PREFACE

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

This volume contains abstracts of scientific papers presented in 1999. It corresponds to the Eighteenth Meetings of the CCAMLR Commission and Scientific Committee and is published only in English.

There are four categories of papers:

(i) scientific papers published elsewhere, for which the full reference and published abstract are given;

(ii) scientific papers submitted for publication, i.e. in *CCAMLR Science* or elsewhere, which are listed as 'submitted' or 'in press' with details of the publisher, if known;

(iii) scientific papers not intended for publication, which are listed as 'unpublished'; and

(iv) supplementary scientific papers (i.e. listing of data submitted, summary of analyses performed, etc.) not intended for publication, for which the title alone is listed.

All abstracts are listed in groups by respective CCAMLR bodies at meetings of which these papers were submitted. Each abstract is preceded with a unique CCAMLR document number, e.g. SC-CAMLR-XVIII/BG/11 (background document number 11 submitted at the Eighteenth Meeting of the Scientific Committee); or WG-EMM-99/8 (document number 8 submitted at the 1999 meeting of the Working Group on Ecosystem Monitoring and Management).

Unpublished papers must not be cited without written permission of the author(s). Addresses of principal authors are given for this purpose.

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CCAMLR-XVIII/BG/6
Beach debris survey – Main Bay, Bird Island, South Georgia, 1997/98. I.J. Staniland (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 15 pp. (English, unpublished).

The eighth year of surveys of beached man-made debris at Bird Island, South Georgia, revealed a total of 430 items, 49% more than the total of 289 items in 1996/97. The increase in the winter (April to September) total was 10%, from 109 items in 1996/97 to 120 items in 1997/98, both of which were considerably less than the winter totals for the previous five years of collections. The number of items collected in the summer was 310, an increase of 72% from the 1996/97 total of 180. Nylon line, identical to that attached to longline gear accounted for 88% of items, nearly all of which clearly came from fishing vessels. The lower levels of debris collected in the winter months is a good sign that increased monitoring in the South Georgia longline fishery may have reduced the amount of man-made debris originating from these vessels. The increased totals of summer debris are a cause for concern and suggest that CCAMLR needs to intensify its campaign to reduce the amount of man-made debris being jettisoned into the Southern Ocean.

CCAMLR-XVIII/BG/7
Beach debris survey – Signy Island, South Orkney Islands, 1998/99. A.S. Lynnes and J.R. Shears (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 18 pp. (English, unpublished).

The ninth annual beach debris survey was carried out at Signy Island, South Orkney Islands, during the 1998/99 austral summer. Debris was cleared each month between November and March from three study beaches. The debris was counted, measured and classified by type, material, mass and size categories. A total of 83 items weighing 12.96 kg was collected. The number of items recovered was the highest since 1996/97 and showed an increase of 86% compared to the previous year. The total mass of items recovered was more than double the mass of items in 1997/98. Classifying the material by source revealed that 40% had come from ships or fishing vessels in the form of packaging bands, fishing nets and foam packing material. The latter accounted for 58% of items small enough to be ingested by seals and seabirds. The proportion of plastic items remained high, accounting for 45% of all items found. Despite the ban on the use of packaging bands aboard fishing vessels, brought into force by CCAMLR in 1995/96, the number of packaging bands recovered remained the same as in the previous season. The fact that the number of bands did not increase may indicate that the regulations are working and that their continued recovery from beaches at Signy may be partly to do with their longevity in the marine environment. The increase in debris reported at Signy Island in 1998/99 highlights the need for continued monitoring and increased effort to ensure that vessels are aware of, and comply with, regulations prohibiting the disposal of debris at sea.

CCAMLR-XVIII/BG/18
Marine debris surveys carried out in the 1998/99 season by Uruguay on the beaches of scientific stations Artigas (BCAA, Drake Passage, King George Island) and Ruperto Echilibehety (ECARE, Antarctic Peninsula). Uruguay, 6 pp. (Spanish, unpublished).

As part of Uruguay's contribution to the conservation of the Southern Ocean, under the Antarctic Treaty in general and the CCAMLR Convention in particular, its monitoring of beached debris has continued at the Artigas Station (BCAA), and this season has extended to cover the coast of the Drake Passage (north of King George/ 25 de Mayo Island) and beaches near the Ruperto Echilibehety Station (ECARE) (Hope Bay, Antarctic Peninsula).

During the 1998/99 summer season, items found awash on the beaches of BCAA and ECARE were collected, counted and classified. Manufacturers labels and

any other identifying traits on the items were recorded, in order to ascertain their origin. The items were collected primarily in:

(i) the area between the high tide and low tide marks, from Collins Glacier to the southwest of BCAA to the highland coastal regions southeast of the base;

(ii) the Drake Passage area between the edge of Collins Glacier and Nedel Point at Fildes Peninsula (the northern coastal area of King George Island); and

(iii) the coastal margin adjacent to ECARE.

CCAMLR-XVIII/BG/22
Beach litter accumulation at sub-Antarctic Marion Island – 1998/99. M.G.W. Jones and D.C. Nel (Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7701, South Africa), 14 pp. (English, unpublished).

As part of an ongoing study on sub-Antarctic Marion Island, we report on beach litter accumulation for the year May 1998 to April 1999. The amount of debris found in both annual and monthly accumulation studies showed a substantial decrease from the peak recorded during the 1997/98 season, but is still double that recorded during 1984. This recent decrease was mainly due to a decrease in the number and proportion of styrofoam items. Plastic items were most numerous this season, while styrofoam dominated for the previous two years. Items originating from South America (Argentina in particular) were the most prevalent, followed by items with oriental script. Monthly accumulation studies showed a strong seasonal effect, with most items arriving during the winter. Litter retention studies showed that most items (60%) collected during the annual survey were less than two months old. This strong seasonal effect and a high turnover rate highlights the dangers of single annual surveys.

CCAMLR-XVIII/BG/39
Synthesis of marine debris survey at Cape Shirreff, Livingston Island, during the Antarctic season 1998/99. D. Torres, D. Jorquera, V. Vallejos and J. Acevedo (Departmento Científico, Instituto Antártico Chileno, Luis Thayer Ojeda 814, Correo 9, Providencia, Santiago, Chile), 2 pp. (English, unpublished).

A new survey on marine debris was carried out during the 1998/99 Antarctic season at Cape Shirreff SSSI No. 32, including the CEMP site, as part of established monitoring activities. 1 450 articles, mainly plastic, glass, metal and paper items, were collected in 12 jute bags. As had occurred in previous seasons, plastic waste was predominant. The total weight was 69.5 kg, of which 57.2 kg was plastic material (82.4% of the total weight).

During the last five Antarctic seasons, 14 pieces of plastic garbage showing signs of having been processed in incinerators were collected, giving reiterative evidence of this kind of practice on board some ships. For the third time, expanded polystyrene (PE) was found to be abundant (38.2% of the total plastic pieces = 1 364), most of it intruded with green algae which indicates that it had been drifting in the Southern Ocean for a relatively long time.

During this season, 167 packaging bands were recorded, of which 22 (13.2%) were transparent and therefore difficult to see when in the water. From our point of view, this could be a possible strategy used by some illegal fishing boats, and possibly by some other vessels too, in order to continue to use these kinds of packaging bands and discard them at sea, assuming that this material might be overlooked by people and animals. In relation to *Arctocephalus gazella*, it is important to note that no entangled animals were seen during this season; nevertheless, three sub-adults and one adult male were observed to have deep marks around their necks, possibly caused by plastic bands or net pieces which may have been removed elsewhere by scientists, spontaneously lost or fortuitously cut.

It was not possible this season to remove a 6 m long rope from the nests of four pairs of *Pygoscelis antarctica* without disturbing or destroying the nests, because the rope was deeply buried under the ground on which the nests were built.

Scientific Committee

SC-CAMLR-XVIII/BG/5
Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Bird Island, South Georgia, during the 1998 winter and 1998/99 pup-rearing season. N.J. Aspey and I.J. Staniland (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 20 pp. (English, unpublished).

Results of the survey of entanglements of Antarctic fur seals at Bird Island, South Georgia, for the ninth consecutive winter (1998) and eleventh consecutive summer (1998/99) are reported here.

The number of entangled seals observed in the winter (13) represented an 86% increase on the 1997 winter total and an 87% decrease on the highest previous total (1992). The proportion of animals showing severe injuries was 39%, up threefold on the 1997 winter and the third highest total since records started. Two animals (15%) were entangled in polypropylene straps, down by 50% on the 1997 winter and the second lowest level (with 1995) since records started.

The number of entangled seals observed in the summer (24) was the fourth lowest total recorded, being 84% more than the 1997/98 summer, but 88% less than the highest previous total (1988/89). The proportion of adult animals affected (8%) was down by half on the previous summer and represents the lowest adult total recorded. The proportion of animals showing severe injuries (30%) was a contrast to 1997/98 when none was noted. Entanglements in polypropylene straps was the third lowest recorded, up 29% on 1997/98, but 93% less than the highest total of 1988/89.

The overall occurrence of entanglement in summer and winter is still down by 80 to 90% in comparison to the early 1990s, with summer adult and net-fragment incidences at their lowest since recording began. The incidence of polypropylene strap entanglements has decreased slightly (35%) since CCAMLR's prohibition of their use (1994), but severity of entanglement has increased. The incidence of synthetic string entanglement is at its highest level since recording began. This highlights the need for sustained monitoring and continuing publicity aimed at preventing the disposal of debris at sea.

SC-CAMLR-XVIII/BG/6
Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Signy Island, South Orkney Islands, 1998/99. A.S. Lynnes (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 11 pp. (English, unpublished).

The results of the third annual survey of entanglement of Antarctic fur seals at Signy Island, South Orkney Islands, are reported for the 1998/99 summer season. There were 10 sightings of seals wearing neck collars of man-made debris, although one individual was observed twice and another observed on three separate occasions. Two additional sightings were of animals that had been previously entangled, but had lost their collars by the time of observation. All of the animals involved were juvenile males, the main component of the population at Signy Island at this time of year. The number of sightings increased by 66% since the previous season, but was 17% lower than the 1996/97 level. Data are compared with results from a parallel study undertaken at Bird Island, South Georgia, in 1998/99. These indicated that the number of entangled fur seals had also increased (by 84%) since 1997/98 and decreased (by 8%) since 1996/97. Packaging bands and synthetic line were the main entangling materials at both sites, although a greater proportion of fur seals was entangled in packaging bands at Signy Island (67%) than at Bird Island (38%). Entanglements in packaging bands at Signy Island were 47% higher than in the previous season. There were no reports of entanglements in fishing net. 'Severe' and 'very severe' injury was being caused to 70% of animals at Signy Island (25% at Bird Island). This suggests that the majority of fur seals had been entangled for some time before arriving at Signy Island and had most likely been entangled in other areas, such as South Georgia,

where fishing activity is higher. The continued presence of packaging bands, despite the CCAMLR restrictions imposed since 1995/96, may be due to their persistence in the environment or to illegal unmonitored fishing activity. The prevalence of synthetic line is also a cause for concern. CCAMLR needs to continue monitoring the incidence of entanglement and intensify its campaign against the disposal of debris at sea.

SC-CAMLR-XVIII/BG/7
Anthropogenic feather soiling, marine debris and fishing gear associated with seabirds at Bird Island, South Georgia, 1998/99. C. Hill (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 19 pp. (English, unpublished).

This report describes and quantifies the occurrence of anthropogenic feather soiling, marine debris and fishing gear associated with seabirds at breeding sites at South Georgia. In this, the sixth year of standardised recording, an unprecedented quantity of line originating from fishing vessels was recorded in association with wandering albatrosses. Quantities of fishing gear remained within the levels of previous years for all other species, except giant petrels, which increased by 75% from the previous maximum. Plastic debris remained within the levels of previous years for all species except the grey-headed albatross, which increased by 50% from the previous maximum; brown skuas were associated with fishing debris for the first time in this study. Feather-soiled (oil, tar or paint) grey-headed and black-browed albatrosses were observed for the first time in this study and one oiled gentoo penguin was observed. Human food waste was associated with wandering albatrosses and giant petrels.

SC-CAMLR-XVIII/BG/10
Monitoring results of marine debris at King Sejong Station, Antarctica, during 1997–1999. S. Kim and S. Kang (Polar Research Center, KORDI, Ansan, PO Box 29, Seoul 425-600, Korea), 5 pp. (English, unpublished).

To monitor man-made marine debris on the Antarctic coast, a beach monitoring survey was carried out at the King Sejong Station (Republic of Korea), King George Island, during austral summers from 1997 to 1999. The survey area was divided into three subareas: Marian Cove coast near the King Sejong Station (Area A), Maxwell Bay coast located 10 km from wintering stations (Area B), and outer Maxwell Bay coast facing open water (Area C). Surveys were usually conducted on a monthly basis until the sea was covered by ice, though there were some missing data.

Usually the amount of debris was the highest in Areas A and B, and the lowest in Area C, where the coast faces the open ocean. The total weight of marine debris collected was about 4 kg in the 1996/97 season, 2.9 kg in 1997/98 and 7.1 kg 1998/99. Debris seemed to increase in the summer season when navigation in Maxwell Bay was at its highest. Marine debris was classified into six groups: plastics, rubber, metal, natural fibres, glass and miscellaneous. Vinyl, styrofoam and other plastics were the predominant materials, accounting for 84% of total weight found during the research period. The percentage of each item was as follows: in 1997 – plastics 70.6%, metal (cans, electric wire etc.) 21.1% and natural fibres (clothing and papers) 6.6%; in 1998 – plastics 85.7%, metal 5.7% and glass 4.4%; and in 1999 – plastics 91.6%, natural fibres 2.9% and glass 1.2%. The especially large proportion of plastics at Area B was in February and May 1999 (mostly nylon rope). The rubber collected in December 1997 was rubber gloves. Most marine debris found in Area A appeared to be waste material from the King Sejong Station, while some items found in Area B seemed to have drifted from stations on the other side of Maxwell Bay.

SC-CAMLR-XVIII/BG/14
Marine debris and fishing gear associated with seabirds at sub-Antarctic Marion Island – 1998/99. D.C. Nel and M.G.W. Jones (Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7701, South Africa), 12 pp. (English, unpublished).

Most (52%) of the 306 debris items found in association with seabirds at

Marion Island during the season May 1998 to April 1999 originated from the fishing industry. The most common items found were rope nooses (79) and fishing hooks (28), both originating from the Patagonian toothfish (*Dissostichus eleginoides*) long-line industry. Wandering albatrosses (*Diomedea exulans*) took the highest proportion of fishing gear, followed by southern giant petrels (*Macronectesgiganteus*). Standardised searches of wandering albatross study colonies showed that there had been a slight decrease in the accumulation rate of marine debris, and in particular fishing gear, since the 1997/98 season, however, these levels were still much higher than the 1996/97 season. This is consistent with a decrease in the number of unsanctioned fishing vessels present in the close vicinity of the island. Standardised searches of grey-headed albatross (*Diomedea chrysostoma*) nests also showed a dramatic decrease since 1997. An adult wandering albatross was found with a hook through its wing, while the carcasses of a wandering albatross chick and an adult northern giant petrel (*Macronectes halli*) were found with ingested Patagonian toothfish hooks.

SC-CAMLR-XVIII/BG/17
First record of *Brucella* spp. antibodies in *Arctocephalus gazella* and *Leptonychotes weddellii* from Cape Shirreff, Livingston Island, Antarctica. O. Blank, P. Retamal, D. Torres and P. Abalos (Departmento Científico, Instituto Antártico Chileno, Luis Thayer Ojeda 814, Correo 9, Providencia, Santiago, Chile), 10 pp. (Spanish and English, unpublished).

This paper describes the first detection of *Brucella* spp. antibodies in Pinnipedia from Cape Shirreff, Livingston Island, South Shetlands, Antarctica. Sixteen Antarctic fur seals (*Arctocephalusgazella*) and one Weddell seal (*Leptonychotes weddellii*) sera were tested by the Rose Bengal test (RBT), the complement fixation test (CFT), by immunodiffusion (AGID) and c-ELISA.

Antibodies against *Brucella* spp. were detected with the RBT, the CFT and the c-ELISA in 6 of the 17 samples involving the two animal species.

It is concluded that a *Brucella* spp. affecting marine mammals in the northern hemisphere could also be present in the Antarctic ecosystem.

