CCAMLR SCIENTIFIC ABSTRACTS
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Commission for the Conservation of
Antarctic Marine Living Resources

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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 1997. It corresponds to the Sixteenth 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(iii) scientific papers not intended for publication, which are listed as 'unpublished'; and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-XII/BG/11 (background document number 11 submitted at the Twelfth Meeting of the Scientific Committee); or WG-EMM-96/8 (document number 8 submitted at the 1996 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Unpublished papers must not be cited without written permission of the author(s).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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The sixth year of surveys of beached man-made debris at Bird Island, South Georgia, revealed a total of 710 items, 2% less than the record total of 725 items in 1994/95. However, whereas the total amount of debris collected during the winter (April–September) was 40% lower than in 1994/95, the number of items collected at the end of summer (March) was 75% greater than the previous year, which was itself an eight-fold increase over any earlier value. Nylon line, identical to that attached to longline gear, accounted for 77% of items, nearly all of which clearly originated from fishing vessels. The continuing high levels of man-made debris and the recent rapid increase in levels during summer, coinciding with increases in entanglement of Antarctic fur seals, is of growing concern. Furthermore, despite the CCAMLR ban on the use of packaging bands being in force during 1995/96, the total number of packaging bands found ashore was the highest for many years, as was the proportion of these which were uncut. CCAMLR needs to take further steps to counteract the current trend of increase in amounts of man-made debris being jettisoned into the Southern Ocean.

CCAMLR-XVI/BG/6

Beach debris survey – Signy Island, South Orkney Islands 1996/97. A.S. Lynnes and J.R. Shears (United Kingdom), 15 pp. (English, unpublished).

The seventh annual beach debris survey was carried out at Signy Island, South Orkney Islands, during the 1996/97 austral summer. Debris was cleared each month between December and March from three study beaches: Cummings Cove, Foca Cove and Starfish Cove. The debris was counted, measured and classified by type, material, weight and size. Logistical difficulties prevented a survey from being carried out at Cummings Cove in January. A total of 34 items weighing 1.61 kg were collected at Cummings Cove, 18 items weighing 1.42 kg were found at Foca Cove and six items weighing 0.68 kg were found at Starfish Cove. The total amount of marine debris collected from the three beaches was the lowest recorded since the surveys began in 1990, both in terms of weight and number of items. This follows a continuing downward trend since 1993/94. The proportion of plastic items found remained high, accounting for 79% of all items. Despite the ban on the use of packaging bands aboard fishing vessels which was brought into force by CCAMLR in 1996, almost half (49%) of the plastic items found at Signy were packaging bands. These had all been cut. Although the amount of debris collected at Signy Island in 1996/97 was the lowest ever recorded, the considerable number of packaging bands still being washed ashore indicates that CCAMLR Members must take further steps to ensure that vessels are aware of, and comply with, regulations preventing the disposal of debris in the Southern Ocean.

CCAMLR-XVI/BG/10

Beach debris surveys – South Sandwich Islands. P. Convey and A. Morton (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 10 pp. (English, unpublished).

Beach debris surveys were carried out at two sites in the South Sandwich Islands (CCAMLR Subarea 48.4) during the 1996/97 austral summer. Two surveys of a northeast-facing beach (1 km length) at Demon Point, Candlemas Island were made, separated by exactly one month, in January and February 1997. A single opportunistic survey of a west-facing beach (c. 200 m length) at Ollivant Point, Saunders Island, was made in late January 1997. Incidental observations were made on several other islands in the group. Only eight items were found in the initial survey of Demon Point, Candlemas

Island. However, during the subsequent month, 26 further items of debris were washed onto the beach. This rate of deposition is similar to, but at the lower end of, the range reported from beaches on Signy Island, South Orkney Islands, during the period from 1991 to 1996. At Ollivant Point 57 items of debris were found, the majority (70%) being pieces of driftwood which had probably been *in situ* for at least several years. Many smaller types of debris are likely to have a short residence time on any beach in the South Sandwich Islands, due to their great exposure and instability, and the uniformly heavy, often stormy, swell. The majority of the items recovered on Demon Point, Candlemas Island, were plastic or polystyrene (6 out of 8 items or 75% of initial survey, 23 out of 26 items or 88% of second survey). Of the 29 such items, 12 were plastic bottles or containers and 16 were whole or fragmented fishing net floats (incidental observations indicated that net floats were present on many beaches in the archipelago). No fragments of net or synthetic fishing line, or packaging bands, were noted on any beach visited in the archipelago. A single entangled female fur seal was freed from a fishing net on Candlemas Island, but no other instances of entanglement or injury to fauna were noted. It was possible to identify the country of origin or manufacture of a small proportion of the debris. Attributable items originated from Argentina and Japan (two each), Chile and Russia (one each). Despite the extremely remote location of the South Sandwich Islands, these results show that the quantity and rate of deposition of marine debris on the islands' beaches is significant, but low when compared to rates found at Signy Island, South Orkney Islands and Bird Island, South Georgia. However, because of the exposure of beaches in the South Sandwich Islands to heavy and often stormy swell, debris washed ashore is likely to have only a short residence time before being washed back to sea. The total absence of nylon line fragments or packing bands is significant given their high frequency of occurrence at Bird Island and Signy Island respectively. This both confirms there is little or no fishing activity around the South Sandwich Islands at present and suggests that these types of fishery debris are not carried to the archipelago from active fisheries around South Georgia and the South Orkney Islands.

