toothfish populations may be connected between the major Southern Ocean basins; and that consequently, changes in toothfish population dynamics within one management area may have broader impacts throughout the Southern Ocean.

WG-FSA-03/85
Sampling toothfish from longlines with unequal probabilities. J.R. Ashford (Center for Quantitative Fisheries Ecology, Old Dominion University, Room 102, Technology Building, 4608 Hampton

Boulevard, Norfolk, VA 23529, USA, jashford@odu.edu), 5 pp. (English, unpublished).

To obtain a representative sample of the catch taken by toothfish longliners, CCAMLR observers are recommended to sample a quota of the first 30 fish that are caught during a sampling session. Since toothfish are often aggregated on a line, this means that fish within aggregations are sampled with less catch effort than those outside; or more generally, sampling effort is applied in inverse proportion to toothfish density on the line. The present recommendation therefore indicates sampling with unequal probabilities which, if unaccounted for, can lead to serious biases in estimates of population vital rates. To resolve this, either the probabilities need to be incorporated in the analysis of sampling data, or sampling effort should be proportional to catch effort. As vessels generally record the number of baskets taken while hauling a line, observers can use this to establish a point at which to start a session. Because there is little evidence of a consistent trend in fish sampled over a line, it does not particularly matter if an observer starts sampling before or after the correct basket arrives; but, preferably, the observer should start as close as feasible, and not be consistently late or early.

WG-FSA-03/86 Rev. 1
Preliminary results from a study examining spatial structure and connectivity in Patagonian toothfish (*Dissostichus eleginoides*) in the South Atlantic sector of the Southern Ocean. J.R. Ashford, A. Arkhipkin and C.M. Jones (Center for Quantitative Fisheries Ecology, Old Dominion University, Room 102, Technology Building, 4608 Hampton Boulevard, Norfolk, VA 23529, USA, jashford@ odu.edu), 9 pp. (English, unpublished).

Using the high-resolution Laser-based Inductively-Coupled Plasma Mass Spectrometry (LA-ICPMS) at Old Dominion University, this study sampled the edge of otoliths from Patagonian toothfish (*Dissostichus eleginoides*), and examined whether the elemental signatures could discriminate between geographic locations along the Scotia Arc and along the eastern South American continental shelf near the Falkland Islands. Furthermore, the elemental signatures of material in the otolith nuclei,

formed during the early life history were examined: similar nucleus signatures can be expected between fish which were spawned on the same spawning ground, even if the samples have subsequently been taken from different locations. It was found that signatures on the otolith edge of fish from South Georgia and Shag Rocks showed distributions characterised by lower levels of Mn/Ca than samples from the Falkland Islands Outer Conservation Zone (FOCZ). Signatures from the nucleus showed separation between the fish from South Georgia and Shag Rocks, and fish caught further west, implying a stock boundary. Although fish caught off the eastern North Scotia Ridge showed nucleus signatures similar to FOCZ fish, the distribution of their edge signatures was similar to South Georgia fish, suggesting that the elemental signature is due to an environmental effect rather than a genetic one.

WG-FSA-03/87
Estimating the age of large numbers of *Dissostichus eleginoides* caught off Kerguelen. J.R. Ashford, G. Duhamel, C.M. Jones and S. Bobko (Center for Quantitative Fisheries Ecology, Old Dominion University, Room 102, Technology Building, 4608 Hampton Boulevard, Norfolk, VA 23529, USA, jashford@ odu.edu), 16 pp. *CCAMLR Science*, submitted (English), abstract not available.

WG-FSA-03/88
Can trace element signatures in the otoliths of *Dissostichus eleginoides* record capture size? J.R. Ashford and C.M. Jones (Center for Quantitative Fisheries Ecology, Old Dominion University, Room 102, Technology Building, 4608 Hampton Boulevard, Norfolk, VA 23529, USA, jashford@odu.edu), 20 pp. (English, unpublished).

The elemental structure of growth increments in the otoliths of fish reflects the composition of water passing across the gills: as a result, elemental signatures can potentially be used to reconstruct the environmental history experienced by fish. To test whether the otolith elemental signatures of Patagonian toothfish (*Dissostichus eleginoides)* can discriminate spatial differences, comparisons were made of signatures from the outer edges (which

are laid down during the interval leading to capture) of otoliths taken from toothfish sampled from management areas off southern Chile, the Falkland Islands, South Georgia, Kerguelen and Macquarie Islands. Edge Ba/Ca values were higher for toothfish caught south of the Sub-Antarctic Front in 1996 and 1997 compared to those caught off the South American continent, whereas Mn/Ca values were lower. Edge signatures also showed differences between samples taken south of the Sub-Antarctic Front, both across the Polar Front and across ocean basins. A sample taken west of South Georgia in 1998 showed similarities to the samples taken in 1996 and 1997 off South America, but very different Mg/Ca concentrations from all other samples. With further development, otolith elemental signatures show promise for identifying the site of capture of sampled toothfish, and for use as retrospective spatial markers to trace toothfish population structure and movement.