SC-CAMLR-XVIII/BG/26
Managing fisheries to conserve the Antarctic marine ecosystem: practical implementation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). A.J. Constable, W.K. de la Mare, D.J. Agnew, I. Everson and D. Miller. *ICES J. Mar. Sci.*, Special Issue, 2nd quarter, 2000, submitted (English).

Apart from exploitation of seals and whales, Antarctic fisheries began in the late 1960s with exploitation of the marbled rockcod, *Notothenia rossii*, in the South Atlantic, a species decimated in the first two years of the fishery following catches of about 500 000 tonnes. Two other species have formed the basis of substantial fisheries, krill (*Euphausia superba*) and mackerel icefish (*Champsocephalus gunnari*), both of which still occur. Finfish catches declined in the 1980s, but the development of deep longlining for toothfish (*Dissostichus eleginoides* and *D. mawsoni*) has caused a resurgence of interest in Antarctic finfish fisheries. Notwithstanding these fisheries, management of fisheries in the Antarctic arose primarily from concern over potential effects of a fishery for the very abundant Antarctic krill, *E. superba*. This species is considered to be an important prey of a wide range of avian and marine predators in the Antarctic. The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) was agreed in 1980 to take a broad 'ecosystem approach' to management. As part of this approach, CCAMLR has (i) adopted a precautionary approach to all fisheries including by-catch; (ii) developed quantitative decision rules to safeguard recruitment of target species and to safeguard predators from over-exploitation of their prey; (iii) developed methods to achieve scientific consensus and account for uncertainty; (iv) adopted a process for authorising new fisheries and for monitoring the development of exploratory fisheries; and (v) adopted measures to avoid localised effort in new fisheries, avoid targeting by-catch species

and minimise mortality of birds. This paper reviews how CCAMLR achieved these results and the future program of work required to develop management procedures that ensure that management measures can be adjusted in sufficient time to ensure the objectives are met. Attention is given in this paper to the development of the CCAMLR Ecosystem Monitoring Program (CEMP), some of the problems in developing a program to monitor for the effects of fishing and the recent discussions on how to incorporate data arising from CEMP into management procedures.

Working Group on Ecosystem Monitoring and Management

WG-EMM-99/4
VNIRO Program of Remote Monitoring of Oceanographic Conditions in Fishing Areas of the World Ocean (the Southwestern Atlantic and the Southeastern Pacific). G.P. Vanyushin, T.B. Barkanova and A.A. Troshkov (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia), 21 pp. (English, unpublished).

This paper describes a program which uses satellite and ship monitoring data on the dynamics of sea-surface temperature (SST) in fishing areas at various time intervals (week, month, year etc.). An example of monitoring fishing areas in the southwestern Atlantic and the southeastern Pacific is described. The following data were used: a set of maps of weekly mean SST and monthly mean SST; maps of gradients, trends, variations and anomalies in SST; analyses of these maps used for a study of monthly mean and interannual variability of SST; comparison of maps of monthly mean SST in various years and mean long-term SST data for the respective periods.

WG-EMM-99/5
BENEFIT – Benguela Environment Fisheries Interaction and Training Science Plan. Delegation of South Africa, 6 pp. (English, unpublished).

WG-EMM-99/6
Population size and trends of some seabirds at Marion Island. R.J.M. Crawford, O.A.W. Huyser, D.C. Nel, J. Cooper, J. Hurford and M. Greyling (Marine and Coastal Management, Private Bag X2, Rogge Bay 8012, South Africa), 22 pp. (English, unpublished).

At least 27 species of seabird breed or are believed to breed at sub-Antarctic Marion Island (Cooper and Brown, 1990). These include four penguins (Spheniscidae), four albatrosses (Doimedeidae), two giant petrels (Procellariidae), one shag (Phalacrocoracidae), one skua, one gull and two terns (Laridae), all of which nest above ground. In addition, there are eight petrels and prions (Procellariidae), two storm petrels (Hydrobatidae) and two diving petrels (Pelecanoididae) that breed in burrows.

For all surface-nesting species, the sizes of breeding populations have been estimated from counts of adults, of chicks or of active nest sites, or from measurements of the density and area occupied by breeders. For some burrowing seabirds, the density of burrows has been estimated for various sectors of the island. This paper collates available data to examine trends in abundance of the four penguins, the two giant petrels, two of the albatrosses, the shag, two petrels and a prion.

WG-EMM-99/8 Rev.1
CEMP indices 1999: analysis of anomalies and trends. CCAMLR Secretariat, 105 pp. (English, unpublished).

WG-EMM-99/9
Fine-scale data from the krill fisheries in 1997/98. CCAMLR Secretariat, 22 pp. (English, unpublished).

WG-EMM-99/11
Estimation of the fishery–krill–predator overlap. CCAMLR Secretariat, 32 pp. (English, unpublished).

WG-EMM-99/12
Draft standard methods for environmental indices F1, F3 and F4. CCAMLR Secretariat, 9 pp. (English, unpublished).

WG-EMM-99/13

Cephalopod diet of the southern elephant seal (*Mirounga leonina*) at King George Island, South Shetland Islands. G.A. Daneri, A.R. Carlini and P.G.K. Rodhouse (Museo Argentino de Ciencias Naturales 'B. Rivadavia', División Mastozoología, Av. Angel Gallardo 470, (1405) Buenos Aires, Argentina), 14 pp. *Ant. Sci.*, submitted (English).

In the austral summer of 1995/96, 25 southern elephant seals, *Mirounga leonina*, were stomach-lavaged at Stranger Point, King George Island, South Shetland Islands. Cephalopod remains were present in 72% of the individuals sampled (n = 18). Seven species of squid and three species of octopus were identified. Overall, the squid species *Psychroteuthisglacialis* was by far the most important prey item in terms of numbers (77%), biomass (80.8%) and frequency of occurrence (94.4%). Next in importance in terms of mass in the diet was, for females, the squid *Alluroteuthis antarcticus* (7%) and, for males, the octopodid *Pareledonecharcoti* (13.2%). Females preyed on a wider variety of squid taxa than males (7 versus 3), but octopodids occurred only in stomach contents of males. The predominance of *P. glacialis* in the prey of the South Shetland elephant seals can be explained by the southerly location of the foraging areas of this population compared to those at South Georgia, Heard and Macquarie Islands, where the diet of southern elephant seals has previously been analysed. *P. glacialis* is the predominant squid in waters close to the Antarctic continent.

WG-EMM-99/14

SCAR Bird Biology Subcommittee ad hoc Working Group on Seabirds at-sea Methodology – synopsis of workshop activities and recommendations. SCAR, 3 pp.

WG-EMM-99/15

Effects of the Antarctic circumpolar current on fishing for squid (*Illex argentinus*) in the Atlantic sector of the Southern Ocean. G.P. Vanyushin and T.B. Barkanova (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia), 8 pp. (English, unpublished).

This paper introduces several approaches to the assessment of hydrological conditions in the Atlantic sector of the Southern Ocean (the southwest Atlantic). The analysis of the SST maps suggests that hydrological factors depend on the strength of two currents, the Antarctic Circumpolar Current and the Falkland/Malvinas Current. The paper shows a correlation between particular hydrological conditions and fishing for squid *Illex argentinus*.

WG-EMM-99/16

Trends of Antarctic fur seal population at SSSI No. 32, Livingston Island, South Shetlands, Antarctica. R. Hucke-Gaete, D. Torres, A. Aguayo, J. Acevedo and V. Vallejos (Universidad Austral de Chile, Facultad de Ciencias, c/o Instituto de Zoología, Casilla 567, Valdivia, Chile), 12 pp. (English, unpublished).

This paper presents an update of the previously reported model of the Antarctic fur seal *Arctocephalus gazella* population breeding at Cape Shirreff and San Telmo Islets (SSSI No. 32), Livingston Island, South Shetland, Antarctica. The reliability of the current model and the relation of population parameters to an environmental index (the Southern Ocean Oscillation Index – SOI) are also discussed.

Two fur seal censuses were carried out at Cape Shirreff during 1998/99, but the population of the San Telmo Islets could not be censused. It was therefore necessary to model the population in order to obtain an estimate of the total population. From this, it was estimated that the total population had increased by 17%; included in this figure was a 10% increase in pup production in SSSI No. 32.

Current population estimates are close to modelled values based on the environment carrying capacity (K). This may not be correct due to the restrictions of the simple model used, the weighted effect of the time series of data over the last eight years, and the scattered historical data.

Further evidence that the breeding population of *A. gazella* is affected by the El Niño Southern Oscillation phenomena may be obtained by comparing the intrinsic rate of population growth (r) with SOI values.

Monitoring of the intrinsic rate of a population increase of top predators, in this case *A. gazella*, can probably predict large-scale environmental phenomena which would require changes in resource management policies.

WG-EMM-99/17
Estimation of krill biomass from an acoustic survey carried out in 1986, during a study of predator–prey interactions around the western end of South Georgia. C. Goss and S. Grant (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 11 pp. (English, unpublished).

An acoustic survey, designed to study the distribution of shore-breeding marine predators and their pelagic prey, was carried out in 1986 around the western end of South Georgia. This paper describes how, as part of an interannual study, this acoustic data has been used to estimate krill biomass of a sector of the original survey area. The radiating transect design gave increased sampling intensity in the shallower part of the area, so a method of post hoc stratification has been devised to define subareas with more even sampling. The results highlight the importance of the shelf slope area for krill.

WG-EMM-99/18
Underwater noises produced by research vessels (some comments on acoustic sampling protocol for the Area 48 synoptic survey). S.M. Kasatkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 7 pp. (English, unpublished).

This paper presents data on the underwater vessel noise levels measured by the echosounder EK500 transducers on three Russian research vessels. These data are compared to the estimate of the underwater noise level produced by the Icelandic research vessel *B. Saemundsson*.

The underwater noise level measured by the echosounder transducer is analysed in relation to its operation frequency and vessel speed. It is shown that the level of underwater noise produced by the vessel is an important factor to be taken into account in assessment of parameters of the Acoustic Sampling Protocol, such as TS and Sv thresholds and vessel speed. The importance for echosurveys of the relationship between the selected TS and Sv thresholds and vessel speed is stressed.

It is shown that a choice of desirable speed for each vessel participating in a multi-ship survey cannot be defined taking into account the difference between the underwater noise levels of vessels and the unique level of TS and Sv thresholds of each vessel. The importance of taking into account the research vessel underwater noise level for the standardisation of acoustic data collection from a number of vessels (e.g. a synoptic survey of krill biomass in Area 48) is discussed.

WG-EMM-99/19
Interannual variation in the autumn diet of the gentoo penguin *Pygoscelis papua* at Laurie Island, Antarctica. N. Coria, M. Libertelli, R.J. Casaux and C. Darrieu (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 15 pp. (English, unpublished).

The diet of the gentoo penguin *Pygoscelis papua* was investigated during three different autumn periods at Laurie Island, South Orkney Islands (60°46'S, 44°42'W), Antarctica. Stomach contents of migrant adults were sampled during 1993, 1995 and 1996. Fish were the most important prey by mass in 1995 (81.1%) and 1996 (60.5%), whereas crustaceans predominated in 1993 (70% by mass). *Euphausia superba* was by far the most important prey among the 11 crustacean taxa identified in the samples. Nototheniidae were the predominant fish species in the diet, with *Gobionotothen gibberifrons* being the most important prey by mass in 1993 and 1995 and *Notiotheniops nybelini* in 1996. Other nototheniid fish such as *Notothenia nudifrons* and *Trematomus newnesi* were also well represented in the three sampling periods. A total of 1 628 lower beaks of squid were found and 1 582 (97%) of them were identified as *Psychroteuthis glacialis*. Diet composition in terms of frequency of occurrence, mass and number is compared with results of previous studies.

WG-EMM-99/20
Acoustic estimates of krill density at South Georgia, December–January

1998/99. A.S. Brierley and C. Goss (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 3 pp. (English, unpublished).

Dual frequency (38 and 120 kHz) acoustic data from grid surveys in two boxes to the northwest and northeast of South Georgia during December and January 1998/99 were used to estimate mean krill density there. Densities (east = 11.1 g m^{-2}, west = 12.0 g m^{-2}) were towards the lower end of the range observed over the past two decades, but not abnormally low, and comprised almost entirely large (>50 mm) adult krill.

WG-EMM-99/21
Draft management plan for Specially Protected Area (SPA) No. 4, Balleny Islands northern Ross Sea, Antarctica. E. Waterhouse (New Zealand), 9 pp. (English, unpublished).

WG-EMM-99/22
Estimates of global krill abundance based on recent acoustic density measurements and their implications for the calculation of precautionary catch limits and the designation of management areas. S. Nicol, A.J. Constable and T. Pauly (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 19 pp. *CCAMLR Science*, submitted (English).

The global abundance of krill is estimated using recent estimates of krill density from acoustic surveys and historical information on the overall range of krill. The biomass estimates fall between 64 and 137 million tonnes – at the low end of values that have been suggested in the past. The differences between our estimates and others can be explained by a number of factors such as: an underestimation of the range, or of the acoustic biomass estimates, the possibility of a large, undetected krill population, and the overestimation of the demand for krill by predators. Even if these low global krill biomass estimates are correct, regional and global precautionary limits are still likely to rise as a result of new surveys because the method used to calculate precautionary limits uses a value of 11% of the biomass. Additionally, the current precautionary catch limits in the South Atlantic are set using the old target strength which has effectively underestimated the krill biomass by a factor of three, so the new survey of the South Atlantic is likely to result in an effective biomass which is greater than that used in the past. The seasonal and local consequences of elevated catch limits will have to be taken into account when managing an expanded krill fishery and the appropriateness of using the existing statistical divisions as management areas will have to be considered.

WG-EMM-99/23
The Second International Krill Symposium. S. Nicol and M. Mangel (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 12 pp. (English, unpublished).

WG-EMM-99/24
Potential effects of UV-B on krill – experimental and genetic studies. S. Newman, S. Jarman, S. Nicol, D. Ritz, H. Marchant, N. Elliott and A. McMinn. *Polar Biol.*, 22: 50–55, 1999 (English).

We irradiated captive juvenile *Euphausia superba* in the laboratory with lower than spring surface levels of ultraviolet-B, ultraviolet-A and photosynthetically active radiation, in order to examine their response in terms of mortality and generalised activity. Levels of photosyntheticallyactive radiation 3–5 times below surface irradiance caused krill to die within a week, while animals in the dark survived. Addition of ultraviolet-B typical of depths up to 15 m were found to significantly accelerate mortality and lead to a drop in activity in all experiments. A drop in activity in krill exposed to ultraviolet-A wavelengths was evident without an increase in mortality. The protein content of animals from various treatments was found not to vary.

WG-EMM-99/25
Poor breeding success of the Adélie penguin at Béchervaise Island in the 1998/99 season. L. Irvine, J.R. Clarke and K.R. Kerry (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 16 pp. *CCAMLR Science*, submitted (English).

This paper describes the diet and

foraging behaviour of Adélie penguins at Béchervaise Island during 1998/99, a season of high chick mortality. One thousand nests perished in the three weeks following first hatch, when the chicks were very small. A total of 802 chicks reached crèche age from 1 880 nests compared to previous 'good' seasons in which between 1 200 and 1 800 chicks crèched on the island. Evidence from analyses of foraging location, foraging trip duration and diet led to the conclusion that the death of chicks during the guard stage resulted from decreased feeding frequency due to adult birds spending longer at sea foraging than in normal years. In most previous seasons birds have foraged both at the continental shelf edge (particularly females) as well as locally (particularly males). This season male penguins carried out fewer local trips, and both sexes spent longer at sea than in 'good' years. Meal masses brought back to the chicks appeared normal, but feeding frequencies were reduced. These findings contrast with observations made in 1994/95 (a season in which all chicks starved to death), when smaller meals were delivered and birds foraged further offshore than in this or any other season studied. The significance to CEMP of these variations in foraging behaviour is discussed.

WG-EMM-99/26
Report on the SCOR/ICES Symposium on the Ecosystem Effects of Fishing, March 1999. A.J. Constable (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 7 pp. (English, unpublished).

WG-EMM-99/27
Correlation between krill and *Champsocephalus gunnari* stocks in the South Georgia area (Subarea 48.3). K.V. Shust, V.L. Senioukov, P.N. Kochkin and N.A. Petrukhina (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia), 23 pp. (English, unpublished).