CCAMLR-XVI/BG/22
Beached debris survey near the Artigas Scientific Research Station, 1997. Uruguay, 4 pp. (Spanish, unpublished).

CCAMLR-XVI/BG/26
Fishing industry pollution observations and associated marine mammal entanglement records at South Georgia, Summer 1996/97. United Kingdom, 11 pp. (English, unpublished).

From various locations on or near the mainland of South Georgia 13 observations of entanglement of marine mammals (one southern elephant seal *Mirounga leonina* and 12 Antarctic fur seals *Arctocephalus gazella*) in anthropogenic debris were reported between November 1996 and January 1997. Of the fur seals, five (42%) were female (three adult, two juvenile) and seven (58%) were male (one adult, six juvenile); seven (58%) were entangled in plastic packaging bands, three (25%) in trawl netting and two (17%) in synthetic rope. All entangling material probably originated from fishing vessels. Marine debris was collected from a 1-km stretch of beach on the south coast of South Georgia from 24 to 26 December 1996. The photographs (originals in colour) illustrate the diversity of debris, most clearly originating from fishing activities. The debris included 361 packaging bands of the type used to secure bait boxes; a considerable proportion of these were uncut. CCAMLR Members need to be more active in ensuring that vessels fishing in the Convention Area comply with packaging band and waste disposal regulations.

CCAMLR-XVI/BG/30
On the establishment of a CCAMLR database for marine debris surveys. CCAMLR Secretariat, 14 pp. (English, unpublished).

CCAMLR-XVI/BG/35
Beach debris survey at Cape Shirreff, Livingston Island, during

the Antarctic season 1996/97. D. Torres, D. Jorquera, V. Vallejos, R. Hucke-Gaete and S. Zarate (Instituto Antártico Chileno, Departamento Científico, Luis Thayer Ojeda 814, Casilla 16521, Correo 9, Providencia, Santiago, Chile), 10 pp. (English, unpublished).

During the 1996/97 season a beach debris survey was carried out on the beaches of Cape Shirreff, Livingston Island, South Shetland Islands, where a total of 1 609 articles weighing a total of 49.03 kg were collected. 178 plastic pieces were collected from an area adjacent to Cape Shirreff to stop this material entering the CEMP site during storms and windy weather. As in all previous seasons, plastic was the principal debris item by number (N) and frequency of occurrence (F) (1 517, F = 94.3%), followed by glass (67, 4.2%), metal (19, 1.2%) and paper (6, 0.4%). Of the plastic items, those used in fisheries comprised 421 articles (207 strapping bands, 205 ropes, and 9 net pieces). The total density of marine debris collected on the site has increased from 0.65 articles/m^2 in 1993/94 to 1.02 articles/m^2 in 1994/95, 1.52 articles/m^2 in 1995/96, and diminished to 0.46 articles/m^2 in 1996/97. For the first time pieces of expanded polystyrene (708, 46.7%) comprised a large proportion of the total amount of 1 517 plastic items collected. We believe that this material may have been used during re-supply operations, because many items had cavities similar to those used in packaging of some types of electronic equipment. This is in contravention of Annex V of the Protocol, and to SCAR's Code of Conduct, which ban this kind of synthetic material being brought into the Convention Area. Several plastic items (15) showed evidence of having been partially burnt. One could conclude that the ashes produced in incinerators may also have been disposed into the sea, as was reported in the previous season. If so, this is yet more proof of actions contrary to international agreements relating to the protection of the sea and its biota. Some plastic fibres continue to appear in some nests of *Larus dominicanus* and *Chionis alba*. Two specimens of *Arctocephalus gazella* were seen entangled in plastic fibres, which were removed from the animals after being immobilised with a piece of net obtained from the beached debris. It is proposed that the findings described above be taken into consideration in the preparation by CCAMLR of educational materials on the prevention of marine debris pollution in Antarctic waters. It is also suggested that the owners of the Antarctic re-supply, research and fishing vessels provide on board a container to store waste materials in order to offload them in ports, preferably outside the Convention Area. The amount of waste produced and offloaded should be recorded in logbooks.

Scientific Committee

SC-CAMLR-XVI/BG/5
Marine debris and fishing gear associated with seabirds at Bird Island, South Georgia, 1996/97. R. Humpidge (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 9 pp. (English, unpublished).

In the fourth year of standardised recording of man-made debris associated with seabirds at Bird Island, South Georgia, ingested and regurgitated plastic items were reported for wandering albatrosses (three items), grey-headed albatrosses (one item) and white-chinned petrels (two items). Fishing gear was reported in association with grey-headed albatrosses (four squid jigs), black-browed albatrosses (three hooks and line, found next to nests), wandering albatrosses (15 hooks and/or line, eight found next to nests, six in squid pellets and one internally lodged in an adult) and adult regurgitates of nylon line thought to originate from trawlers (three items). There was a four-fold increase in the incidence of southern giant petrels involved with fishing gear (four items) compared with previous reports. Levels of fishing gear associated with black-browed and grey-headed albatrosses are similar to previous years but the amount for wandering albatrosses was halved compared to last year. Neverthe-

less, evidence of continued discarding of plastic material and the loss of longline fishing gear, especially hooks, remains a cause for concern.

SC-CAMLR-XVI/BG/6
Entanglement of Antarctic fur seals (*Arctocephalus Gazella)* in man-made debris at Bird Island, South Georgia, during the 1996 winter and 1996/97 pup-rearing season. R.I. Taylor (British Antarctic Survey) Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 22 pp. (English, unpublished).