WG-FSA-03/89
Monitoring of relative abundance of fjord *Notothenia rossii*, *Gobionotothen gibberifrons* and *Notothenia coriiceps* at Potter Cove, South Shetland Islands, from 2000 to 2003. E. Barrera-Oro, E. Marschoff, R. Casaux and B. Gonzalez (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina, ebarreraoro@dna.gov.ar), 14 pp. (English, unpublished).

The monitoring program of demersal fish at inshore sites of the South Shetland Islands has continued at Potter Cove from 2000 to 2003, covering a continuous sampling period of 20 years, and in Harmony Cove, Nelson Island, in the austral summers from 2001 to 2003. The decline in trammel net catches of fjord fishes of the species *Notothenia rossii* and *Gobionotothen gibberifrons* in relation to the non-commercially fished *N. coriiceps*, which was previously reported for the period from 1983 to 1999, is still evident. At Potter Cove, higher catches of *N. rossii* were obtained from 1991 to 2000, but the actual levels of relative abundance of this species and of *G. gibberifrons* are well below those found in the early 1980s. At Harmony Cove, the relative abundance of *N. rossii* showed an increase in 2002 and 2003, whereas *G. gibberifrons* was absent in the catches. No recovery of the stocks

of these two fish species was observed, more than two decades after the end of the commercial fishery. However, the increase observed in the catches of *N. rossii* in some years since 1997 might be indicative of events of higher recruitment, not yet confirmed by the offshore scientific surveys carried out in the region. The results are consistent with diet information of the piscivorous Antarctic shag (*Phalacrocorax bransfieldensis*) in the South Shetland/Antarctic Peninsula area obtained from the early 1990s.

WG-FSA-03/90
A tagging protocol for toothfish (*Dissostichus* spp.) in the Ross Sea. N.W.McL. Smith and K.J. Sullivan (Ministry of Fisheries, PO Box 1020, Wellington, New Zealand, smithn@fish.govt.nz), 8 pp. (English, unpublished).

WG-FSA-03/91
Seabird mortality and the Falkland Islands trawling fleet. B.J. Sullivan, T.A. Reid, L. Bugoni and A.D. Black (Seabirds at-Sea Team, Falklands Conservation, Jetty Centre, Stanley, Falkland Islands, seabirds@horizon.co.fk), 23 pp. (English, unpublished).

Specifically tasked seabird observers recorded seabird interactions during shooting, trawling and hauling operations for 157 days on board finfish trawlers in the Falkland Islands in 2002/03. It is estimated that more than 1 500 seabirds, predominantly black-browed albatross (*Thalassarche melanophris*), were killed by finfish trawlers during this period. Significant levels of mortality were also recorded on the Patagonian shelf, north of the islands. Birds were killed after being dragged under water by the warp cable, while feeding on factory discharge at the stern of the vessel. An unknown proportion of these birds become impaled on a splice in the cable, which was situated on average around 50–100 m from the surface of the water, and are subsequently hauled on board. In over 600 observed hauls from 2001 to 2003 no birds were observed to become impaled on splices during hauling operations.

WG-FSA-03/92
Longliners, black-browed albatross mortality and bait scavenging in the

Falkland Islands: what is the relationship? T.A. Reid and B.J. Sullivan (Seabirds at-Sea Team, Falklands Conservation, Jetty Centre, Stanley, Falkland Islands, seabirds@horizon.co.fk), 30 pp. (English, unpublished).

The rate of foraging attempts by black-browed albatrosses on baited hooks during Spanish-system (demersal) longline setting operations, and a range of environmental and operational variables were used to investigate the relationship between their foraging behaviour and their mortality level. Logistic regression highlighted that a complex range of environmental and operational variables and black-browed albatross abundance combined to determine their mortality level. Our results suggest that, examined over a relatively short time period with minimal environmental variation, the rate of black-browed albatross foraging attempts during line setting significantly affects their level of mortality. However, as a range of variables influence mortality, until targeted experimental studies are conducted, we suggest that caution should be exercised using the rate of black-browed albatross foraging attempts as an index of their mortality.

WG-FSA-03/93
United States research under way on seabirds vulnerable to fisheries interactions. Delegation of the USA (compiled by K.S. Rivera, National Marine Fisheries Service, Alaska Region, PO Box 21668, Juneau, AK 99802 USA, kim.rivera@ noaa.gov), 11 pp. (English, unpublished).