After an almost 10-year gap in fishing for *Champsocephalus gunnari* in the area around South Georgia and Shag Rocks, the large Russian trawler *Zakhar Sorokin* undertook a short fishing opera tion in February–March, 1999. Overall, 85 pelagic trawls yielded 264 tonnes of *C. gunnari*. The search for fish stocks covered all the traditional sites; this allowed observers to note a clear correlation between concentrations of adult fish and krill on the northwestern shelf of South Georgia. At the same time, duration of the feeding aggregations of *C. gunnari* was found to be dependent on weather conditions. Comparison of the results obtained with data of trawl-and-hydroacoustic surveys revealed that dense concentrations of *C. gunnari* occur regularly on the northwestern shelf of South Georgia.

WG-EMM-99/28
Light levels experienced by foraging Antarctic fur seals, *Arctocephalus gazella*. D.J. McCafferty, I.L. Boyd and T.R. Walker (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 29 pp. (English, unpublished).

This study examined the feasibility of using time-depth recorders (TDRs) to measure light levels experienced by a diving marine mammal. TDRs were deployed on 10 female Antarctic fur seals (*Arctocephalus gazella*) at Bird Island, South Georgia (54°00'S, 38°02'W) in the 1994/95 austral summer. Depth and light measurements were made during 11 foraging trips which lasted on average (±SE) 7.1 ± 0.7 d. A total of 25 657 dives were recorded with a mean dive depth and duration of 18.0 ± 3.6 m and 49.5 ± 6.9 s respectively. Depending on time of day, fur seals experienced between 6 and 57% of the surface illumination when diving. Illuminance ranged from full sunlight (10^2 lux) at the surface to minimum starlight (10^{-6} lux) at night and during deep daytime dives. The change in illuminance with depth did not follow a simple exponential decrease as recorded in clear oceanic waters. TDRs recorded strong light attenuation in the top 50 m of the water column. The mean attenuation coefficient was 0.140 ± 0.014 m^{-1} which was in the upper range of values measured by ship surveys at South Georgia. When fur seals made shorter and shallower dives, TDRs also recorded greater light attenuation. These findings suggest that Antarctic fur seals forage in relatively turbid waters containing large concentrations of phytoplankton and/or

dense aggregations of krill. Night-time foraging and deep daytime diving indicates that fur seals are well adapted to locating prey in low illumination.

WG-EMM-99/29

Influence of sampling protocol on diet determination of Gentoo penguins, *Pygoscelis papua* and Antarctic fur seals, *Arctocephalus gazella*. S.D. Berrow, R.I. Taylor and A.W.A. Murray. *Polar Biol.*, in press (English).

The influence of two sampling protocols on diet determination of two marine predators, the gentoo penguin *Pygoscelis papua* and Antarctic fur seal *Arctocephalus gazella*, was investigated. The collection of diet samples on three occasions over a two-week period was compared with collecting all samples during a single session, as current CEMP monitoring protocols recommend. Some differences in the mass of food recovered from penguins were found but this was attributed to the mass of penguin sampled. There were no differences in diet composition between protocols and although body mass was a significant determinant of the mean length of krill *Euphausia superba* recovered from penguins, there were no differences between sampling protocols. This study has shown that differences between sampling frequencies are small and a variety of sampling protocols can produce results acceptable for interannual monitoring. Mass of sampled individuals can account for significant variation and should be recorded, especially if sampling frequencies and sizes are low.

WG-EMM-99/30

Relationships between the distribution of whales and Antarctic krill *Euphausia superba* at South Georgia. K. Reid, A.S. Brierley and G.A. Nevitt. *J. Cetacean Res. Management*, in press (English).

The distribution of whales and krill in two survey boxes north of South Georgia was examined by comparing sightings and underway acoustic data collected as part of a multi-disciplinary research cruise during January/February 1998. A total of 222 cetaceans of 10 species was recorded with southern right whale (*Eubalaena glacialis*) and humpback whale (*Megaptera novaeangliae*) the two most frequent. The largest aggregation of cetaceans (21 southern right whales, 18 fin whales (*Balaenoptera physalus*), 4 sei whales (*B. borealis*), 1 humpback whale and 8 hourglass dolphins (*Lagenorhynchus cruciger*)) occurred close to the largest single aggregation of krill. The level of association between baleen whales and krill was examined at a number of spatial scales. There was a positive relationship between whale abundance and mean krill density at the largest spatial scale examined (80 x 100 km). At progressively smaller scales the relationship weakened, due mainly to the increased frequency of areas of high krill density where whales were not recorded. In particular whales were absent from inshore areas (up to 300 m depth) that had higher mean krill densities compared with areas where whales were recorded. To compare krill and whale distribution, particularly at smaller scales, may require information on krill swarm structure and density. Such information may also be crucial to understanding the role of scale-dependence in potential interspecies competition among krill-feeding marine predators.

WG-EMM-99/31

Determining the sex of Antarctic krill (*Euphausia superba*) using carapace measurements. K. Reid and J. Measures. *Polar Biol.*, 19: 145–147, 1998 (English).

A discriminant function using simple carapace measurements correctly determined the sex of 87% of male and 89% of female Antarctic krill *Euphausia superba*. This facilitated the use of sex-specific regression models which increased the accuracy of total length estimates.

WG-EMM-99/32

Foraging and provisioning in Antarctic fur seals: interannual variability in time–energy budgets. I.L. Boyd. *Behav. Ecol.*, 10 (2): 198–208, 1999 (English).

This study examined three competing hypotheses to explain how lactating Antarctic fur seals (*Arctocephalus gazella*) respond to changes in the level of resource availability. Antarctic fur seals have episodic bouts of suckling (1–3 days), alternating with foraging trips (3–10 days). Foraging time budgets varied significantly

($p < .001$) among 8 consecutive years at Bird Island, South Georgia. Foraging trip duration increased during periods of relative food shortage. Time spent ashore was more consistent among years than foraging trip duration but declined during a year of particularly low food availability. In 4 of the 8 years, there was a significant positive correlation between time spent ashore and foraging trip duration. In the other years, the relationship was close to statistical significance. Energy delivery to pups during suckling bouts followed an asymptotic power function. Energy gain during foraging trips was estimated from diving behaviour, which suggested that the energy gain function was linear. Distance travelled during foraging trips was correlated with foraging trip duration, and long foraging trips were associated with reduced foraging intensity. There was support for the hypothesis that lactating Antarctic fur seals compensate for reduced resources by increasing the foraging trip duration rather than working harder and increasing their energy expenditure. However, there was most support for the hypothesis that lactating Antarctic fur seals adjust time spent ashore as well as foraging trip duration, possibly to maximise the delivery of food to their offspring. Lactation appears to impose constraints on provisioning of offspring that differ from those of seabirds foraging in the same environment and often on the same prey.

WG-EMM-99/33

A proposal for large-scale sampling of krill in the diet of predators across Area 48 to coincide with the CCAMLR synoptic survey. K. Reid (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 12 pp. (English, unpublished).

There is a high degree of spatial and temporal variability in the population of Antarctic krill (*Euphausia superba*) across the Scotia Sea. Resolution of the spatial component of this variability requires a 'snapshot' of the krill population over the region (e.g. the CCAMLR B_0 survey) whereas temporal changes have been addressed using time series of samples from the diet of predators. At South Georgia, krill in the diet of Antarctic fur seal (*Arctocephalus gazella*) show a good level of concordance with scientific net samples. In order to examine the potential of using krill in the diet of predators to examine both the temporal and spatial variability across the Scotia Sea, it is essential to determine the level of concordance at other sites. Samples of krill from South Georgia, the South Orkney Islands and the South Shetland Islands, where predator foraging ranges overlap with intensive krill sampling areas within the CCAMLR B_0 survey, will be collected from Antarctic fur seal scats between December and March using a standard methodology. This data will be used to examine the level of concordance between krill in the diet of predators and from net hauls, to compare the timing of temporal changes in krill population between sites and to create a basis upon which to assess how the population structure during the CCAMLR B_0 survey fits into a longer time frame.

WG-EMM-99/34

Relative abundance of large whales around South Georgia. M.J. Moore, S.D. Berrow, B.A. Jensen, P. Carr, R. Sears, V.J. Rowntree, R. Payne and P.K. Hamilton. *Marine Mammal Science,* in press (English).

To assess large whale stocks following the cessation of land-based South Georgia whaling in 1965, we report three independent sighting databases: a cruise in 1997, observations from Bird Island (NW of South Georgia) between 1979 and 1998, and mariner sightings between 1992 and 1997. All species were rare, with southern right whale sightings being the most common event. Two right whales photographed off South Georgia matched animals known from Peninsula Valdés, Argentina, a population known to be growing at 7% per annum. In contrast, blue and fin whales appear to be less abundant. A single blue whale mother–calf pair was observed off the Shag Rocks in February 1997. Extirpation of animals from this particular feeding ground is the most likely reason for ongoing low numbers of all species. Other factors may include: competition for krill by traditional predators such as penguins and seals and more recently by humans, an unusually high rate of natural mortality,

habitat change such as alteration in sea-ice coverage, and/or the impact of ongoing whaling. The history of this critical area of large-whale habitat and this report demonstrate the need for improved, consistent long-term monitoring of population trends for these depleted stocks.

WG-EMM-99/35

Foraging response of Antarctic fur seals to changes in the marine environment. D.J. McCafferty, I.L. Boyd, T.R. Walker and R.I. Taylor. *Mar. Ecol. Prog. Ser.*, 166: 285–299, 1998 (English).

This study examined the relative contribution of environmental variation and the seasonal demands of pup rearing on the foraging behaviour of female Antarctic fur seals *Arctocephalus gazella* at Bird Island, South Georgia (54°S, 38°W), during 3 austral summers (1994 to 1996). Time-depth recorders measured the diving behaviour of 72 individuals during a total of 385 foraging trips totalling 1 964 days at sea. The frequencies of krill, fish and squid in the diet were estimated from prey items contained in scats. In 1996, a year of high krill abundance, females made shorter foraging trips, fewer dives and spent more time ashore than in 1994 when krill was scarce. Females fed exclusively on krill in 1996, and frequent shallow daytime diving indicated that krill were close to the surface during the day. In 1994 and 1995 deeper and longer-duration daytime dives were associated with a higher proportion of fish and squid in the diet. Foraging trip duration, ashore duration and dive frequency increased through the course of the 1995 and 1996 lactation seasons. Females, therefore, appeared to match pup demands by increasing both time feeding at sea and energy delivery to the pup on land. However, the importance of sea surface temperature and duration of night in multiple regression models suggested that physical factors were also important in explaining the seasonal pattern of fur seal foraging behaviour.

WG-EMM-99/36

Heart rate and behaviour of fur seals: implications for measurement of field energetics. I.L. Boyd, R.M. Bevan, A.J. Woakes and P.J. Butler. *Am. J. Physiol.*, 276 (*Heart Circ. Physiol.*, 45): H844–H857, 1999 (English).

Archival data loggers were used to collect information about depth, swimming speed, and heart rate in 23 free-ranging Antarctic fur seals. Deployments averaged 9.6 ± 5.6 days (SD) and totalled 191 days of recording. Heart rate averaged 108.7 ± 17.7 beats/min (SD) but varied from 83 to 145 beats/min among animals. Morphometrics explained most variations in heart rate among animals. These interacted with diving activity and swimming speed to produce a complex relationship between heart rate and activity patterns. Heart rate was also correlated with behaviour over time lags of several hours. There was significant ($P < 0.05$) variation among animals in the degree of diving bradycardia. On average, heart rate declined from 100–130 beats/min before the dive to 70–100 beats/min during submersion. On the basis of the relationship between heart rate and rate of oxygen consumption, the overall metabolic rate was 5.46 ± 1.61 W/kg (SD). Energy expenditure appears to be allocated to different activities within the metabolic scope of individual animals. This highlights the possibility that some activities can be mutually exclusive of one another.

WG-EMM-99/37

Predicting changes in the Antarctic krill *Euphausia superba* population at South Georgia. K. Reid, K.E. Barlow, J.P. Croxall and R.I. Taylor. *Mar. Biol.*, in press (English).

Variability in the Southern Ocean is frequently reflected in changes in the abundance of Antarctic krill *Euphausia superba* and subsequent effects on dependent predators. However, the nature and consequences of changes in krill population dynamics that accompany fluctuations in its abundance are essentially unknown. A conceptual model, developed from quantitative measures of krill length in the diet of predators at South Georgia from 1991–1997, allowed predictions to be made about the abundance and population structure of krill in 1998 and the consequences for predators. Consistent with model predictions, in 1998 there was a serial change in krill population structure, low krill biomass and low predator reproductive

performance. The change in modal size of krill, from 56 mm in December to 42 mm in March was apparently a result of the transport of krill into the region. This is the first occasion when the future status and structure of the krill population at South Georgia has been successfully predicted. By representing local krill population dynamics, which may also reflect large-scale physical and biological processes, predators have a potential key role as indicators of Southern Ocean environmental variation at a range of spatial scales.

WG-EMM-99/38
Improvements to the multiple-frequency method for *in situ* target strength measurements. D.A. Demer and M.A. Soule (Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), 23 pp. (English, unpublished).

Refinements have been made to the multiple-frequency method that was recently developed to improve the accuracy and precision of *in situ* target strength (TS) measurements using split-beam echosounders (Demer et al., *J. Acoust. Soc. Am*. 105 (4): 2359–2376, 1999). The multiple-frequency method improves the rejection of unresolvable and constructively interfering target multiples by combining synchronised signals from two or more adjacent split-beam transducers of different frequencies which are not integer multiples of each other. In this study, the method itself was improved by: (i) optimising the accuracy and precision of the angular and range measurements of the individual frequency detections; (ii) more precisely determining the relative three-dimensional (3-D) locations (x, y, and z) and angular orientations (pan and tilt) of the transducers and thus the positional transformation; and (iii) increasing the range resolution of one or more of the frequencies. These improvements are demonstrated through controlled test tank experiments using 38 and 120 kHz split-beam transducers and a 200 kHz single-beam transducer. Tolerances for matching target positions at two or more frequencies were determined to be ±0.5 m in radial range and ±0.7° off-axis (compared to ±1.0 m ±1.5° in the previous study). These experimental results indicate that such careful application of the multiple-frequency TS method can reject 100% of multiple targets while allowing 90% of the resolvable single targets to be measured.

WG-EMM-99/39
The CCAMLR-2000 krill synoptic survey; a description of the rationale and design. P.N. Trathan, J.L. Watkins, A.W.A. Murray, A.S. Brierley, D.A. Demer, I. Everson, C. Goss, S. Hedley, R. Hewitt, S. Kawaguchi, S. Kim, M. Naganobu, T. Pauly, J. Priddle, K. Reid and P. Ward (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 26 pp. (English, unpublished).

WG-EMM-99/40
Combining data vectors from CEMP indices. I.L. Boyd and A.W.A. Murray (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 15 pp. (English, unpublished).

Ecosystem management requires data about long-term trends in biological parameters together with the empirical functional relationship between these parameters and the physical and biological forcing factors within the ecosystem. Combining subsets of data time series that, individually, may represent a restricted view of the overall variability experienced by animals operating at a particular trophic level, has the potential to provide a broader view of the overall variability. The study examined the problems associated with how such time series can be combined, especially when the data matrix has missing values (and does not have the property of being positive and semidefinite) and time series vectors are of widely varying duration. A cyclical function was used to simulate a complete data matrix with vectors that were correlated to different degrees. Random deletion of data, in a pattern similar to that expected for time series that have been taken up within a formal monitoring program, was used to examine the effects of missing values. Smoothing procedures were applied to the covariance matrix to enable all the data within the matrix to be used to calculate a

combined index after transformation and standardisation of the data. We showed that by using all the data, together with a covariance matrix smoothing procedure, it was possible to produce a combined standard index (CSI) that was consistently more robust to missing values than if only the complete portion of the data matrix was used. This was also more robust than a simple mean vector within each time step. The example of 20 parameters measured from three species of marine predators across a maximum of 22 years was used as a case study. Three methods were used to examine the relative contribution made by each data vector towards the CSI and, of these, a non-parametric influence function and a principal components analysis were found to be more informative than a jacknife correlation analysis. The CSI in this example had a significant non-linear relationship with food biomass. Analyses involving the calculation of indices from the most important parameters within the first and second principal components suggested that such analyses may be able to detect different underlying functional responses within a suite of biological time series.