The results of the survey of entanglement of Antarctic fur seals at Bird Island, South Georgia, for the sixth consecutive winter (1996) and eighth consecutive summer (1996/97) are reported. In winter, 17 seals were observed entangled, double the number in 1995 and the third highest total so far. As usual most (88%) entanglements were of juveniles; however one-third were of females, an unusually high proportion. Synthetic string (fishing line) (47%), fishing net (24%) and packaging bands (18%) were the main entangling materials, with the abundance of string and fishing net reversed from most previous years. In summer, 27 seals were recorded entangled, the third lowest total and a 21% reduction from 1996. Most animals involved were juvenile females; the overall severity of injury was the lowest yet recorded. The proportion of entanglements in synthetic string (41%) was much greater than in recent years, with fishing net (22%) commensurately reduced and packaging bands (33%) similar to last year. The relatively low level of entanglements in summer is encouraging. The increase in winter records, however, is discouraging and fishing vessels are the only likely source of debris at this time. The evidence of continued use and discarding of packaging bands within the Convention Area is of particular concern.

SC-CAMLR-XVI/BG/7
Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Signy Island, South Orkney Islands 1996/97. A.S. Lynnes (United Kingdom), 11 pp. (English, unpublished).

The results of the first annual survey of entanglement of Antarctic fur seals at Signy Island, South Orkney Islands, are reported for the 1996/97 season. Neck collars of man-made debris were seen on 12 seals, all of which were juvenile males. Five entangled seals were observed in an area around the Signy Island research station, where approximately 1.3% of the fur seal population come ashore. It was estimated that the incidence of entanglement was 0.33%. Data are compared with results from a parallel study undertaken in 1996/97 at Bird Island, South Georgia. Although synthetic line and packaging bands were the main entangling materials at both sites, a greater proportion of fur seals was entangled in these items at Signy Island (50% and 42% respectively) than at Bird Island (22% and 33% respectively). Severe injury was being caused to 75% of animals at Signy Island (15% at Bird Island) and none was seen to have a neck collar loose enough to come off. Since 1991, 47 entanglements have been reported at Signy Island compared with only 20 entanglements recorded at sites in the South Shetland Islands. However, it is difficult to determine if this is a site-specific difference or the result of different observer effort. The prevalence of packaging bands shows that these are still being used and discarded at sea within the Convention Area. This is despite the ban by CCAMLR on the use of packaging bands aboard vessels that was brought into force in 1996. The high incidence of synthetic line and fishing net highlights the need for CCAMLR Members to take further steps to ensure that vessels are aware of, and comply with, regulations prohibiting the disposal of debris in the Southern Ocean.

SC-CAMLR-XVI/BG/10
An analysis of future prospects for the squid (*Martialia Hyadesi*) fishery in Subarea 48.3 (South Georgia). P.G. Rodhouse (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 8 pp. (English, unpublished).

SC-CAMLR-XVI/BG/17
Estimates of seabed areas within selected depth ranges using the Sandwell/Smith global sea floor topography dataset. CCAMLR Secretariat, 5 pp. (English, unpublished).

SC-CAMLR-XVI/BG/28
Catch rates and length composition data of the longline fishery for *Dissostichus eleginoides* at the Prince Edward Islands: 1996/97). M.G. Purves (Sea Fisheries Research Institute, Private Bag X2, Roggebaai 8012, Cape Town, South Africa), 18 pp. (English, unpublished).

The first reports of commercial catches of Patagonian toothfish (*Dissostichus eleginoides*) made in the vicinity of the Prince Edward Islands, a South African territory in the Indian Ocean sector of the Southern Ocean, surfaced early in 1996. This generated both national and international interest in the fishery, leading to a great influx of vessels into the area. By the end of 1996 up to 40 vessels had already landed catches of more than 23 000 tonnes in South Africa and Namibia. It is against this backdrop that permits were issued in October 1996 to five vessels, each with an allocation of 240 tonnes per year, to fish in the South African zone at the Prince Edward Islands. The sanctioned fishery was conducted according to CCAMLR guidelines and scientific observers were deployed on most of the trips. From October 1996 to June 1997 sanctioned vessels at the Prince Edward Islands deployed around 3.7 million hooks and landed 2 100 tonnes of toothfish. Although catch rates were initially high at around 0.7 kg per hook at the end of 1996, a steady decline in CPUE to less than 0.4 kg per hook towards the end of the season was noticed. The length-frequency distribution showed that fish caught at the Prince Edward Islands were generally smaller than those reported from the South American and South Georgia longline fisheries. A decrease in fish sizes was also noted since the inception of the fishery. Although probably related to the overexploitation of the resource by unregulated vessels, a trend was also discerned that vessels were targeting shallower areas as the season progressed, possibly influencing the size of fish caught. Intensive fishing for *D. eleginoides* over the past year at the Prince Edward Islands, mostly by unregulated vessels, was probably largely responsible for the sharp decline in catch rates. There are, however, indications that catch rates have stabilised during the latter half of the season, although any sound management of the fishery in the future will depend on the curtailment of the unregulated exploitation of the resource.

SC-CAMLR-XVI/BG/29
Observations of oceanic debris in the Southern Ocean whale sanctuary, from the Antarctic Peninsula to the Ross Sea: December 1994 to March 1995. ASOC Observer, R.V. Grace (56 Bertram Street, Warkworth, New Zealand), 29 pp. (English, unpublished).