WG-FSA-03/94
2003 Report of the CCAMLR Otolith Network. 11 pp. (English, unpublished).

WG-FSA-03/95
Operational interactions between cetaceans and the Patagonian toothfish (*Dissostichus eleginoides*) industrial fishery off Southern Chile. R. Hucke-Gaete, C.A. Moreno and J.A. Arata (Instituto de Ecología y Evolución, Universidad Austral de Chile, Casilla 567, Valdivia, Chile, rhuckeg@telsur.cl), 15 pp. *CCAMLR Science*, submitted (English).

Operational interactions between marine mammals and the Patagonian toothfish (*Dissostichus eleginoides*) fishery were assessed in southern Chile through seven surveys with observers on board industrial vessels between April 2002 and March 2003. Sperm whales (*Physeter macrocephalus*) occurred in higher frequency than any other species during fishing operations. In 60% of all monitored sets sperm whales were present, while orcas (*Orcinus orca*) were found in only 10% of these. When cetaceans were present, evidence of damaged catch included lips, heads and trunks and a total of 121 lips, 16 heads and three trunks were recovered. Mean rate of predation was 3% (±2% CI 95%; $n = 180$ sets) and ranged between 0% and 100%. Considering that in 153 (84%) of the effectively monitored sets no interaction whatsoever was recorded and that the mode and median of the predation rate was 0, the global impact of cetaceans over the fishing yield is considered to be low. When mixed sightings of orcas and sperm whales were encountered ($n = 12$) the rate of predation decreased to 0%. When detecting orca presence, sperm whales modified their surface behaviour, grouping into tight parallel formations. This suggests that orcas prefer attacking aggregated sperm whales instead of the line. High sperm whale densities were found associated to different hotspots which had high fishing yields. This relationship tends to support the hypothesis that the richest fishing grounds are also traditional feeding grounds for sperm whales. Monetary loss associated with operational interactions associated with predation reach US$92.684 (CI 95% US$47.302–153.745) for the whole fleet, with a mean loss per set of US$138 (CI 95% US$74.76–249.3).

WG-FSA-03/96
Integrating CPUE with the GY model: examination of the effects of shortening the CPUE series and incorporating elements of uncertainty into the *Dissostichus eleginoides* assessment of Subarea 48.3. I.R. Ball, S.G. Candy and A.J. Constable (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, ian.ball@ aad.gov.au), 15 pp. *CCAMLR Science*, submitted (English).

This year the Subgroup on Assessment Methods (SAM) requested that WG-FSA consider whether a shorter CPUE time

series would be preferable for use in its annual assessments. (WG-FSA-03/40, paragraph 2.27). This paper explores some of the consequences of shortening the dataset in the application of the usual assessment method. In addition, the incorporation of uncertainty in the standardised CPUE series into the method of Kirkwood and Constable (2000) via Monte Carlo simulations of the CPUE series is investigated. Truncation of the standardised series from WG-FSA-02 results in only slight modification to the median escapement but will generally diminish the probability of depletion as the dataset is truncated towards the more recent years. The use of the standardised series from the GLMM of Candy (2003) shows a more pronounced consequence of reducing the time series, such that the escapement level increases while the depletion probability decreases as the time series is reduced to recent years. In contrast, the explicit incorporation of uncertainties in the CPUE series in the overall assessment shows that truncation of the CPUE series could have a much greater effect on the final assessment, depending on the model used. These results indicate that the procedure for incorporating CPUE into the assessment process needs to be generally evaluated as to the consequences of its use in providing assessments that will meet the objectives of CCAMLR.

WG-FSA-03/97
Progress on the application of an Age-Structured Production Model fitted to commercial catch-rate and catch-at-length data to assess the toothfish (*Dissostichus eleginoides*) resource in the Prince Edward Island vicinity. A. Brandão and D.S. Butterworth (Marine Resource Assessment and Management Group (MARAM), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa), 30 pp. (English, unpublished).

The Age-Structured Production Model (ASPM) presented to previous meetings is refined to allow the estimation of a selectivity-at-age function that decreases at larger ages. This is, in particular, to accommodate the view of the August 2003 meeting of the Subgroup on Assessment

Methods that 0.2 yr^{-1} is likely the largest value of natural mortality (*M*) that is plausible for toothfish. Catch, catch-at-length and GLM standardised CPUE data are all extended for one further year. Despite model refinements, the CPUE data and catch-at-length data remain sharply inconsistent within the modelling framework considered. The former suggests the resource to be heavily depleted, whereas the latter suggests quite the reverse. Priority areas for further investigation to attempt to resolve this inconsistency are suggested. In the meantime, based on a cautious interpretation of projections over the wide range of current stock status that can be argued from these analyses, it is suggested that annual catch levels should not exceed a few hundred tonnes.