WG-EMM-99/41

Effect of orientation on broadband acoustic scattering of Antarctic krill *Euphausia superba*: implications for inverting zooplankton spectral acoustic signatures for angle of orientation. L.V. Martin Traykovski, R.L. O'Driscoll and D.E. McGehee. *J. Acoust. Soc. Am.*, 104 (4), 1998 (English).

Acoustic scattering experiments involving simultaneous acquisition of broadband echoes and video footage from several Antarctic krill were carried out to determine the effect of animal orientation on echo spectral structure. A novel video analysis technique, applied to extract krill angle of orientation corresponding to each insonification, revealed that echo spectra from krill near broadside incidence relative to the incident acoustic wave exhibited widely spaced, deep nulls, whereas off-broadside echo spectra had a more erratic structure, with several closely spaced nulls of variable depth. The pattern of changes in echo spectra with orientation for the experimentally measured acoustic returns was very similar to theoretically predicted patterns based on a distorted wave Born approximation (DWBA) model. Information contained in the broadband echo spectra of the krill was exploited to invert the acoustic returns for angle of orientation by applying a newly developed Covariance Mean Variance Classification (CMVC) approach, using generic and animal-specific theoretical and empirical model spaces. The animal-specific empirical model space was best able to invert for angle of orientation. The CMVC inversion technique can be implemented using a generic empirical model space to determine angle of orientation based on broadband echoes from individual zooplankton in the field.

WG-EMM-99/42

Effects of orientation on acoustic scattering from Antarctic krill at 120 kHz. D.E. McGehee, R.L. O'Driscoll, L.V. Martin Traykovski (Woods Hole Oceanographic Institution, MS 11, Woods Hole, Ma. 02543-1049, USA), 21 pp. *Deep-Sea Research*, II, 45: 1273–1294, 1998 (English).

Backscattering measurements of 14 live individual Antarctic krill (*Euphausia superba*) were made at a frequency of 120 kHz in a chilled insulated tank at the Long Marine Laboratory in Santa Cruz, Ca. Individual animals were suspended in front of the transducers, were only loosely constrained, had substantial freedom to move, and showed more or less random orientation. One thousand echoes were collected per animal. Orientation data were recorded on video. The acoustic data were analysed and target strengths determined from each echo. A method was developed for estimating the three-dimensional orientation of the krill based on the video images and was applied to five of them, giving their target strengths as functions of orientation. Scattering models based on a simplified distorted-wave Born approximation (DWBA) method were developed for five animals and compared with the measurements.

Both measured and modelled scattering patterns showed that 120 kHz acoustic scattering levels are highly dependent on animal orientation. Use of these scattering patterns with orientation data from shipboard studies of *E. superba* gave mean scattering levels approximately 12 dB lower than peak

levels. These results underscore the need for better *in situ* behavioural data to properly interpret acoustic survey results. A generic *E. superba* DWBA scattering model is proposed that is scalable by animal length. With good orientation information, this model could significantly improve the precision and accuracy of krill acoustic surveys.

WG-EMM-99/43
Supplement to the krill synoptic survey design in Area 48 (with participation of a Russian scientific research vessel). V.A. Sushin, S.M. Kasatkina and F.F. Litvinov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 11 pp. (English, unpublished).

The necessity for a synoptic survey to cover the South Sandwich Islands, which are an integral part of Area 48, is discussed. For the first time in 20 years, it will be possible to collect material which will provide an indication of the simultaneous distribution of krill over the whole marine area of Subareas 48.1 to 48.4, which covers a vast zone of krill flux, and the fishing grounds between the Antarctic Peninsula and the most southern Sandwich Islands up to 20°W. It is emphasised that this study will provide data which are important both to improve our knowledge of horizontal distribution of krill over the whole Area 48, and to clarify interrelations between individual subareas of this area. A supplement to the most up-to-date survey design is provided, including the participation of the Russian RV *Atlantida* in Subarea 48.4 in the forthcoming synoptic survey in Area 48.

WG-EMM-99/44
Fatty acid signature analysis from the milk of Antarctic fur seals and southern elephant seals from South Georgia: implications for diet determination. D.J. Brown, I.L. Boyd, G.C. Cripps and P.J. Butler (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, and School of Biological Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, United Kingdom), 33 pp. *Mar. Ecol. Prog. Ser.*, submitted (English).

Fatty acid signature analysis (FASA) makes use of specific fatty acids, as well as entire profiles, to study dietary relationships at different trophic levels. Previously, FASA has been used in marine ecosystems in which diet determination by more direct methods is difficult and sometimes misleading. This study examined fatty acid profiles in milk from two species of pinniped from the Southern Ocean, that were expected to have highly contrasting diets. Milk samples were collected from Antarctic fur seals (*Arctocephalus gazella*) in three consecutive years, from 1991 to 1993 (n = 72) and from southern elephant seals (*Miroungaleonina*) in 1988 (n = 53) at South Georgia. Lipids were extracted and fatty acid profiles determined by temperature-programmed gas chromatography. Possible prey species collected from waters around South Georgia were also analysed. Cluster analysis as well as classification and regression trees (CART) indicated that profiles from fur seals and elephant seals were significantly different. Southern elephant seal data could be distinguished from Antarctic fur seals by lower levels of the fatty acids 16:4 *n*1, 18:2 *n*6, 18:4 *n*3, 18:4 *n*1 and 20:5 *n*3 and by higher levels of 18:0, 18:1 *n*9/*n*11 (i.e. 18:1 *n*9 co-eluting with 18:1 *n*11) and 20:1 *n*9. Fatty acid signatures from the milk of Antarctic fur seals were closest to krill and fish species that were also known to feed on krill. Southern elephant seal fatty acid profiles were closest to species that are not known as krill predators such as larger nototheniids and myctophids. The fatty acid profiles of Antarctic fur seals showed considerable inter- and intra-annual variability which was congruent with diet variability detected using scat analyses. Southern elephant seals showed little variation in profile through lactation. In contrast to previous diet analyses based on examination of stomach contents, the results from FASA were consistent with a fish-based diet for southern elephant seals.

WG-EMM-99/45
An examination of variance and sample size for female Antarctic fur seal trip durations. M.E. Goebel (Antarctic Ecosystem Research Group, NOAA/NMFS, Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038,

USA), 11 pp. (English, unpublished).

This paper uses power analysis and bootstrap functions to examine the importance of sample size in detecting differences between two years of fur seal trip duration data. Female foraging trip duration for the first six trips to sea for 1997/98 (n = 30) and 1998/99 (n = 31) at Cape Shirreff, Livingston Island, was used to calculate minimum sample sizes necessary to detect differences from year to year. A bootstrap function was used to examine the effect of sample size on variance. Currently CCAMLR Ecosystem Monitoring Program Standard Method C1.2 for measuring fur seal trip duration sets the sample size at 40 females. Based on my results, I propose incorporating some flexibility in sample size and suggest changing the protocol from 40 to 25–40 females.

WG-EMM-99/46
The effect of different methodologies used in penguin diet studies at three US AMLR predator research sites: Admiralty Bay, Palmer Station and Cape Shirreff. W. Trivelpiece, S. Trivelpiece and K. Salwicka (Antarctic Ecosystem Research Group, Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), 35 pp.

Diet studies are a key component of the CCAMLR predator monitoring program as they provide direct assessments of the prey types and amounts of importance to predators, which, in turn, are hypothesised to influence variability in related parameters such as breeding success, foraging trip duration and chick fledging weight. Given the importance and interdependence of diet studies with regard to monitoring work, we compared data on stomach weights and prey types among three US AMLR land-based predator study sites in the Antarctic Peninsula region where different methodologies were used to select, pump and sort the diet samples. At Palmer Station, Adélie penguins selected for diet sampling were not confirmed to be breeding, while all Adélie and chinstrap penguins selected for diet sampling at Admiralty Bay and Cape Shirreff were confirmed breeders. Adélie penguins at Palmer Station had significantly smaller mean stomach weights (349 versus 550 g) and a significantly higher proportion of birds with small (<200 g) stomach weights (15% versus 1%), compared to Admiralty Bay. In contrast, no significant differences in chinstrap penguin stomach weights were found between Admiralty Bay and Cape Shirreff (593 versus 610 g respectively), where all birds selected were confirmed breeders. We found a significant positive correlation between Adélie penguin stomach weights and chick fledging weights at Admiralty Bay; no such relationship was found in the Palmer Station data. The significantly lower stomach weights of Adélie penguins at Palmer Station were likely the result of including non-breeding birds in the diet samples. This significantly reduced the mean meal size reported and masked any correlation among food load sizes, provisioning rates and chick fledging weights.

WG-EMM-99/47
AMLR 1998/99 field season report: objectives, accomplishments and tentative conclusions. USA, 16 pp. (English, unpublished).

WG-EMM-99/48
CPUE and body length of Antarctic krill during the 1997/98 season in Area 48. S. Kawaguchi and M. Naganobu (National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan), 13 pp. (English, unpublished).

This paper summarises data on Japanese krill catches during austral summer through winter of the 1997/98 season in Area 48. The fishing grounds were situated around the South Shetland Islands, west of the Antarctic Peninsula, and around the South Orkney Islands from mid-December to mid-May. From late May till late June, fishing took place to the north of the South Shetland Islands and northeast of South Georgia. Size composition differed between the areas. To the west of the Antarctic Peninsula, the modal size was approximately 50 mm, with a small size range. Around the South Shetland and the South Orkney Islands, the size range was from 30 to 50 mm, and modal size differed between the periods. To the northeast of South Georgia, a single mode (approximately 37 to 39 mm) with a small range was observed. Variations in CPUE were dramatic for some vessels, but tended to

increase over time. The main reason for the variations of the CPUE between the vessels was thought to be due to differences in the fishing grounds.

WG-EMM-99/49
Plan for the eighth Antarctic survey by the RV *Kaiyo Maru*, Japan, in 1999/2000. M. Naganobu, S. Kawaguchi, T. Kameda, Y. Takao and N. Iguchi (National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan), 4 pp. (English, unpublished).

WG-EMM-99/50
An index of per capita recruitment. R. Hewitt (Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), 22 pp. *CCAMLR Science*, submitted (English).

An index of per capita recruitment (*PCR*) is proposed such that

$$PCR_{y-1} = \frac{R1_y}{(1 - R1_y)e^M}$$

where $R1$ is the proportion of age-1 animals sampled in year y, and M is the post-recruit mortality rate. The intent of the index is to facilitate investigation of reproductive success and the factors postulated to affect it. The formulation of *PCR* is based on the assumptions that: (i) post-recruit mortality does not vary over age or between years; (ii) 100% of age-1 animals spawn; (iii) a representative sample of the population is available; and (iv) the proportion of age-1 animals in the sample can be determined unambiguously. Normal, log-normal and uniform probability distributions of $R1$, and three levels of M, were assumed in order to investigate the resulting distributions of *PCR*. Distributions of *PCR* are skewed toward higher values such that the dynamic range of *PCR* is largest with high values of $R1$; increasing M tends to offset this effect but only slightly. A simple population model was then constructed to test the sensitivity of *PCR* to relaxation of its underlying assumptions. *PCR* is not biased relative to recruits per spawner when mortality is constant over all ages and years, and when all age-1 animals spawn. These conclusions are insensitive to changes in the shape of the functional relationship between spawners and recruits. *PCR* is biased low with age-specific decline in mortality and reduction in the proportion of age-1 spawners. Introducing year-to-year random variability in both mortality and proportion of age-1 spawners resulted in broader distributions of *PCR* relative to recruits per spawner but did not appear to introduce additional bias. On average, *PCR* will underestimate recruits per spawner by 30% if reasonable assumptions are made regarding the variability of mortality and the proportion of age-1 spawners. The effectiveness of *PCR* to track changes in recruits per spawner over time was confirmed by introducing cycles in the shape of the functional relationship between spawners and recruits. *PCR* was also able to track cycles in recruits per spawner after a 20% random sampling error was added to the value of $R1$ used in the calculation of *PCR* and year-to-year random variability in mortality and proportion of age-1 spawners was introduced, although errors were larger. A time series of *PCR* for Antarctic krill sampled in the vicinity of the South Shetland Islands from 1979 to 1998 is presented.

WG-EMM-99/51
An idea to incorporate potential recruitment in the krill density model. S. Kawaguchi and M. Naganobu (National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan), 10 pp. *CCAMLR Science*, submitted (English).

A krill density model suggested during WG-EMM in 1998,

$$D_y \cdot (1 - R1) - D_{y-1} \cdot e^{-M} = 0,$$

still involved uncertainties regarding age-1 krill. This paper proposes improving on the model by taking the uncertainties into account, and assuming a reasonable mortality. The model suggests that if we expect the currently accepted values of mortality M (0.8–1.0), the potential proportional recruitment should be larger than the observed values. Although potential recruitments were incorporated, and a reasonable mortality was used in the model, the dramatic variation of densities after the 1994/95 season could not be satisfactorily explained.

WG-EMM-99/52
Relationship between Antarctic krill (*Euphausia superba*) variability and

westerly fluctuations and ozone depletion in the Antarctic Peninsula area. M. Naganobu, K. Kutsuwada, Y. Sasai, T. Taguchi and V. Siegel. *J. Geo. Res.*, in press (English).

An assessment of the environmental processes influencing variability in the recruitment and density of Antarctic krill (*Euphausia superba*) is important, as variability in krill stocks affects the Antarctic marine ecosystem as a whole. We have assessed variability in krill recruitment and density with hypothesised environmental factors, including strength of westerly winds (westerlies) determined from sea level pressure differences across the Drake Passage, sea-ice cover, and ozone depletion. We found a significant positive correlation between krill recruitment in the Antarctic Peninsula area and the strength of westerlies during 1982–1998. Years with strong westerlies during the austral summer season resulted in high krill recruitment in 1987/1988, 1990/1991 and 1994/1995, while the years of weak westerlies resulted in low krill recruitment in 1982/1983, 1988/1989, 1992/1993 and 1996/1997. The strength of westerlies was significantly related to recruitment of 1-year-old krill (r = 0.57) and 2-year-old krill (r = 0.69) with a level of significance of 5%. In addition, the strength of westerlies also had a strong correlation with chlorophyll *a* (r = 0.63) and sea-ice cover with a 1-year time lag (r = 0.67). The strength of westerlies is considered to be a key environmental factor. We also found significant correlations between krill density in the Antarctic Peninsula area and the Antarctic ozone depletion parameters during 1977–1997 (e.g. total ozone in October at Faraday/Vernadsky Station of r = 0.76 with a level of significance of 1%). We suspect that ozone depletion impacts directly and/or indirectly on the variability in krill density.

WG-EMM-99/53
Note: time series of the extent of polynyas in the Antarctic Ocean. K. Segawa and M. Naganobu (National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424-8633, Japan), 3 pp. (English, unpublished).

WG-EMM-99/54
Observations of a large number of icebergs in krill fishing grounds (Subarea 48.1) in May 1999. Japan Deep Sea Trawlers Association, 2 pp. (English, unpublished).

WG-EMM-99/55
Distribution and abundance of Antarctic krill (*Euphausia superba*) around the South Shetland Islands, Antarctic Ocean. D. Kang, D. Hwang and S. Kim (Polar Research Center, Korea Ocean Research and Development Institute, Ansan PO Box 29, 425-600, Korea), 6 pp. (English, unpublished), (abstract not available).

WG-EMM-99/56
Modelling the dynamics of krill populations in the Antarctic Peninsula region. E.J. Murphy, A.J. Constable and D.J. Agnew (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 24 pp. (English, unpublished).

The current long-term estimates of mean recruitment rates suggest that the population is unsustainable, as these rates are too low to sustain the estimated mortality rate. The variable annual estimates of recruitment to the population can be used to model, in detail, interannual variation in the population dynamics of krill, and estimate the expected mortality rates. A number of models of the population dynamics of krill are used to assess to what extent they can explain the observed changes in the density of the population in the Antarctic Peninsula region. Two approaches have been explored: the first uses the bulk density estimates and uses a non-linear regression method to estimate the mortality rate. The second method develops a fully age-structured population model and uses only the recruitment data to develop a model of the long-term dynamics. Data on the recruitment of the first and second age groups were used to derive different estimates of mortality rates. Both model approaches, applied to the recruitment data for the first age class, produced an instantaneous mortality rate estimate of approximately 0.6 (≈43% per annum). In

both cases, however, the mortality rate estimate is poorly constrained in a range from about 0.3 to 1.0 (26–63%), and the long-term trajectories of density estimated by the models give a relatively poor fit to the observed data. Using the recruitment data for the second age class produced higher mortality rate estimates of between 0.8 and 1.0 (59–63%) and produced better fits to the observed density changes. The need for caution in interpreting the model results was emphasised by an analysis of their sensitivity, which showed that the density data strongly constrain the model trajectories, which are themselves less sensitive to changes in the recruitment rates.