Observations of natural and man-made floating megalitter, macrolitter and mesolitter in the Pacific section of the Southern Ocean whale sanctuary from December 1994 to March 1995 are reported. Natural megalitter, mostly seaweed, was concentrated in the more northern latitudes near the start and finish of the expedition, especially near the Antarctic Convergence south of the Tasman Sea. Man-made megalitter was nowhere common, but was seen mostly near and to the west of the Antarctic Peninsula, and north and northwest of the Ross Sea, and consisted mostly of plastic items, especially styrofoam fragments. Fishing gear was not a major component of man-made debris. Macrolitter consisted mainly of seabird feathers. A very high density (544 items per 10 n mile) of penguin feathers occurred northeast of the Ross Sea, whereas non-penguin feathers dominated north and northwest of the Ross Sea. In the southern Ross Sea a single sample contained 31 small dead fish. Natural mesolitter quantities were usually low, but high densities (to 391 items/ha) of penguin feathers occurred northeast of the Ross Sea, and pumice granules were concentrated near the Antarctic Convergence south of the Tasman Sea. Man-made mesolitter was usually absent but reached 8.7 items/ha midway between the Antarctic Peninsula and the Ross Sea. Most items were individual styrofoam beads, but north of the

convergence small numbers of hard plastic fragments were encountered. Biological associations with debris were not common, but included a filamentous green alga and small goose barnacles.

SC-CAMLR-XVI/BG/33
Entanglement of Antarctic fur seals in marine debris at Cape Shirreff and San Telmo Islands, Livingston Island, Antarctica: 1988–1997. R. Hucke-Gaete, D. Torres and V. Vallejos (Universidad Austral de Chile, Facultad de Ciencias, Instituto de Zoología, Casilla 567, Valdivia, Chile), 21 pp. (English, unpublished).

We have compiled the records of Antarctic fur seals (*Arctocephalus gazella*) entangled in marine debris (neck collars) at SSSI No. 32 and CEMP site 'Cape Shirreff and San Telmo Islands' Livingston Island, Antartica, obtained during the summer seasons between 1988 and 1997. Our results indicate that 45% of the entangling materials found in a total of 20 individuals (nine subadult males, four juvenile males, five females, and two pups) comprised plastic debris and synthetic packing bands, and 55% comprised discarded fishing debris such as net fragments (ghost nets) and nylon ropes. We were able to release 35% of the entangled animals (four females, one juvenile male, and two pups). The total percentage of entangled animals versus total population in the area per season was considered to be low, and never exceeded the percentage of entanglement reported for the South Georgia Islands, where the most important longlining fishery in the Southern Ocean is carried out. Nevertheless, we consider that our records could be underestimates. To reduce this problem we propose: (i) the monitoring of Antarctic fur seals entangled in marine debris in the South Shetland archipelago area through a cooperative inter-institutional sighting network to assess, on the basis of more complete data, the impact that marine debris is having on the marine biota, especially on Antarctic fur seals, and for this purpose we present as an annex to this document a form to be completed by every Antarctic base, sanctuary, or camp present in the aforementioned area; (ii) the implementation of more regulations over fishing vessels operating in CCAMLR waters in the Southern Ocean, with further instruction of scientific observers in relation to discarded debris; (iii) education of captains and crews of fishing vessels with the aid of an informative booklet; and (iv) the ratification and implementation of Annex V of MARPOL (International Convention for the Prevention of Pollution from Ships) by Members who have not yet done so.

Subgroup on Statistics

WG-EMM-STATS-97/4
Development of indices of at-sea behaviour. I.L. Boyd (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 13 pp. (English, unpublished).

WG-EMM-STATS-97/5
Diet and foraging range of penguins and fur seals at South Georgia. J.P. Croxall, I.L. Boyd, K. Reid and P.N. Trathan (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 37 pp. (English, unpublished).

WG-EMM-STATS-97/6
Tests for anomalous years in the CCAMLR index series (draft). B.F. Manly and D. MacKenzie (Centre for Applications of Statistics and Mathematics, University of Otago, PO Box 56, Dunedin, New Zealand), 24 pp. (English, unpublished).

The properties of a method for detecting anomalous years in the CCAMLR index series are discussed. In simple cases this method involves comparing a standardised residual with a critical value obtained on the assumption that the series being considered consists of random values from a constant normal distribution. This idea is extended to situations (i) where the series values are still normally distributed, but contain a linear trend and autocorrelation, and (ii) where the series values are from some other constant distribution. For cases like (i), it is proposed that the standardised deviations

from a fitted linear regression line be compared with a critical value that is obtained on the assumption that there is no autocorrelation. This test is shown to have good properties even when autocorrelation is present, at least according to one model. For cases like (ii), it is proposed that a Box-Cox transformation to normality be applied before testing standardised residuals. This test has good properties for data from a wide range of distributions. Some examples are given to illustrate the performance of the proposed method under various conditions.

WG-EMM-STATS-97/7
Some considerations for the further development of statistical summaries of CEMP indices. W.K. de la Mare (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 6 pp. (English, unpublished).

A potential method is presented for combining data collected as part of the CCAMLR Ecosystem Monitoring Program (CEMP) into a single index for each of the predator, prey and environment parameters. The proposed method is based on the usual theory of multivariate statistics and takes into account the covariance between parameters. The power of the statistical procedure recently adopted by WG-EMM for identifying anomalies in CEMP parameters is examined by means of simulation tests. The power of the procedure to detect anomalies was found to fall to low levels once more than a few anomalous values have appeared in the data. An alternative procedure, using baseline mean and variance estimates, was found to have consistently better statistical power regardless of the accumulation of anomalies. An approach to the further development of CEMP indices is outlined.