WG-FSA-03/98
Analysis of the operations of the longline fleet targeting Patagonian toothfish (*Dissostichus eleginoides*) in the South Georgia subarea (48.3) in 1989–2003. N.V. Kokorin and A.F. Petrov (VNIRO, 17 V. Krasnoselskaya, Moscow 107140, Russia, antarctica@vniro.ru), 5 pp. (English, unpublished).

The main characteristics of Patagonian toothfish (*Dissostichus eleginoides*) catch dynamics off the South Georgia Island and Shag Rocks (Subarea 48.3) for the 1989–2003 period are described. From data on the intensity of fleet operation in the subarea, it was confirmed that there has been a decrease in catches both for 1 000 hooks and vessel/day. The given objective long-term data evidenced a substantial decrease in catch per unit value, highlighting the need to pay more attention to the assessment of the toothfish population in this area of traditional fishing and to a more precautionary approach to the limitation of catches.

WG-FSA-03/99
Patagonian toothfish maturity in Subarea 48.3 (South Georgia and Shag Rocks). K.V. Shust and A.N. Kozlov (VNIRO, 17 V. Krasnoselskaya, Moscow 107140, Russia), 10 pp. (English, unpublished).

Patagonian toothfish size composition in Subarea 48.3 was studied to determine size-at-maturity for male and female

individuals. A considerable amount of the primary data indicated that male Patagonian toothfish attained maturity at a smaller size than females. Half the males attained maturity at a length of 73–75 cm, while females matured at 94–96 cm. A toothfish maturity ogive was drawn and compared with size composition in catches of recent years to show that the current longline fishery has been taking large amounts of immature and newly matured fish <90 cm long. Obviously the large quantity of immature Patagonian toothfish taken in catches has negatively affected the population status in this most productive traditional fishing area. It is suggested that conservation measures, namely the introduction of a minimum size for longline catches of toothfish, could considerably reduce the negative effects of overfishing.

WG-FSA-03/100
The efficacy of video-based electronic monitoring technology for at-sea monitoring of the halibut longline fishery. Prepared for the Pacific Halibut Management Association and the Pacific Scientific Advice Review Committee (Fisheries and Oceans Canada) by H. McElderry, J. Schrader and J. Illingworth (Archipelago Marine Research Ltd, Victoria, BC, Canada). 75 pp. (English, unpublished).

This project involved the large-scale deployment of electronic monitoring (EM) systems on the 2002 British Columbia halibut longline fishery to evaluate the feasibility of EM as an alternative to observer-based at-sea monitoring. EM systems were deployed on 59 regular halibut fishing trips involving 19 fishing vessels, providing about 700 usable sets, 1 000 hours of imagery and 350 000 observed hooks. Catch items identified by EM represented over 60 fish, invertebrate or seabird species or species groupings, and the 15 most abundant fish species accounted for 98% of the catch. Data from fishing trips where EM and observers were deployed (about 55% of trips) were compared by total overall catch, total catch by set, and catch by individual hook. Overall EM and observer catch estimates agreed within 2%, and individual identifications by hook agreed in over 90% of the catch records. EM reliably (i.e. accuracy within 10%) distinguished 13 species that represented 97% of the halibut fishery

catch. Some species, particularly non-distinct forms, were not identified well by EM. Sample sizes were too small among half the species for determination of an EM species identification capability. Close agreement between EM and observer was also evident with species utilisation determination (i.e. kept or discarded) and time, location and depth at set start and finish.

The results of this study demonstrated that EM is a promising tool for at-sea monitoring applications. EM and observer program differ in many ways in terms of data collection capabilities and program design issues. While the utility of this new technology will depend on the specific fishery monitoring objectives, the substantially lower cost and broader fleet suitability of EM over observers makes this an attractive option. The authors suggest that a combined EM-based monitoring for the halibut fishery should be continued using two approaches: an integrated EM-observer program using both methods in a complimentary fashion to achieve fleet sampling objectives; and using EM and an electronic fishing log as an at-sea monitoring audit tool. Further testing using combined EM and observers on the same trip should occur in the 'ZN' fishery to improve EM rockfish identification capability. The authors also recommend that Fisheries and Oceans more comprehensively define the at-sea monitoring objectives of the halibut fishery and strengthen their support for EM-based monitoring approaches to further the development of this technology.

WG-FSA-03/101
Conservation status of seabirds at risk from longline fishing in the Convention Area. (from BirdLife International 2003 *BirdLife's online World Bird Database: the site for bird conservation.* Version 2.0. Cambridge, UK: BirdLife International. Available: www.birdlife.org). (English).

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