WG-EMM-99/57
Penguins, fur seals and fishing: prey requirements and potential competition in the South Shetland Islands, Antarctica. D.A. Croll and B.R. Tershy. *Polar Biol.*, 19: 365–374, 1998 (English).

Antarctic and sub-Antarctic seabirds, marine mammals, and human fisheries concentrate their foraging efforts on a single species, Antarctic krill (*Euphausia superba*). Because these predators may have a significant effect on krill abundance, we estimated the energy and prey requirements of Adélie (*Pygoscelis adeliae*), chinstrap (*Pygoscelis antarctica*), and gentoo (*Pygoscelis papua*) penguins and female Antarctic fur seals (*Arctocephalus gazella*) breeding on the South Shetland Islands, Antarctica and compared these estimates with catch statistics from the Antarctic krill fishery. Published data on field metabolic rate, population size, diet, prey energy content, and metabolic efficiency were used to estimate prey requirements of these breeding, adult, land-based predators and their dependent offspring. Due to their large population size, chinstrap penguins were the most significant krill predators during the period examined, consuming an estimated 7.8×10^8 kg krill, followed by Adélie penguins (3.1×10^7 kg), gentoo penguins (1.2×10^7 kg), and Antarctic fur seals (3.6×10^6 kg). Total consumption of all land-based predators on the South Shetland Islands was estimated at 8.3×10^8 kg krill. The commercial krill fishery harvest in the South Shetland Island region (1.0×10^8 kg) was approximately 12% of this. Commercial harvest coincides seasonally and spatially with peak penguin and fur seal prey demands, and may affect prey availability to penguins and fur seals. This differs from the conclusions of Ichii et al. who asserted that the potential for competition between South Shetland predators and the commercial krill fishery is low.

WG-EMM-99/58
Marine ecosystem sensitivity to climate change. R.C. Smith, D. Ainley, K. Baker, E. Domack, S. Emslie, B. Fraser, J. Kennett, A. Leventer, E. Mosley-Thompson, S. Stammerjohn and M. Vernet. *BioScience*, 49 (5), 1999 (English), (abstract not available).

WG-EMM-99/59
Susceptibility to oxidative stress in different species of Antarctic birds: preliminary results. S. Corsolini, F. Regoli, S. Olmastroni, M. Nigro and S. Focardi (Dipartimento di Biologia Ambientale, Università di Siena, Italy), 8 pp. (English, unpublished).

Antioxidant defences in aerobic organisms represent the detoxification pathway against toxicity of reactive oxygen species (ROS). These highly reactive molecules are normally produced during the 4-electron reduction of molecular oxygen to water associated with oxidative phosphorylation and also during the activity of several enzymatic systems which produce ROS as intermediates. If the antioxidant capacity is exceeded (i.e. as a consequence of enhanced intracellular formation of ROS) a pathological condition, generally known as oxidative stress, may arise.

This preliminary work provides a comparison of the susceptibility of Adélie penguins (*Pygoscelis adeliae*) and south polar skuas (*Catharacta maccormicki*) breeding at Edmonson Point (Wood Bay, Ross Sea) to oxidative stress. At the time of sampling, Adélie penguins were rearing chicks; as for skuas, predation on eggs and chicks makes this period of their biological cycle also very stressful.

In the framework of the Italian Research Program in Antarctica (PNRA), blood samples were collected during the austral summer of 1998/99 and the Total Oxyradical Scavenging Capacity (TOSC) analysed. The TOSC assay, measuring the capability

of biological samples to neutralise different oxyradicals, has recently been standardised to provide a quantifiable value of biological resistance to toxicity of ROS.

Penguins exhibited a higher scavenging capacity towards peroxyl radicals than south polar skuas. The greater resistance to toxicity of oxyradicals might suggest that penguins are naturally exposed to a higher basal prooxidant pressure than skuas.

WG-EMM-99/60
Breeding biology of Adélie penguins *(Pygoscelis adeliae)* at Edmonson Point CEMP site (Ross Sea, Antarctica): report of the first five years. S. Olmastroni, S. Corsolini, F. Pezzo, S. Focardi and K.R. Kerry (Dipartimento di Biologia Ambientale, Università di Siena, Italy), 9 pp. (English, unpublished).

During 1998/99 austral summer the Adélie penguin monitoring program was carried out for the fifth year. The study site was located in the Adélie penguin (*Pygoscelis adeliae*) colony at Edmonson Point (74°20'56.7"S, 165°08'10.03"E). The aim of this research was to obtain CEMP data and data on the feeding ecology of the Adélie penguin. The program was established to investigate the possibility that the harvest of krill may impact on the reproductive success of its major predators, in this instance the Adélie penguin. It is believed that any such impact will be difficult to detect initially because this species is long-lived and changes which may affect long-term survival will be subtle. Large sample sizes and the continuation of monitoring over a long period of time will be required to detect changes. The penguin colony was studied in terms of colony layout, breeding chronology, foraging trip duration, feeding localities and diet composition of breeding males and females. Penguins were monitored using satellite transmitters, time-depth recorders and electronic tagging. An Automated Penguin Monitoring System (APMS) was used to record the weight, identity and direction of penguins as they move between the sea and their breeding colony and these data were supported by direct observations. The penguins at Edmonson Point are guided by small fences to cross the weighbridge. This enables researchers to monitor all birds which enter the study area of 500 to 600 nests.

To date, the results of this study have enabled colony trends and breeding biology to be documented and have shown gender differences in foraging strategies during the various stages of the reproductive period and between different study seasons. Moreover the automated system enabled collection of baseline data on the Edmonson Point penguin population with reduced disturbance of the colony by researchers.

Working Group on Fish Stock Assessment

WG-FSA-99/4
Data and resources available to WG-FSA-99. CCAMLR Secretariat, 2 pp. (English, unpublished).

WG-FSA-99/5
Results of experimental trials of bird by-catch reduction methods conducted by the UK-registered longliner *Argos Helena* in Subarea 48.3. D.J. Agnew, A. Black, J.P. Croxall and G. Parkes (Renewable Resources Assessment Group, Imperial College, London, United Kingdom), 18 pp. *CCAMLR Science*, submitted (English).

A series of experiments were carried out in February 1999 at South Georgia (CCAMLR Subarea 48.3) to examine the effects of different weighting regimes on the incidental mortality of birds caught on longlines fishing for toothfish. Three regimes were examined, with weights of 4.25 kg, 8.5 kg and 12.75 kg attached at 40 m intervals on a Spanish-rigged longline. There was a significant reduction in bird mortality when 8.5 kg was used compared to 4.25 kg, but no further significant reduction when 12.75 kg was used. Therefore, to minimise seabird by-catch, line-weighting regimes of at least 0.21 $kg.m^{-1}$ (8.5 kg every 40 m) should be used. There was some suggestion from the results that seabird by-catch on lines using effective weighting regimes may be even further reduced where all lines being set in

the vicinity use effective line-weighting regimes. The importance of good design in experiments of this type is emphasised, because even though conditions may be held as constant as possible within experiments, the ability to separate treatment effects from other sources of variation (e.g. environmental factors) must be preserved.

WG-FSA-99/6
Off the hook? Initiative to reduce seabird by-catch in longline fisheries. J. Cooper, J.P. Croxall and K.S. Rivera. In: Melvin, E.F. and J.K. Parrish (Eds). *Proceedings of the Symposium on Seabird By-catch: Trends, Roadblocks and Solutions*. Fairbanks: Alaska Sea Grant Program, submitted (English).

The recent history of global initiatives to reduce seabird by-catch in longline fisheries are reviewed, highlighting in turn the activities of environmental and industry non-governmental organisations (NGOs), national governments and intergovernmental bodies. At least 40 species of seabirds, especially albatrosses and petrels, are affected, with unsustainable mortality rates in a number leading to population decreases. An International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries, adopted by the Food and Agriculture Organization of the United Nations in June 1999, has much promise for effectively addressing the problem, if nations are willing to develop and implement it. Environmental NGOs and scientists should collaborate with the fishing industry to assist governments (and intergovernmental bodies where appropriate) to implement National Plans of Action in a way that would solve the problem and thereby keep the world's seabirds off the hook.

WG-FSA-99/9
Fishery information for WG-FSA-99. CCAMLR Secretariat, 32 pp. (English, unpublished).

WG-FSA-99/10
A summary of observations on board longline vessels operating within the CCAMLR Convention Area. CCAMLR Secretariat, 11 pp. (English, unpublished).

WG-FSA-99/11
Summary of observations aboard trawl vessels operating in the Convention Area during the 1998/99 season. CCAMLR Secretariat, 5 pp. (English, unpublished).

WG-FSA-99/12
A summary of observations on compliance with Conservation Measures 29/XVI and 63/XV. CCAMLR Secretariat, 8 pp. (English, unpublished).

WG-FSA-99/13
Estimates of seabed areas within the range of distribution of *Dissostichus* spp. CCAMLR Secretariat, 4 pp. (English, unpublished).

WG-FSA-99/14
Research survey data. CCAMLR Secretariat, 11 pp. (English, unpublished).

WG-FSA-99/15
Catch-weighted length frequencies from commercial data. CCAMLR Secretariat, 25 pp. (English, unpublished).

WG-FSA-99/16
Biological characteristics of Antarctic fish stocks in the southern Scotia Arc region. K.-H. Kock, C.D. Jones and S. Wilhelms (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany), 41 pp. *CCAMLR Science*, submitted (English).

Commercial exploitation of finfish in the southern Scotia Arc took place from 1977/78 to 1989/90 and was in its heyday from 1977/78 to 1981/82. Except for Elephant Island, the state of fish stocks of the southern Scotia Arc region has been accorded little attention until 1998, despite substantial catches in the first four years of the fishery and extensive sampling of these catches. The only scientific surveys of these stocks during these years were conducted by Germany in 1985 and by Spain in 1987 and 1991. More recently, the US Antarctic Marine Living Resources Programme carried out two extensive surveys around Elephant Island and the lower South Shetland Islands in 1998 and around the South Orkney Islands in 1999.

In this paper, the authors present new data on species composition, species assemblages, length composition, length–weight relationships, length at sexual maturity and length at first spawning, gonadosomatic indices and oocyte diameter.

Lesser Antarctic species predominate in the fish fauna. Their species assemblages, however, differed by up to 55–60% from one shelf area to the other, mostly due to differences in the occurrence of the abundant species on each shelf area and the increase in the number of high-Antarctic species in the South Orkney Islands. Length compositions and the proportion of large (= old) specimens in the populations provided no evidence of illegal fishing since the closure of the region some 10 years ago. Differences in length–weight relationships between areas are primarily due to differences in length compositions of the fish caught, but do not suggest substantial geographical differences in length to weight growth. Differences in estimates of length at sexual maturity and length at first spawning indicate that in some species final maturation of the gonads takes one year or more, whereas in others gonad maturation is completed within one season. Length at sexual maturity and length at first spawning in *Champsocephalus gunnari* is one year later on the southerly grounds than at South Georgia. The distribution of gonadosomatic indices in March suggested that *Lepidonotothen squamifrons* was spawning while *Trematomus hansoni* was already coming to the end of its reproductive season. *Chionodraco rastrospinosus* and *Trematomus eulepidotus* were close to spawning. Other species, such as *Notothenia rossii* and *Pseudochaenichthys georgianus* spawn at least one to two months later than at South Georgia. Channichthyids (except *C. gunnari*) and *N. rossii* and N. *coriiceps* have egg diameters of 4.3 to 5.2 mm at spawning. *Trematomus* species usually have egg diameters of 2.8 to 3.2 mm while in species of the genera *Gobionotothen* and *Lepidonotothen,* egg diameters rarely exceed 2 mm. Measurements of oocyte diameters confirmed the findings on spawning time estimated from gonadosomatic indices.

WG-FSA-99/17 Rev. 1
United Kingdom research under way on Southern Ocean seabirds vulnerable to fisheries interactions. J.P. Croxall (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 5 pp. (English, unpublished).

WG-FSA-99/18
Seabird mortality on longlines in Australian waters: a case study of progress and policy. R. Gales, N.P. Brothers, T. Reid, D. Pemberton and G.B. Baker. In: Adams, N.J. and R.H. Slotow (Eds). *Proc. 22 Int. Ornithol. Congr.*, Durban: 648–675. BirdLife South Africa, Johannesburg, 1999 (English).

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

seabird by-catch and/or adoption of mitigation methods has been slow. This is a cause for concern, given that awareness of the seabird by-catch issue has risen rapidly in ten years. In analysing seabird by-catch data it is important to understand the limitations of observer-derived datasets. In particular, large amounts of data are necessary to gain clear insights into the suite of species impacted by a fishery, and the effect of different fishing gear, environmental variables, and the mitigation measures employed. In many cases, it is unlikely that such data will be available for a fishery. To overcome some of these problems, we recommend the retention of all seabird carcasses for accurate identification and processing of samples, and also a pragmatic approach to the assessment and implementation of mitigation measures. The implementation and efficacy of the existing mitigation measures are discussed, together with the approach taken by Australia in preparing a Threat Abatement Plan to mitigate the threat posed to seabirds by oceanic longline fishing. In recognising the need for international action to address the decline in albatross populations, the Australian Government is pursuing such action through international fora such as the Convention for Conservation of Migratory Species of Wild Animals, the Ecologically Related Species Working Group of the Commission for the Conservation of Southern Bluefin Tuna and the IMALF of the Convention for the Conservation of Antarctic Marine Living Resources.

WG-FSA-99/19
Quantifying habitat use in satellite-tracked pelagic seabirds: application of kernel estimation to albatross locations. A.G. Wood, B. Naef-Daenzer, P.A. Prince and J.P. Croxall (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 19 pp. (English, unpublished).

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

WG-FSA-99/20
Foraging location and range of white-chinned petrels (*Procellaria aequinoctialis*) breeding in the South Atlantic. S.D. Berrow, A.G. Wood and P.A. Prince (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 23 pp. (English, unpublished).

The foraging range and principal feeding areas of white-chinned petrels breeding at South Georgia were determined using satellite telemetry. Foraging trips during incubation lasted 12 to 15 days and covered 3 000–8 000 km, and 2 to 11 days and 1 100–5 900 km during chick rearing. Adults covered less distance per day during chick rearing (71 km) than during incubation (91 km), but the distance covered at night (47%) was the same. Mean (31 to 34 km/h) and maximum (80 km/h) flight velocities were similar during both periods of the breeding season and during day and night. Between incubation shifts, white-chinned petrels travelled to the Patagonian shelf; during chick rearing they forage more extensively. Most locations were between 30°–55°W and 52°–60°W around South Georgia/Shag Rocks and south to the South Orkney Islands. Diet samples from known foraging locations suggested that birds fed mainly on krill and squid. They caught the squid *Brachioteuthis picta* and *Galiteuthis glacialis* around Shag Rocks/South Georgia and also at sites close to the South Orkney Islands and *Illex argentinus* on the Patagonian shelf. After breeding failure, adults dispersed south to the South Orkney Islands, then west to the Falkland/Malvinas Islands. This study confirms that breeding

white-chinned petrels are amongst the widest-ranging of seabirds; they may minimise competition with other Procellariiformes in the South Atlantic by their more extensive foraging range. The nature and extent of their range also brings substantial risk of a high mortality rate in South Atlantic longline fisheries.

WG-FSA-99/21
Areas and scales of interactions between albatrosses and the marine environment: species, populations and sexes. P.A. Prince, H. Weimerskirch, A.G. Wood and J.P. Croxall. In: Adams, N.J. and R.H. Slotow (Eds). *Proc. 22 Int. Ornithol. Congr.*, Durban: 2001–2020. BirdLife South Africa, Johannesburg, 1999 (English).