WG-EMM-STATS-97/8
Treatment of missing values in CEMP datasets. A.W.A. Murray (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 15 pp. (English, unpublished).

Working Group on Ecosystem Monitoring and Management

WG-EMM-97/4
Draft standard method for the measurement of annual survival rate and pregnancy rate in adult female Antarctic fur seals.. I.L. Boyd (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 6 pp. (English, unpublished).

WG-EMM-97/5
Draft standard methods for monitoring diet in Antarctic fur seals. I.J. Staniland and K. Reid (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 4 pp. (English, unpublished).

WG-EMM-97/6
Hydrographic conditions in the Elephant Island plateau region during December 1996. M. Stein (Institut für Seefischerei, Palmaille 9, 22767 Hamburg, Germany), 23 pp. (English, unpublished).

Based on historic data contained in the *World Ocean Atlas*, 1994, the general climatic background for temperature, salinity and silicate is given for the area between the Falkland/Malvinas Islands and the Antarctic Peninsula region. A dataset collected during December 1996 in the Elephant Island plateau region by RV *Polarstern* is compared to the climatic background data and to more recent data collected by German research vessels in this region. A new interactive software was used to outline water mass boundaries which reveal the approximate location of the Weddell–Scotia Confluence. Vertical distribution of oceanographic parameters, including temperature, salinity and density, is discussed. Geopotential anomaly charts with a reference to 0/300 dbar depict the general flow as revealed by the geostrophic part of the circulation. Compared to krill abundance data, the thermal and the dynamic fields indicate some correlation in the distribution of biotic and abiotic parameters. Analysis of time-series data at a station site to the north of Elephant Island

indicates slow seasonal oscillations of the water-mass boundary between the Weddell Sea waters and the southeast Pacific surface waters, i.e. the Weddell–Scotia confluence. The paper reiterates the recommendation of the necessity to conduct a cooperative analysis of data collected over a number of years in the Elephant Island plateau region. The new software described in this paper makes handling large databases a simple task.

WG-EMM-97/7
Predator–prey interactions between higher predators and fish and cephalopods in the Southern Ocean. I.L. Boyd, J.P. Croxall and P.A. Prince (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 2 pp. (English, unpublished).

WG-EMM-97/8
Variation in foraging effort by lactating Antarctic fur seals: response to simulated increased foraging costs. I.L. Boyd, D.J. McCafferty and T.R. Walker. *Behav. Ecol. Sociobiol.*, 40: 135–144, 1997 (English).

Seasonally breeding predators, which are limited in the time available for provisioning young at a central location, and by the fasting abilities of the young, are likely to maximise energy delivery to the young by maximising the rate of energy delivery averaged over the whole period of investment. Reduction in food availability or increased foraging costs will alter the optimal behaviour of individuals. This study examined the behavioural adaptations of a diving predator, the Antarctic fur seal, to increased foraging costs during lactation. One group of mothers (n = 5, treatment) was fitted with additional drag to increase the cost of transport in comparison with a control group (n = 8). At the scales of the individual dives, the treatment group made more shorter, shallower (<30 m) dives. Compensation for slower swimming speeds was achieved by diving at a steeper angle. Overall, diving behaviour conformed to several specific theoretical predictions but there were also departures from theory, particularly concerning swimming speed during diving. Diving behaviour appears to be adjusted to maximise the proportion of time spent at the bottom of dives. At the scale of diving bouts, no difference was observed between the treatment and control groups in terms of the frequency and duration of bouts and there was also no difference between the two groups in terms of the proportion of time spent diving. At the scale of complete foraging cycles, time taken to return to the pup was significantly longer in the treatment group but there was no difference in the rate of delivery of energy (measured from pup growth rate) to the pups in each group. Since mothers in the treatment group did not use significantly more body reserves, we conclude that behavioural adjustments at the scale of individual dives allowed mothers in the treatment group to compensate for the additional foraging costs. Pup growth rate appears to be less sensitive to the foraging conditions experienced by mothers than foraging trip durations.

WG-EMM-97/9
Fish and squid in the diet of king penguin chicks, *Aptenodytes patagonicus*, during winter at sub-Antarctic Crozet Islands. Y. Cherel, V. Ridoux and P.G. Rodhouse. *Marine Biology*, 126: 559–570, 1996 (English).

The diet of king penguins, *Aptenodytes patagonicus*, rearing chicks was studied during three consecutive austral winters (1990, 1991 and 1992) at Crozet Islands. The mean stomach content mass of the 47 samples was 503 g. Percentages of wet and reconstituted masses showed that both fishes (66 and 36%, respectively) and squid (34 and 64%) are important components of the winter diet. Juveniles of the demersal onychoteuthid squid *Moroteuthis ingens* form the bulk of the cephalopod diet, and this was the main prey by reconstituted mass (57%). Myctophid fish (lanternfishes) accounted for most of the fish diet, constituting together 32% by mass. The three main species of myctophids eaten in summer by king penguins were either very rare in winter (*Electrona carlsbergi*) or accounted for a smaller proportion of the diet (*Krefftichthys anderssoni* = 1.5% by mass and *Protomyctophum tenisoni* = 4.6%). Five other myctophids, which are rarely consumed in summer, contributed