Until recently, little has been known about how albatrosses organise their time at sea. Satellite tracking studies of albatrosses, coupled with the use of activity recorders, are providing unique data on the scales of interactions between albatrosses and the marine habitat, ranging from the total realised annual home range to favoured locations for feeding. Home ranges may differ between species by orders-of-magnitude, as exemplified by data for black-browed, grey-headed and wandering albatrosses, *Diomedea melanophrys*, *D. chrysostoma* and *D. exulans*, breeding at South Georgia (South Atlantic Ocean), Iles Crozet and Kerguelen (South Indian Ocean). For wandering albatrosses, we also examine seasonal variation in the overall ranges and restricted foraging areas for birds of different sexes and populations. The data for the three species illustrate the diversity of spatial scales of interaction and also the variation in the nature of features of the marine environment targeted by a single seabird species. These range from shelf and shelf-slope, to frontal systems to basin-wide searches using quasi-random movements. The resulting patterns are reviewed in terms of the foraging strategies of albatrosses, and in relation to their conservation implications, particularly in respect of interactions with fisheries.

WG-FSA-99/22
Seabird by-catch in the Patagonian toothfish longline fishery at the Prince Edward Islands: 1998–1999. P.G. Ryan and B.P. Watkins (Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7701, South Africa), 16 pp. (English, unpublished).

Longline fishing for Patagonian toothfish (*Dissostichus eleginoides*) in the South African Exclusive Economic Zone around the Prince Edward Islands commenced in 1996. This paper summarises seabird by-catch during the year July 1998 to June 1999. Data on seabird by-catch were obtained from fishery observers aboard all 11 sanctioned fishing trips, representing a fishing effort of 5.1 million hooks. This is 19% more than the number of hooks set in 1997/98, but observers reported only 79 seabirds (15% of the total killed in 1997/98) as having been killed. Average seabird by-catch rate by sanctioned vessels was 0.016 birds/1 000 hooks, compared with 0.289 in 1996/97 and 0.117 in 1997/98. Comparisons between years for the same vessel, using the same gear design and at the same time of year, show marked decreases in seabird by-catch rate during 1998/99.

Birds of five species were reported as having been killed: white-chinned petrels (*Procellaria aequinoctialis*) predominated (79%), giant petrels (*Macronectes* spp.) (13%) and grey petrels (*P. cinerea*) (6%). A worrying development is the increase in numbers of grey petrels (*P. cinerea*) killed (only one prior to this year). Birds were caught on only 3.1% of lines set (n = 1 187). Bird by-catch was primarily linked to daytime sets, with most birds caught in the late afternoon or shortly after dusk. Use of an underwater setting device (a Mustad funnel) significantly reduced bird by-catch to acceptable levels (0.002 birds/1 000 hooks), but it was not tested during the period when seabird by-catch typically peaks (mid- to late summer). An average of 4.5 live birds were caught per 100 hauls; although these were released alive, the much higher catch rate of Spanish double-line gear is cause for concern.

Seabird by-catch rates during 1998/99 are the lowest reported for any toothfish fishery in the Southern Ocean. Continued application of mitigation measures (use of streamer lines, setting lines at night or in conjunction with an underwater setting device) coupled with increasing experience

by both crews and observers undoubtedly contributed to the low by-catch rate. Other factors that might account for the small numbers of birds killed include a switch in fishing to waters more distant from the Prince Edward Islands, and a reduction in the amount of offal released from vessels. The former factor may be especially important during the high-risk late summer period; consideration should be given to limiting fishing within 200 km of the islands during this period. Permit holders should be congratulated for achieving such a low seabird by-catch rate, but continued vigilance is required to ensure that by-catch rates remain at this low level.

WG-FSA-99/23

The incidental catch of seabirds by longline fisheries: worldwide review and technical guidelines for mitigation. N.P. Brothers, J. Cooper and S. Løkkeborg. *FAO Fisheries Circular*, No. 937. FAO, Rome, 1999 (English).

The content of this report was originally prepared as three separate background papers describing longline fisheries of the world, the nature and extent of incidental catch of seabirds in those fisheries and a description of technical and operational measures that can mitigate such incidental catch. An FAO appointed Technical Working Group (TWG) of experts in the field of fishing technology, seabird biology and fisheries management reviewed the content and decided to compile it into one document.

The report, first in general terms, describes the interaction of seabirds with longline fisheries with reference to typical behaviour patterns of seabirds and why and how the incidental longline catch of seabirds has become an international issue.

The various longline fisheries (demersal and pelagic) of the world are described with regard to technology and effort. The pelagic fisheries, which mainly target tunas, swordfish and billfishes are operated widely from temperate to tropical waters in all oceans. The most important demersal fisheries are found in the North Atlantic and the North Pacific but a longline fishery for Patagonian toothfish has been developed in the Southern Ocean over the last few years.

Certain longline fisheries result in large numbers of seabirds being hooked on setting lines. The major 'problem' fisheries are the demersal fisheries of the Northeast Pacific, North Atlantic, Southern Ocean and the Atlantic coast of South America, and the tuna pelagic fisheries of cool temperate seas in the North Pacific and the Southern Ocean. However, data on the incidental catch of seabirds are lacking for a number of longline fisheries, including the Pacific coast of South America, the Mediterranean Sea and in tropical waters of all oceans. Species of seabirds most commonly taken are the albatrosses and large petrels of the family Procellariidae.

A comprehensive number of mitigation measures for reducing the incidental catch of seabirds in longline fisheries has been developed during the past 5–10 years. These are all described in detail in the report. With widespread use of such mitigation measures, a significant reduction in incidental catch of seabirds is achievable at a minimal cost and with much potential financial benefit to longline fisheries.

WG-FSA-99/24

Effect of a shore-based sampling program on *Notothenia coriiceps* populations. R.J. Casaux and E.R. Barrera-Oro (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 10 pp. (English, unpublished).

The effect of an intensive sampling program on an inshore population of *Notothenia coriiceps* was studied at Potter Cove, South Shetland Islands, by comparing catch data taken in successive summers from 1992/93 to 1994/95 in one specific zone (site 1) with those taken in the same summer in two close but not previously sampled zones (sites 2 and 3). The fish were caught with trammel nets under similar sampling conditions (depth, net measurements, bottom type). At site 1, a marked decrease in length (TL) of the fish was observed throughout the whole period. The fish from sites 2 ($\overline{x}$ = 32.4 cm) and 3 ($\overline{x}$ = 31.8 cm) exhibited no significant differences in mean length. They were significantly larger than those from site 1 caught in the summers of 1994/95 ($\overline{x}$ = 28.8 cm) and 1993/94 ($\overline{x}$ = 30.2 cm), but were similar in size to those sampled in the summer of 1992/93 ($\overline{x}$ = 31.7 cm), just when the sampling program started at site 1. Present results show that the size

variations of *N. coriiceps* observed at Potter Cove were not due to a natural decrease of the proportion of larger fish in the population, but related to an intensive sampling effort carried out at one specific site.

WG-FSA-99/25

Foraging ecology of grey-headed mollymawks at Marion Island in relation to longline fishing activity. D.C. Nel, J.L. Nel, P.G. Ryan, N.T.W. Klages, R.P. Wilson and G. Robertson. *Biological Conservation*, submitted (English).

Grey-headed mollymawks (*Thalassarche chrysostoma*) are killed by longline fishing operations in the southern Indian Ocean. We studied the foraging ecology of breeding grey-headed mollymawks at Marion Island by tracking their foraging trips and sampling their diets. During the incubation period, birds made longer foraging trips, mostly towards the subtropical convergence and sub-Antarctic zone. This brought them into contact with areas of intense southern bluefin tuna (*Thunnus maccoyii*) longline fishing. During the early post-guard phase, foraging trips were shorter and to the southwest of the island, in the Polar Frontal and Antarctic zones. Short foraging trips (<2 days) during this period were made within the area of known Patagonian toothfish (*Dissostichus eleginoides*) longline fisheries around Marion Island. Diet samples during this period revealed a predominance of species associated with the Polar Front and waters to the south of it. The presence of the ommastrephid squid *Martialia hyadesi* in this study is in contrast to previous studies at Marion Island and is of conservation importance due the potential commercial exploitation of this squid. Female grey-headed mollymawks spent a higher proportion of their time in areas of intense southern bluefin tuna longline fishing during the incubation period, while males spent more time within the boundaries of Patagonian toothfish sets during the early post-guard phase. This may account for the male-biased mortality of grey-headed mollymawks observed in the toothfish fishery around Marion Island.

WG-FSA-99/26

Factors affecting the number and mortality of seabirds associated with trawlers and longliners in the Kerguelen area. H. Weimerskirch, D. Capdeville and G. Duhamel (Centre National de la Recherche Scientifique, Centre Biologique de Chizé, 79360 Villiers en Bois, France), 51 pp. (English, unpublished).

The factors affecting the number and the mortality of seabirds associated with longliners and trawlers fishing in the Kerguelen area were studied over four successive seasons (1994 to 1997), using observations carried out on board by dedicated observers. Twenty-four species of seabirds were observed to be associated with fishing vessels with an average of 591 birds per observation. The total numbers following a vessel varied from year to year, depending on cloud cover and the presence of offal from longliners. The dumping of offal led to an increase in the number of birds following the vessel, especially since the offal is an easy target for birds. The activity of the vessels also affected the numbers attending, birds being more abundant during line setting and during trawl hauling. The white-chinned petrel was the most abundant seabird associated with vessels, followed by the black-browed albatross, the giant petrel and the cape petrel. The number of white-chinned petrels and black-browed and grey-headed albatrosses following fishing vessels increased through the season, whereas it was the reverse situation for giant petrels and cape petrels. Four species of birds were caught by fishing gear, mainly longlines; in order of importance white-chinned petrels, black-browed, grey-headed and wandering albatrosses. Taking into account the number of birds from each species following longliners and known to be caught incidentally, it appears that some species are more susceptible to being caught than others. White-chinned petrels and grey-headed albatrosses appear to be caught in much larger proportions than could be expected, whereas black-browed albatrosses are caught in lower numbers. Giant petrels were abundant around longliners,

but were never caught. On longliners, most birds were killed when the lines were set during the day or when the deployment of the scaring device was not successful, with an overall figure of 0.47 birds/1 000 hooks. Only one albatross was caught when the lines were set during the night. The white-chinned petrel represented 92.2% of all birds killed by longliners. The number of birds caught varied significantly between months and between years. The type of bait used also affected the catch rate. The catch rate was related to the number of birds following the longliner only for black-browed albatrosses. Most birds killed by trawlers were caught by the netsonde cable. The efficiency of mitigation measures in reducing seabird mortality is discussed and it is stressed that night setting is the most efficient way of reducing mortality and should be enforced everywhere when possible. However, additional methods should be developed to reduce the mortality of species active at night, especially the white-chinned petrel whose populations in the Indian Ocean may be threatened by longline fisheries.

WG-FSA-99/27

French research under way on Southern Ocean seabirds vulnerable to fisheries interactions. H. Weimerskirch (Centre National de la Recherche Scientifique, Centre Biologique de Chizé, 79360 Villiers en Bois, France), 5 pp. (English, unpublished), (abstract not available).

WG-FSA-99/28

Preliminary analysis of seabird by-catch using CCAMLR observer data. D.J. Agnew and J.P. Croxall (Renewable Resources Assessment Group, Imperial College, London, United Kingdom), 17 pp. (English, unpublished).

We used data collected by CCAMLR international scientific observers in 1997 and 1998 to examine potential relationships between seabird incidental mortality rates on longline vessels fishing for *Dissostichus eleginoides* and various factors, including the nature and use of mitigating measures, as well as environmental variables such as time of day and time of year.

Of 3 283 longline sets analysed, only 311 caught birds (9.4%). Data conformed most closely to a delta distribution (many zero values and lognormal distribution of non-zero values) and were analysed using two generalised linear models, a binomial model for presence/absence of seabird catches and a gamma model for the magnitude of non-zero catches.

Sparsity of data precluded analysis of seabirds at a taxon level more detailed than albatrosses and petrels combined. Other analytical difficulties, particularly in using generalised linear models, related to the large number of potentially important factors, the lack of overlap between factors and the fact that fishing has purposely avoided making catches of seabirds. There are, for instance, only three records in the entire dataset where none of the mitigation measures have been used.

The only factors consistently significant were time of year (very few birds caught after April) and use of streamer lines, but the effects of most other factors cannot be fully analysed with the present data. Even vessels using streamer lines and setting at night were found to catch albatrosses occasionally. The 'residual' mortality associated with using all prescribed mitigation measures provides a more useful indication of the success of mitigation measures than general bird by-catch rates.

Given the difficulties of analysing this dataset, especially the problem of very low numbers, of hauls not using mitigation measures and hauls catching birds, experimental approaches to identifying effective mitigation measures may be preferable to post-hoc analysis of observer data.

WG-FSA-99/30

Increase in relative abundance of fjord *Notothenia rossii* in Potter Cove, South Shetland Islands, after the decrease associated with commercial fishing in the area. E.R. Barrera-Oro, E.R. Marschoff and R.J. Casaux (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 13 pp. *CCAMLR Science*, submitted (English).

A program of monitoring demersal fish in inshore sites of the South Shetland Islands has continued in Potter Cove from 1991 to 1999, covering a continuous sampling period of 16 years, and in Harmony Cove, Nelson Island, in the austral summer

1995/96. The decline in trammel net catches of fjord fishes of the species *Notothenia rossii* and *Gobionotothen gibberifrons* in relation to the non-commercially fished *Notothenia coriiceps,* which was already reported for the period 1983 to 1990 in a previous study, is still evident. A trend of increasing *N. rossii* catches was observed, but the actual levels of relative abundance of this species and *G. gibberifrons* are well below those found in the early 1980s. These results are supported by our knowledge of the diet of the piscivorous Antarctic shag *Phalacrocorax bransfieldensis* in the South Shetland–Antarctic Peninsula area in this decade. The most likely explanation for the decrease in recruitment to the inshore sub-populations of *N. rossii* and *G. gibberifrons* in the last 16 years is the effect of the offshore commercial fishery in the area in the late 1970s. This interpretation is consistent with the information on historical offshore commercial fishing and with results of scientific surveys in the area.

WG-FSA-99/31

Notes on the availability of three important finfish species in offshore and inshore waters of the lower South Shetland Islands (Subarea 48.1). C.D. Jones, E.R. Barrera-Oro, E.R. Marschoff and R.J. Casaux (Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, Ca. 92038, USA), 13 pp. (English, unpublished).

In 1998, an offshore scientific trawl survey of bottom fish within the 50 to 500 m isobath of the lower South Shetland Islands (King George Island to Low Island) was conducted. In addition, the abundance of two commercially important Antarctic fish, *Notothenia rossii* and *Gobionotothen gibberifrons,* has been monitored with reference to the abundance of another potentially exploitable fish, *Notothenia coriiceps,* in the lower South Shetland Islands from inshore sites mainly at Potter Cove from 1983 to 1999. These studies have been conducted using trammel nets sampling bottom depths from 5 to 50 m. Information from this trawl survey was compared to the 1998 Potter Cove data to examine potential inshore–offshore relationships for these three species. In general, these two datasets are complementary, and demonstrate well-defined changes in size that take place between inshore and offshore sampling. By combining samples collected from a single year, the sample size and regression range available for length–weight relationships can be increased. However, the value of these data combined in a single dataset for one year is limited. A future offshore survey coupled with inshore sampling would provide a good deal more information, and allow a more direct comparison of the two datasets to be realised, particularly with respect to trends between the three species.

WG-FSA-99/32

Changes in biomass of eight species of finfish around the South Orkney Islands (Subarea 48.2) from three bottom trawl surveys. C.D. Jones, K.-H. Kock and E. Balguerías (National Oceanic and Atmospheric Administration, National Marine Fisheries Service, US Antarctic Marine Living Resources Program, PO Box 271, La Jolla, Ca. 92038, USA), 24 pp. *CCAMLR Science,* submitted (English).

Stocks of finfish around the South Orkney Islands (Subarea 48.2) suffered substantial declines from split-year 1977/78 to 1989/90 when the fishery was open. Scientific bottom trawl surveys of finfish biomass within the 500 m isobath of the South Orkney Islands have been conducted by the Federal Republic of Germany in 1985, Spain in 1991, and USA in 1999. Estimates of total stock biomass were computed for eight species which comprised 98% of survey nominal catch. Biomass levels in March 1999 were compared to previous trawl surveys conducted in February 1985 and January to February 1991. Species examined were *Gobionotothen gibberifrons, Lepidonotothen squamifrons, Pseudochaenichthys georgianus, Champsocephalus gunnari, Chaenocephalus aceratus, Chionodraco rastrospinosus, Notothenia rossii* and *Lepidonotothen larseni.* Although there is substantial variability in point estimates, biomass levels of most species appear to be unchanged or may have declined slightly since 1991. The stock of C. *gunnari* is currently extremely low, while there appears to be a strong signal of recovery for

N. rossii. However, overall levels of biomass indicate very little potential for commercial exploitation at this time.

WG-FSA-99/33
Revised estimates of seabed areas within the 500 m isobath of the South Orkney Islands (Subarea 48.2) and consequences for standing stock biomass estimates of nine species of finfish. C.D. Jones (National Oceanic and Atmospheric Administration, National Marine Fisheries Service, US Antarctic Marine Living Resources Program, PO Box 271, La Jolla, Ca. 92038, USA), 10 pp. *CCAMLR Science*, submitted (English).

A revised bathymetric map of the South Orkney Islands (Subarea 48.2) was generated using several integrated bathymetric databases and newly available acoustic seafloor data. The region extends from 60.2°S–62.2°S latitude and 42.5°–47.5°W longitude. From the integrated datasets, areas of seabed within the 500 m isobath were computed for 50 m depth intervals. Areas were calculated based on interpolated surface area of seabed incorporating seafloor slope. These results were compared to the previously reported estimates of Everson (1997) for the 50–150, 150–250 and 250–500 m depth intervals. The updated estimates are about 1 424 (20%) n miles larger in area within the 50–500 m isobaths than Everson's estimates, though changes in area are specific to the depth interval. There is a corresponding change in estimated biomass within strata when these areas are incorporated into swept-area trawl survey models, though not for total estimated biomass. Of the nine species examined, the point estimate of total biomass increased from 5 to 30% for eight species and decreased by 20% for one.

WG-FSA-99/34
Research under way on South African seabirds vulnerable to fisheries interactions. South Africa, 2 pp. (English, unpublished).

WG-FSA-99/35
Avoidance of incidental mortality of seabirds and the implementation of Conservation Measure 169/XVII in Subarea 88.1 in the 1998/99 season. J. Molloy and N. Smith (Biodiversity Recovery Unit, Department of Conservation, PO Box 10-420, Wellington, New Zealand), 7 pp. (English, unpublished).

New Zealand conducted longline-weighting trials in the 1998/99 fishery for *Dissostichus* spp. in Subarea 88.1. Daylight setting was allowed south of 65°S in Subarea 88.1 under special provisions of Conservation Measure 169/XVII. The provisions included strictly applied line-weighting regimes and rigorous monitoring of line sink rates.

In the trials, two autoline vessels set weighted longlines in Subarea 88.1 between 30 December 1998 and 27 February 1999. Time-depth recorders were used to record the actual sink rate achieved on 30% of all sets. For all sets combined, the average sink rate achieved was greater than the minimum required standard of 0.3 m/s (mean = 0.37 m/s, 1 SD = 0.06, n = 74). Observer coverage was 31% of all hooks hauled and 100% of all sets during the trials. During the trials, zero seabird mortalities were recorded.

The need for further line-weighting trials and the development of new line-weighting technologies is recommended.

WG-FSA-99/36
Risk assessment of wandering albatrosses (*Diomedea exulans*), breeding on Marion Island, to by-catch within CCAMLR statistical areas. D.C. Nel, J. Cooper and G. Robertson (Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7701, South Africa), 4 pp. (English, unpublished), (abstract not available).

WG-FSA-99/37
Longline sink rates on bottom autoline vessels. (Department of Conservation, PO Box 10-420, Wellington, New Zealand), 1 p. poster (English).

WG-FSA-99/38
Sexual dimorphism and sexual segregation in foraging strategies of northern giant petrels (*Macronectes halli*) during incubation. J. González-Solís, J.P. Croxall and A.G. Wood (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United

Kingdom), 36 pp. (English, unpublished).

Giant petrels (*Macronectes* spp.) are the most sexually dimorphic of all seabirds. We used satellite tracking and mass change during incubation to investigate the influence of sexual size dimorphism, in terms of the intersexual food competition hypothesis, on foraging and fasting strategies of northern giant petrels (*Macronectes halli*) at South Georgia. Females foraged at sea, whereas males foraged mainly on the South Georgia coast, scavenging on seal and penguin carcasses. Foraging effort (flight speed, distance covered, duration of foraging trips) was greater for females than for males. In contrast, foraging efficiency (proportionate daily mass gain while foraging) was significantly greater for males than for females. Females were significantly closer to the desertion mass threshold than males and could not compensate for the mass loss during the incubation fast while foraging, suggesting greater incubation costs for females than for males. Both sexes regulated the duration and food intake of foraging trips depending on depletion of body reserves. In males, the total mass gain was best explained by mass at departure and body size. We suggest that sexual segregation of foraging strategies arose from size-related dominance at carcasses, promoting sexual size dimorphism. Our results indicate that sex-specific differences in fasting endurance, contest competition over food and flight metabolic rates are key elements in maintenance of sexual size dimorphism, segregating foraging strategies and presumably reducing competition between sexes.

WG-FSA-99/39

Foraging partitioning between giant petrels (*Macronectes* spp.) and its relationship with breeding population changes at Bird Island, South Georgia. J. González-Solís, J.P. Croxall and A.G. Wood (British Antarctic Survey, Natural Environment Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 40 pp. (English, unpublished).

We tracked by satellite the foraging trips of males and females of the two sibling species of giant petrels, *Macronectes halli* and *M. giganteus*, breeding sympatrically at Bird Island, South Georgia, during the incubation period (November and December). Size of the activity range as well as speed and distance covered on foraging trips were similar between species but lower for males than females in both species. Sex differences agree with previous observations on diet and on attendance at seal carcasses, suggesting that females mainly forage at sea, whereas males mainly scavenge on the coast. Overall, however, foraging ecology of both species seems very similar. Inter-specific competition may be reduced by the limited overlap in the activity range, with southern giant petrels foraging further south than northern giant petrels, suggesting some spatial partitioning in foraging areas. Male northern giant petrels foraged almost exclusively on the South Georgia coast; their strong dependence during the breeding season on fur seals, which have increased exponentially in recent years, may be reflected in their recent population increase at South Georgia. Foraging areas of giant petrels overlapped extensively with longline fishery distribution, confirming their susceptibility to being caught on longline hooks. Females were at higher risk during the study period since they made longer trips and further west than males, into areas where local longline fisheries are more active.

WG-FSA-99/40

Rajid by-catch in the longline fishery for toothfish in Subarea 48.3. D.J. Agnew, J. Taylor and I. Everson (Renewable Resources Assessment Group, Imperial College, London, United Kingdom), 13 pp. (English, unpublished).

In response to concern about rajid by-catch in CCAMLR finfish fisheries, we conducted a preliminary analysis of data collected by UK scientific observers on vessels fishing for toothfish in Subarea 48.3 from April to July 1999. The overall average catch rate of rays was 0.7/1 000 hooks, compared with 34.7/1 000 hooks for toothfish and 2.2/1 000 hooks for grenadier species. Generalised linear models demonstrated that there are significant differences between the catch rates of rays for different vessels, areas and depths in Subarea 48.3. Some vessels, fishing on the northern shelf edges of both Shag Rocks and South Georgia, achieved

average catch rates of over 1 ray/1 000 hooks, and 20 to 30 rays/1 000 toothfish. Catch rates were lowest to the south and east of South Georgia. The two species most frequently found on hooks were *Raja georgiana* and *Bathyraja murrayi*. *R. georgiana* was found in all areas, *B. murrayi* was not found in this study to the east or south of South Georgia. Modal length of *R. georgiana* caught was 65 to 69 cm for males and 80 to 84 cm for females, for *B. murrayi* it was 65 to 69 cm and 70 to 74 cm for males and females respectively.

WG-FSA-99/41
Notification of research vessel activity in the Convention Area. United Kingdom, 10 pp. (English, unpublished).

WG-FSA-99/42 Rev.1
Seabird by-catch in the Patagonian toothfish longline fishery at the Prince Edward Islands: 1998–1999. P.G. Ryan and B.P. Watkins (Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7701, South Africa), 14 pp. (English, unpublished), (abstract not available).

WG-FSA-99/43
Age and growth of Patagonian toothfish (*Dissostichus eleginoides*) and Antarctic toothfish (*D. mawsoni*) in waters from the New Zealand Exclusive Economic Zone to CCAMLR Subarea 88.1. P.L. Horn (National Institute of Water and Atmospheric Research Ltd, PO Box 14-901, Kilbirnie, Wellington, New Zealand), 17 pp. (English, unpublished), (abstract not available).

WG-FSA-99/44
Fishes collected during the 1998/99 exploratory fishery by New Zealand in CCAMLR Subarea 88.1 and registered in the National Fish Collection at the Museum of New Zealand Te Papa Tongarewa. A. Stewart (Fish Section, Museum of New Zealand Te Papa Tongarewa, 135 Taranki Street, Wellington, New Zealand), 5 pp. (English, unpublished), (abstract not available).

WG-FSA-99/45
Assessing the impact of the proposed exploratory fishery for *Dissostichus* spp. in CCAMLR Subarea 88.1 in the 1999/2000 season on the family Rajidae. N. Smith (Science Policy Group, Ministry of Fisheries, PO Box 1020, Wellington, New Zealand), 5 pp. (English, unpublished), (abstract not available).

WG-FSA-99/46
Genetic studies on toothfish (*Dissostichus eleginoides* and *Dissostichus mawsoni*): progress report for CCAMLR. N. Smith (Science Policy Group, Ministry of Fisheries, PO Box 1020, Wellington, New Zealand), 3 pp. (English, unpublished), (abstract not available).

WG-FSA-99/47
Satellite tracking of white-chinned petrels and comparison with other Procellariiformes. A. Catard and H. Weimerskirch. In: Adams, N.J. and R.H. Slotow (Eds). *Proc. 22 Int. Ornithol. Congr.*, Durban: 3008–3023. BirdLife South Africa, Johannesburg, 1999 (English).

The foraging behaviour of 16 white-chinned petrels *Procellariaaequinoctialis* (mass 1 to 1.4 kg) breeding on the Crozet Islands was studied with miniaturised satellite transmitters taped to the back feathers of birds leaving the nest for a foraging trip. The results show that birds breeding in the sub-Antarctic forage in marine environments as diverse as the edge of pack-ice along Antarctica to the Benguela current off South Africa, 2 342 and 3 495 km from their nest, respectively. This is the longest distance from the nest that has been measured for a breeding seabird. The foraging pattern of these petrels are compared with those of several species of albatross, in terms of flight pattern and speeds, diurnal/nocturnal activity and the influence of wind. Albatrosses appear to be more specific in their foraging zones than white-chinned petrels, which appear to range further from the breeding grounds because they move during the day as well as at night. Albatrosses and petrels are threatened by the development of

fisheries in the Southern Ocean and a good knowledge of their foraging zones is essential for conservation management. Indeed, the white-chinned petrel is the commonest species in the by-catch of longliners and their extended foraging range overlaps with fisheries from Antarctic to tropical waters.

WG-FSA-99/48
Use of isoelectric focussing in the identification of Patagonian toothfish (*Dissostichus eleginoides*) specimens (Smitt, 1898) in the Southwest Atlantic. A. Pereira, H. Nion, Y. Marín and O. Pin (Instituto Nacional de Pesca, Constituyente 1497, CC 1612, CP 11200, Montevideo, Uruguay), 1 p. (Spanish, unpublished).

Samples of water-soluble protein were extracted from muscle and crystallin of individual toothfish specimens caught in the fishing zone shared by Argentina and Uruguay and in the southwest region of the Atlantic. These samples were analysed using the isoelectric focusing technique. Fish originating from either region exhibited external morphological characteristics which were so different as to obscure identification of individuals within the species.

Fish muscle and crystallin have a high content of water-soluble proteins which can be separated by electrophoresis. The protein profile resulting from electrophoretic separation is characteristic of the species. Thus, these electrophoretic types may be utilised as molecular markers to identify species.

The electrophoretic types or patterns obtained from muscle and crystallin samples show that fish from both regions undoubtedly belong to *the same species*. However, the existence of intra-species genetic variation cannot be dismissed, though this particular hypothesis should be tested by other methods.

WG-FSA-99/49
Research under way on New Zealand seabirds vulnerable to fisheries interactions. J. Molloy (Biodiversity Recovery Unit, Department of Conservation, PO Box 10-420, Wellington, New Zealand), 4 pp. (English, unpublished), (abstract not available).

WG-FSA-99/50
Variations in condition indices of mackerel icefish at South Georgia from 1972 to 1997. I. Everson and K.-H. Kock (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 16 pp. (English, unpublished), (abstract not available).

WG-FSA-99/51
Undeclared catches of *Dissostichus eleginoides* (compilation of available data). Report of the Subgroup on Illegal, Unregulated and Unreported Fisheries. G. Duhamel, S. Fitch, M. Purves and B.P. Watkins (Laboratoire d'Ichtyologie générale et appliquée, Muséum national d'histoire naturelle, France), 13 pp. (French, unpublished).

It is clear that during the 1998/99 season (1 July 1998 to 30 June 1999) and during the period July to September 1999, undeclared longline fishing for toothfish *(Dissostichus eleginoides)* took place within the CCAMLR Convention Area. More than 25 longliners were implicated in these activities which were concentrated in Area 58. Area 48, and in particular South Georgia (Subarea 48.3), seems to have been somewhat less affected by these activities (D. Agnew, pers. comm.) although consistent reports mention unregulated fishing activities at various times during the year. However, no data are available and it is impossible to assess the extent of these activities in this area. No illegal, unregulated and unreported fishing activities have been detected in Area 88.

WG-FSA-99/52
Protection of young fish and spawning aggregations in the fishery for *Champsocephalus gunnari* in Subarea 48.3 (South Georgia): a discussion. G. Parkes (MRAG Americas Inc., Suite 303, 5445 Mariner Street, Tampa, Fl. 33609-3437, USA), 16 pp. *CCAMLR Science*, submitted (English).

The need to protect young fish and spawning aggregations in fisheries generally, and specifically in the *Champsocephalus gunnari* fishery in Subarea 48.3,

is reviewed. Mechanisms available to achieve these objectives are discussed, including the measures put in place by CCAMLR to date. These measures are re-examined in the light of new information, and a strategy for the future protection of young fish and spawning aggregations of *C. gunnari* in Subarea 48.3 is proposed.

WG-FSA-99/53
Progress in Australian initiatives for the conservation of albatrosses. G.B. Baker, N. Montgomery and A. McNee (Biodiversity Group, Environment Australia, GPO Box 8, Canberra 2601, ACT, Australia), 3 pp. (English, unpublished), (abstract not available).

WG-FSA-99/54
Interannual variation in spawning status of mackerel icefish. I. Everson and K.-H. Kock (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 15 pp. (English, unpublished).

The spawning cycle of mackerel icefish at South Georgia was investigated using results from research surveys and data from commercial fisheries. Samples from January, about four months prior to spawning, gave a poor indication of the proportion of the mature fish in the population which would come into spawning condition. The spawning cycle has been shown to have considerable plasticity and appears to be dependent on food availability.

WG-FSA-99/55 Rev. 1
A comparison of the maturity stages used to estimate the reproductive status of mackerel icefish (*Champsocephalus gunnari*). I. Everson, J. Ellison and K.-H. Kock (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 9 pp. (English, unpublished), (abstract not available).

WG-FSA-99/56
An interlaboratory comparison of ages estimated for *Dissostichus eleginoides* using otoliths. J. Ashford and P.L. Horn (Center for Quantitative Fisheries Ecology, Old Dominion University, 1034 West 45th St, Norfolk, Va. 23529, USA), 7 pp. (English, unpublished).

To examine consistency between laboratories in age estimation of Patagonian toothfish, otoliths were taken from 100 fish caught in the South Atlantic, and transverse sections prepared by baking, then grinding the anterior and posterior sides of the otolith. Ages were estimated from the otoliths by one reader from the Center for Quantitative Fisheries Ecology (CQFE) at Old Dominion University and one reader from the National Institute of Water and Atmospheric Research (NIWA), without auxiliary information: the readers generally read the sections similarly, with 84.7% of the estimates falling within two years or less of each other. Variation in estimates between readers did not increase markedly with age; however, the CQFE reader tended to give higher age estimates than the NIWA reader consistently over the full age range, indicating differences in the criteria used to interpret the first few years of age, possibly in identification of the first annulus.