24% of the diet by mass in winter (*Gymnoscopelus piabilis* = 18.1%, *Lampichthys procerus* = 2.4%, *G. nicholsi* = 1.3%, and *Metelectrona ventralis* and *Electrona subaspera* = 1.0%). The greater diversity of prey in winter suggests a more opportunistic feeding behaviour at a time probably marked by a change in prey availability. Both the known ecology of the fish and squid prey and the barely digested state of some items suggest that in winter breeding adults forage in the outer shelf, upper slope and oceanic areas in the close vicinity of the Crozet Islands to feed their chicks. Finally, using king penguins as biological samplers, the present work provides novel data on the previously unstudied mesopelagic/epibenthic marine community in waters surrounding the Crozet Islands. Seventeen myctophid fish have been identified to species level. These include several poorly known species in the southern Indian Ocean. The occurrence of small, nearly intact, cephalopods in the diet of king penguins suggests that spawning grounds of four squid species may be located near the Crozet Archipelago.

WG-EMM-97/10

Diet and feeding ecology of the diving petrels *Pelecanoides georgicus* and *P. urinatrix* at South Georgia. K. Reid, J.P. Croxall, T.M. Edwards, H.J. Hill and P.A. Prince. *Polar Biol.*, 17: 17–24, 1997 (English).

The diet of the diving petrel *Pelecanoides georgicus* and *P. urinatrix* was studied during 1986 (*P. georgicus*) and 1987 (both species) by lavaging adults as they returned to feed chicks on Bird Island, South Georgia. The diet of both species was dominated by crustaceans, in particular euphausiids (mainly *Euphausia superba* and some *Thysanoessa*), which contributed 47 to 76% of the biomass of crustaceans in the diet of *P. georgicus*, and copepods, which contributed 71% of the biomass of crustaceans in the diet of *P. urinatrix*. *Calanoidesacutus* was the most numerous copepod in the diet of both species; however, *Rhincalanus gigas* was more common in *P. urinatrix* than in *P. georgicus*. The dominant amphipod in the diet of *P. georgicus*, *Primnomacropa*, was absent from the diet of *P. urinatrix*, in which *Themisto gaudichaudii* (rare in *P. georgicus*) dominated. Dietary differences were maintained in the period (two weeks of a total of 10 weeks) when both species were simultaneously rearing chicks. Knowledge of the prey species and of the diving abilities and foraging habits of diving petrels suggests that at South Georgia *P. urinatrix* feeds closer inshore and dives deeper than *P. georgicus*.

WG-EMM-97/11

Milk consumption and growth efficiency in Antarctic fur seal (*Arctocephalus gazella*) pups. J.P.Y. Arnould, I.L. Boyd and D.G. Socha. *Can. J. Zool.*, 74: 254–266, 1996 (English).

The body composition, milk consumption and growth efficiency of Antarctic fur seal (*Arctocephalus gazella*) pups were measured over three consecutive lactation periods (1990–1992) at Bird Island, South Georgia. The body composition of pups differed between the sexes; whereas for any given age females were lighter than males, they had proportionately higher body lipid reserves than males. Milk consumption was determined on 388 occasions in 177 pups. Mean estimates of milk consumption ranged from 2.5 to 3.2 kg (42–53 MJ) during the 6-day perinatal period and from 2.9 to 3.6 kg (49–68 MJ) during the 1- to 2-day maternal attendance periods (feeding bouts). There were no differences in milk consumption between the sexes in any year. Both per-bout and per-day milk consumption increased steadily with age before decreasing significantly in the last 30 to 40 days of lactation. Per-bout milk consumption was positively related to the duration of the maternal foraging trip and attendance cycle, and both per-bout and per-day milk consumption were related to pup mass. Pups of both sexes consume the same amount of milk, but males direct more of their milk consumption into lean tissue growth than females, which accumulate greater adipose stores. Therefore, mass and mass changes may not be appropriate parameters for investigating differential maternal investment between the sexes in otariid pups.

WG-EMM-97/12
Interannual variation in the diet of the Antarctic Prion *Pachyptila desolata* at South Georgia. K. Reid, J.P. Croxall and T.M. Edwards. *EMU*, Vol. 97: 126–132, 1997 (English).

The diet of the Antarctic Prion *Pachyptila desolata* was examined using food samples regurgitated by adult birds during five breeding seasons at Bird Island, South Georgia. In all years the diet was mainly crustaceans, with a small proportion of myctophid fish and trace amounts of cephalopods. Antarctic krill *Euphausia superba* was the dominant prey item in three years and was replaced by calanoid copepods, especially *Rhincalanus gigas* and *Calanoides acutus*, in two years of low krill abundance. Differences in the prey species taken and observations of foraging behaviour suggest that in years of low krill availability Antarctic Prions forage closer inshore, taking copepods by filtering surface water through their palatal lamellae. By switching to feeding on copepods Antarctic Prions are apparently able to maintain a comparable level of reproductive success, unlike most other krill feeding species which suffer much reduced reproductive performance in years of reduced krill availability.

WG-EMM-97/13
Lactation and the cost of pup-rearing in Antarctic fur seals. J.P.Y. Arnould (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), *Marine Mammal Science*, in press. (English) (Abstract not available).

WG-EMM-97/14
Milk fatty acid signatures indicate both major and minor shifts in foraging ecology of lactating Antarctic fur seals. S.J. Iverson, J.P.Y. Arnould and I.L. Boyd. *Canadian Journal of Zoology*, in press (English).