WG-FSA-99/57
Fishing cruise of the Russian trawler *Zakhar Sorokin* to the Antarctic (Subarea 48.3) from 16 February to 10 March 1999. V.L. Senioukov and P.N. Kochkin (PINRO, 6 Knipovich Street, Murmansk 183763, Russia), 12 pp. (English, unpublished).

From 16 February to 10 March 1999, a large-capacity Russian trawler, *Zakhar Sorokin*, fished for mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.3. During the cruise, 88 hauls were carried out and 264.9 tonnes of *C. gunnari* were caught. 86% of the catch was taken from 28 February to 3 March on the northwestern slope of South Georgia Island, where *C. gunnari* fed actively on Antarctic krill and, therefore, formed dense commercially exploitable concentrations. In this period, catches constituted 3.4 tonnes per trawling hour and 57 tonnes per day of fishing. *C. gunnari* of 27 to 33 cm long were the basis of catches. Total catch of other fish species constituted 9.2 tonnes.

In the opinion of the captain of the Russian vessel and Russian scientists

who have extensive experience in fisheries and research in this area, the results of the cruise show a complex nature of the fishery for this species, but do not prove that the status of *C. gunnari* is poor in Subarea 48.3.

WG-FSA-99/58
On observations of ectoparasites of mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.3 in March 1999. V.L. Senioukov (PINRO, 6 Knipovich Street, Murmansk 183763, Russia), 7 pp. (English, unpublished).

In February and March 1999, the Russian fishing vessel *Zakhar Sorokin* carried out a fishery for mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.3. During the processing of catches taken in the northwestern slope area, two species of parasites were revealed: the copepod *Eubrachiella antarctica* and the leech *Trulliobdella capitis* Brinkman, 1948. Statistical data collected during examination of more than 3 000 specimens of *C. gunnari* have shown that the average infestation of fish with copepods constituted 24.4% and 18.5% with leeches.

WG-FSA-99/59
Relative abundance of seabirds at sea within CCAMLR statistical areas. E.J. Woehler, E.J. Appleyard and D.J. Watts (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 39 pp. (English, unpublished), (abstract not available).

WG-FSA-99/60
Using additional information for the generalised yield model. P.S. Gasiukov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 7 pp. (English, unpublished).

A method of adjusting the generalised yield model (GYM) using additional data from observations, represented as abundance indices, is proposed. Catch per effort data or results of inventory surveys can be used to obtain such indices. General principles of the proposed adjustment consist of a selection of those realisations of GYMs, a certain function of which runs through the set of points defined by confidence intervals of abundance index estimates. To give an example, it is shown that for *Dissostichus eleginoides* from Subarea 48.3, a GYM adjustment to the catch per effort values will give estimates of potential yield (2 500 tonnes), essentially differing from those obtained by means of a standard model (3 500 tonnes).

WG-FSA-99/61
Australian research under way on seabirds vulnerable to fisheries interactions. G.B. Baker (Biodiversity Group, Environment Australia, GPO Box 8, Canberra 2601, ACT, Australia), 6 pp. (English, unpublished), (abstract not available).

WG-FSA-99/62
Report on meetings with Norwegian gear manufacturers Mustad and Fiskevegn. G. Robertson (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 3 pp. (English, unpublished).

WG-FSA-99/63
Variation in standing stock of the mackerel icefish *Champsocephalus gunnari* at South Georgia. I. Everson, G. Parkes, K.-H. Kock and I.L. Boyd. *J. Appl. Ecol.*, 36: 591–603, 1999 (English).

1. Bottom trawl surveys on the South Georgia shelf indicate episodic declines in the abundance of the mackerel icefish *Champsocephalus gunnari* that, since 1990, are not directly attributable to commercial fishing.

2. The greatest effect has been observed in years when krill are known to have been scarce on the South Georgia shelf.

3. It is thought that *C. gunnari* survival is closely related to, but indirectly influenced by, krill availability.

4. Examination of food chain relationships indicates that predation by fur seals is likely to play a major role in the observed changes in *C. gunnari* abundance.

5. Periodic shifts in food chain relationships, involving krill, *C. gunnari* and fur seals, are postulated that could explain the episodic declines in the abundance of *C. gunnari* in the absence of fishing.

6. The study demonstrates how a key predator can have an over-riding impact on

a commercial fish species, highlighting the importance of the ecosystem approach to fisheries management.

WG-FSA-99/64
On the problem of diurnal migrations of some fish species on the South Georgia shelf (Subarea 48.3). I.A. Trunov, Zh.A. Frolkina, M.P. Konstantinova (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 18 pp. *CCAMLR Science*, submitted (English).

The authors present the results of experiments on the South Georgia shelf carried out in the period from 1986 to 1990. The vertical distribution of fry and young individuals (including adult specimens) of *Champsocephalus gunnari, Champsocephalus aceratus, Pseudochaenichthys georgianus* (Channichthiidae family) and *Nototheniops larseni* (Nototheniidae family) was studied daily at six stations. The most representative data obtained were for *C. gunnari* and *N. larseni*. The vertical migration trend was the most distinctive in *C. gunnari* fry. The individuals moved upwards in the water column before sunrise and completed their return migration before sunset. Juvenile and adult individuals were found in the pre-bottom layer by day, and were present in small quantities in the water column, including the superficial layer, at night. The vertical daily migration pattern of *N. larseni* fry was not very obvious. It was distinctly observed in juvenile and adult individuals: they remained close to the bottom during the day and were not caught within the pre-bottom layer. At night (after sunset) they ascended into the water column where they were found in the superficial layer. No substantial variations in medium-sized fry of either species were observed at different depth levels during 24-hour periods. *C. aceratus* fry were found throughout the water column during 24-hour periods, being mainly observed within the two lower depth levels. Juvenile and adult individuals remained close to the bottom by day and were found throughout the water column at night. However, major catches were taken within the limits of the pre-bottom depth level, being larger than those taken by day. *P. georgianus* fry were caught over 24 hours in almost equal quantities in the pre-bottom layer by day and at higher depth levels at night. Juvenile and adult individuals were almost never found during the day, being observed throughout the water column at night and mainly caught within the pre-bottom layer.

WG-FSA-99/65
Distribution and some biological features of mackerel icefish (*Champsocephalus gunnari*) at different life cycle stages in the South Georgia subarea. Zh.A. Frolkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia), 55 pp. *CCAMLR Science*, submitted (English).

The results of mackerel icefish (*Champsocephalus gunnari)* ecology were summarised for a period of over 20 years of study within the South Georgia subarea. Ecological aspects were considered, taking into account spatial–temporal variability. The functional structure of *C. gunnari* distribution area was described on the basis of juvenile fish distribution at different physiological stages. Juvenile fish are mainly found in the south, immature fish in the east and southwest, while adults are found to the north of the shelf. It was revealed that the life mode changed from pelagic occurring at early life stages, to near-bottom – pelagic once the fish attain 20 cm length and near-bottom at lengths of over 40 cm. *C. gunnari* undertakes vertical migrations: young fish above 4 cm in length are found within 75 cm of the bottom and migrate into shallower depths in the daytime and back to the bottom at night. Immature fish are found in the water column for most of the time and are caught using a midwater trawl. Their diurnal migration pattern is similar to that of the larger fish. Diurnal migrations of adult fish are opposite to those of juveniles: they migrate to the bottom in the daytime and up into the water column at night. Mature fish form dense aggregations near the bottom where they are fished using bottom gear. The annual cycle of fish can be subdivided into three periods: feeding (October to March), spawning (April to June) and wintering (July to September). Feeding migrations of fish of over 25 cm in length occur on the northern shelf and are associated with migrations of krill being the main food item of *C. gunnari*. Two major

directions of pre-spawning migrations were revealed: from the northeast to coastal areas in the northern and northeastern part and to the open shelf areas in the southeast, while in the northwest part the fish migrated westwards and southwestwards. Post-spawning migrations took the opposite direction. Overwintering of *C. gunnari* occurred at the depths of 200 to 250 m far from the coast, mainly to the north of South Georgia.

WG-FSA-99/66
Extract from *Natural History of British Fishes*. (submitted by I. Everson). In: Buckland, F. *Natural History of British Fishes; their Structure, Economic Uses, and Capture by Net and Rod*. Society for Promoting Christian Knowledge, London, 1906 (English).

WG-FSA-99/67
Draft working paper on scientific issues related to a unified regulatory framework for CCAMLR based on stages of fishery development. Ad hoc Task Group on the Development of a Unified Regulatory Framework for CCAMLR. 10 pp. (English, unpublished).

WG-FSA-99/68
Revision of biological and population parameters for *Dissostichus eleginoides* on the Heard Island Plateau (Division 58.5.2) based on a comprehensive survey of fishing grounds and recruitment areas in the region. A.J. Constable, R. Williams, T. Lamb and E.M. van Wijk (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 23 pp. (English, unpublished).

Based on a survey of *Dissostichus eleginoides* in the Heard Island region in April 1999 and information from an observer program on the commercial fishery begun in 1997, this paper aims (i) to provide an assessment of biomass and stock structure in the vicinity of Heard Island; (ii) to examine the relationship between commercial fishing grounds and the wider plateau and banks where surveys have been undertaken previously; and (iii) to revise the population parameters, where possible, including fishing selectivity, growth, maturity and recruitment. The results demonstrate clear differences between populations of *D. eleginoides* at Heard Island in the southern Indian Ocean and South Georgia Island in the South Atlantic. For example, *D. eleginoides* at Heard Island are considerably older and slower growing than those at South Georgia. This raises questions as to the appropriateness of the current range of natural mortality used in the assessment of yield at Heard Island. The revised estimates of recruitment indicate that the variability of recruitment at Heard Island is much greater than originally estimated and that, in recent years, there has been an influx of a large number of young fish compared to the period during the first surveys in the early 1990s. A notable outcome of the 1999 survey is the identification of Ground B as the most important area for 7- to 8-year-old fish in the Heard Island region. Careful thought will need to be given to how best to manage a stock that aggregates in this manner while still juvenile and with some years before becoming reproductively mature.

WG-FSA-99/69
Assessment of yield and status of *Macrourus carinatus* on BANZARE Bank in the southern Indian Ocean: implications for managing by-catch in CCAMLR fisheries. E.M. van Wijk, A.J. Constable, R. Williams and T. Lamb (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 12 pp. *CCAMLR Science*, submitted (English).

This paper provides an assessment of the status and abundance of *Macrourus carinatus* on BANZARE Bank (Divisions 58.4.1 and 58.4.3). The long-term precautionary yield was estimated using the Generalised Yield Model (GYM) used previously by the CCAMLR Working Group on Fish Stock Assessment. Estimates of population and biological parameters were not available for this species at BANZARE Bank. Length and weight data were taken from a trawl survey conducted at Macquarie Island in 1999. Where parameters were not directly available for *M. carinatus*, estimates were obtained from

the literature for similar species elsewhere in the world. The trawl survey data were used to calculate estimates of biomass and density for the area and showed that *M. carinatus* did not appear to be aggregated over any part of BANZARE Bank. The long-term annual yield calculated for *M. carinatus* was 550 tonnes, based on a critical value of γ of 0.033 (the proportion of the estimate of pre-exploitation biomass) found using the CCAMLR decision rules. The binding rule for this assessment was the decision rule on the probability of depletion below 0.2 of the median pre-exploitation spawning biomass. This assessment could be used as a basis for setting catch rates of *M. carinatus* in longline fisheries targeting *Dissostichus eleginoides*. Applying the critical γ to the mean density observed in the survey gives a catch rate of 5.81 kg/km^2 which translates into a precautionary yield of 17.9 tonnes per fine-scale rectangle. Such a yield represents 18% of the total catch allowed for *D. eleginoides* in fine-scale areas in new and exploratory fisheries. This catch rate may be useful in setting general by-catch rules for *M. carinatus* to protect the species from localised depletions.

WG-FSA-99/70
Preliminary evaluation of global aggregate long-term annual yield for Patagonian toothfish (*Dissostichus eleginoides*). A.J. Constable, L.S. Meyer and R. Williams (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 9 pp. (English, unpublished).

The sustainability of Patagonian toothfish (*Dissostichus eleginoides*) is being threatened by illegal, unregulated and unreported (IUU) fishing in the CCAMLR area. CCAMLR takes a precautionary approach to managing these fisheries and has established precautionary catch limits for many of the toothfish fishing grounds in the Convention Area. The CCAMLR Scientific Committee has noted that the current levels of illegal fishing are much higher than the total catch allowed under all the CCAMLR conservation measures. This paper aims to evaluate the potential global long-term annual yield of *D. eleginoides*. It uses the methodology applied by CCAMLR for new fisheries. These results are used to assess the potential sustainability of known catches within and outside the CCAMLR area by comparing these yields with trade and catch figures derived by WG-FSA. The results show that current trade is likely to be well in excess of the sustainable levels of yield. Notably, current trade figures are underestimates of total trade. In 1997, WG-FSA estimated that trade in toothfish was in the order of 130 000 tonnes. The total annual catch well exceeds the estimated sustainable yields for fishing grounds and far exceeds the precautionary approach taken by CCAMLR when the discount factor is applied. The appropriateness of extrapolating recruitments from two areas to estimate yields in unknown areas is open to question. A number of issues are discussed concerning the urgent research required to improve the assessments for these areas where new fisheries are being established.

WG-FSA-99/71
1999 Report of the WG-FSA Subgroup on Approaches to Assessments. A.J. Constable, G. Parkes, D.J. Agnew, G. Kirkwood, R. Williams and D. Ramm (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 7 pp. (English, unpublished).

WG-FSA-99/72
Seabird, seal and fishing vessel interactions in the Heard and McDonald Islands and Macquarie Island Patagonian toothfish trawl fishery. G. Robertson and B. Wienecke (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 12 pp. (English, unpublished), (abstract not available).

WG-FSA-99/73
Seabird interactions with longline fishing in the AFZ: 1998 seabird mortality estimates and 1988–1998 trends. N.P. Brothers, R. Gales and T. Reid. *Wildlife Report 99/x.* Parks and Wildlife Service, Tasmania, 1999 (English).

No fishing was carried out within the AFZ by Japanese longline fishing vessels during 1998. This has been due to deliberations by the Commission for the Conservation of Southern Bluefin Tuna.

Fishing in the AFZ by domestic pelagic longliners is logically treated as two fleets; a heterogenous, local-style fleet, and a much more homogenous, Japanese-style fleet. The increase in local-style pelagic effort during the 1990s was sustained this year, with over 9 million hooks being set, a 22% rise over the number of hooks set during 1997. Of these, 13 700 (0.1%) were observed. Over 770 000 hooks were set in the AFZ by Australian-owned Japanese-style vessels. This number has been fairly constant throughout the 1990s. Of these, approximately 50 000 (6.5%) were observed.

In the local-style pelagic fishery, all observations were made around Tasmania in summer, and the observed by-catch rate was 0.58 birds killed/1 000 hooks. Shy albatrosses were the most commonly caught species of seabird in the area of observation in this fishery. Most observed hooks were set at night. By-catch rates are influenced by the moon phase. The use of factors in addition to the use of bird lines (such as weights) for the reduction of bird by-catch rates is reiterated.

The observed by-catch rate in the Australian-owned Japanese-style fishery was 0.40 birds killed/1 000 hooks. In Japanese-style operations, the species of birds caught were more similar to the species composition of Japanese vessels rather than those of other domestic vessels. Most observed hooks were set during the day. Bird lines were found to lower the observed by-catch rate, but only if they were of a good quality. Thawed bait, and fewer birds around the vessel were observed to result in lower by-catch rates.

Measured by-catch rates of birds by both parts of the fleet are high (in the order of 0.4 to 0.6 birds/1 000 hooks during 1998), and this suggests that both of these fleets continue to catch a significant number of seabirds in the AFZ. Because of the small percentage of hooks observed, estimates of the total numbers of seabirds caught would be premature. Approximately 43 000 hooks were observed set by domestic demersal longline fishing vessels. No birds were observed to be caught by these hooks.

WG-FSA-99/74
Problems with estimation of size at maturity of *Dissostichus mawsoni* in Subarea 88.1. G. Patchell (Sealord Group Ltd, PO Box 11, Nelson, New Zealand), 5 pp. (English, unpublished), (abstract not available).

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