Fatty acid signature analysis is based on the conservation and unique signatures of fatty acids in the marine food chain and it may be useful in determining the composition of seal diets or in detecting changes in diets. We apply fatty acid signature analysis to milks collected from Antarctic fur seals at South Georgia during the perinatal period (n = 19) and subsequently during early (n = 11), mid (n = 11), and late (n = 8) foraging trip intervals, and demonstrate its use in detecting shifts in prey intake which correspond with changes observed in diving and foraging behaviour during a poor food year (austral summer 1990/91). In lactating otariid females, milk fatty acids secreted during the perinatal fast are derived largely from blubber mobilisation and thus likely resemble an integration of dietary fatty acids consumed during the fattening period prior to parturition, whereas milk fatty acids secreted during foraging trip intervals are derived primarily from immediate dietary intake during the lactation period. To compare groups, we used methods of classification and regression tree (CART) analysis in S-plus, which allows the statistical interpretation of complicated fatty acid patterns containing up to 70 variables per observation. The fatty acid signature of perinatal milks was significantly different (0/19 misclassificationrate) from all other milks and late attendance (0/8 misclassification rate) was correctly distinguished from early and mid attendance (1/22 misclassification rate). Our results confirm that adult female fur seals have a distinctly different diet prior to parturition while away from breeding grounds and likely switch to a diet of krill during lactation. Additionally, at least in a poor food year, fur seals do not feed exclusively on krill throughout lactation but rather begin to shift to a diet of teleost fish during late attendance. These findings were consistent with independent 1990/91 scat data and indicate that fatty acid signature analysis promises to be a valuable tool in trying to understand aspects of foraging ecology in free-ranging pinnipeds.

WG-EMM-97/15
Dietary segregation of krill-eating South Georgia seabirds. J.P. Croxall, P.A. Prince and K. Reid. *J. Zool. Lond.*, 242: 531–556, 1997 (English).

The diets of six of the main seabird species (two petrels, two albatrosses, two penguins) breeding at Bird Island, South Georgia were studied simultaneously during the chick-rearing period in 1986. For five species, Antarctic krill *Euphausia*

superba was the main food (39–98% by mass); grey-headed albatrosses took mainly the ommastrephid squid *Martialia hyadesi* (71%) and only 16% krill. The size of the krill taken was similar between seabird species, although there were small but significant differences between penguins and the other species. Sex and reproductive status of krill, however, was different between all seabird species, reflecting some combination of differences in foraging ranges, selectivity by predators, or differences in escape responses of krill. For the krill-eating species, the rest of the diet varied substantially between species, comprising *Martialia* and nototheniid fish (black-browed albatross and, along with lanternfish, white-chinned petrel), lanternfish and amphipods (Antarctic prion and macaroni penguin) and icefish (gentoo penguin). Long-term data on breeding success and information on diet in 5 to 10 other years suggest that in 1986 seabird diet and reproductive performance was indicative of a year of good availability of krill around South Georgia. In such circumstances, ecological segregation between krill-eating species appears to be maintained chiefly by differences in foraging range and feeding methods, which are reviewed. This situation is rather different from the few studies of seabird communities elsewhere where prey type and size are believed to be the main mechanisms of dietary segregation.

WG-EMM-97/16

Development of the krill stock in the Elephant Island region during the 1996/97 season. V. Siegel (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, 22767 Hamburg, Germany), 12 pp. (English, unpublished).

During December 1996 the Elephant Island standard grid was surveyed for krill and salps. Krill and salps were present at almost all of the stations, other epipelagic zooplankton species were relatively scarce. Maximum krill density exceeded 7 350 juvenile krill per 1 000 m^3. In general, krill density was much higher than in previous years. The krill stock was dominated by length classes around 35 mm, representing age group 2+ and the 1994/95 year class (proportional recruitment $R_2 = 0.85$). The 1995/96 year class, the present juvenile age group 1+, did not repeat the very successful recruitment of the preceding year class. In December 1996 adult krill was mostly (68%) found to be in the pre-spawning stage, indicating an average year for krill reproduction in this area, which is not the optimum starting point for a good recruitment of this year class. At the same time the salp abundance was above average, but still one order of magnitude lower than in the salp bloom years 1992/93 and 1993/94.

WG-EMM-97/17

Consumption of krill by minke whales in Areas IV and V of the Antarctic. T. Tamura, T. Ichii and Y. Fujise (Faculty of Fisheries, Hokkaido University, 3-1-1, Minator-cho, Hakodate, Hokkaido 041, Japan), 9 pp. Submitted to the IWC intersessional working group to review data and results from special permit research in minke whales in the Antarctic. (English, unpublished).

The consumption of Antarctic krill (*Euphausia superba*) by the southern minke whale (*Balaenoptera acutorostrata*) in Areas IV and V of the Antarctic was estimated using methods based on diurnal changes in the forestomach content mass, standard metabolism and body mass. Data were collected under the Japanese Whale Research Program Under Special Permit in the Antarctic (JARPA). Estimates of the rate of daily food consumption obtained using the three methods ranged from 3 to 4%. Consumption estimates during the austral summer in Areas IV and V were 14.7–17.8 x 10^5 tonnes and 63.2–77.0 x 10^5 tonnes respectively. The values in Area IV were equivalent to roughly one-fourth of the total estimate of krill biomass in Area IV. Consumption in Area V by minke whales was an order of magnitude greater than the estimated consumption by Adélie penguins and crabeater seals. These results indicate the importance of minke whales to the ecosystems in Areas IV and V during the austral summer.

WG-EMM-97/18

Interannual changes in body fat condition, stomach content mass and distribution of minke whales in Antarctic Areas IV and V. T. Ichii,

T. Tamura, Y. Fujise, S. Nishiwaki and K. Matsuoka (National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424 Japan), 19 pp. (English, unpublished).

As an indicator of body fat condition, interannual variability in the girth of minke whales (*Balaenopteraacutorostrata*) was analysed in relation to sea-ice extent, stomach content mass and the distribution of minke whales in Antarctic Areas IV (70°–130°E) and V (130°E–170°W) from 1989/90 to 1994/95. Of the six years included in the study, two were categorised as years of poor body fat condition, and three as years of good condition. Estimated body weight gain during the feeding season in poor years was 25% lower than in good years. The relationship between girth and stomach content mass in the ice-edge zone suggests that girth can be a useful indicator of food availability. In Areas IV and V krill (*Euphausia superba*) was the dominant prey species, but in the southern part of the Ross Sea (in Area V), *E. crystallorophias* was the dominant prey species. Distribution of minke whales showed a greater interannual variability in Area V than in Area IV, reflecting a greater degree of variability in sea-ice extent in Area V. In Area V, in a year of extensive sea-ice cover, the krill-rich slope region in the western zone was covered by ice. This may have led to low food availability and resulted in a very low density of minke whales along the ice-edge. The Ross Sea zone was an area of low food supply throughout the study period. Paradoxically, this zone always contained numerous minke whales, especially pregnant females.

WG-EMM-97/19

Establishment of a CCAMLR Ecosystem Monitoring Program at Bouvetøya. K. Isaksen, V. Bakken, I. Gjertz and F. Mehlum (Norwegian Polar Institute, PO Box 5072, Majorstua, N–0301 Oslo, Norway), 20 pp. (English, unpublished).

A CCAMLR Ecosystem Monitoring Program (CEMP) has been initiated by Norway at Bouvetøya in the South Atlantic Ocean. A permanent research station was established at the Nyrøysa CEMP site on the western coast of the island during the 1996/97 field season. Species included in the monitoring program are the chinstrap penguin, macaroni penguin and Antarctic fur seal. During the first field season (1996/97), monitoring of the following parameters was initiated for the two species of penguins: breeding population size (A3), age-specific annual survival and recruitment (A4), duration of foraging trips (A5), breeding success (A6), chick diet (A8) and breeding chronology (A9). The program includes monitoring of the duration of Antarctic fur seal cow foraging/attendance cycles (C1) and pup growth (C2).

WG-EMM-97/20

Preliminary results from CEMP monitoring of Antarctic fur seals, chinstrap penguins and macaroni penguins at Bouvetøya 1996/97. K. Isaksen, G.J.G. Hofmeyr, B.M. Dyer, A. Næstvold, F. Mehlum, I. Gjertz, V. Bakken and O. Huyser (Norwegian Polar Institute, PO Box 5072, Majorstua, N-0301 Oslo, Norway), 27 pp. (English, unpublished).

A CCAMLR Ecosystem Monitoring Program (CEMP) was initiated at Bouvetøya, in the South Atlantic Ocean, during an expedition to the island from 9 December 1996 to 22 February 1997. A research station was established at the CEMP site, Nyrøysa, on the western coast of the island. Species included in the monitoring program are the chinstrap penguin, macaroni penguin and Antarctic fur seal. Preliminary results from the first season of CEMP monitoring (parameters A3, A4, A5, A6, A8, A9, C1 and C2) are reported together with results from other CEMP-related work (entanglement of fur seals, and diving behaviour and population changes of penguins and fur seals). The population of chinstrap penguins at Nyrøysa has declined sharply since the last count in 1989/90. The population of macaroni penguins has shown a more moderate decline, whereas the population of Antarctic fur seals has grown dramatically since the last visit.

WG-EMM-97/21

Avoidance, a problem in sampling Antarctic krill at night. I. Everson, D. Bone and C. Goss (British Antarctic Survey, High Cross, Madingley Road,

Cambridge CB3 0ET, United Kingdom), 10 pp. *CCAMLR Science*, submitted (English).

It has been known for some time that Antarctic krill (*Euphausia superba*) avoid plankton nets in the daytime and it had been assumed that after dark the net would be less visible with the result that catches would more closely reflect numerical density and size composition at the sampling location (Everson and Bone, 1986). This study was undertaken in the vicinity of South Georgia to determine the extent of avoidance after dark. A 120-kHz echosounder was used for the study, with its transducer mounted on the net rig and directed down across the mouth of the net; another echosounder, installed on RRS *John Biscoe*, was used with a downward-directed hull-mounted transducer. As the ship passed over a swarm we compared the densities of krill in front of the mouth of the net and the catch of krill in the codend of an RMT8 net. The numerical density of krill at the net was much lower compared to the same layer as seen on the hull-mounted transducer, but this difference was strongly depth dependent – 1:10 at 20 m and 1:1 at 100 m. The numerical density of krill as seen on the net-mounted echosounder was close to that derived from the actual catch in the codend. This suggests avoidance was visually triggered and occurred mostly well in advance of the net, probably as a result of the presence of the ship. If this is true it would mean that acoustic estimates of krill are underestimated, by an unquantified amount, due to the presence of the survey vessel.

WG-EMM-97/22

Catch-per-unit-effort data from the early years of commercial krill fishing operations in the Atlantic sector of the Antarctic. V. Siegel and V.A. Sushin (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, 22767 Hamburg, Germany), 23 pp. *CCAMLR Science*, submitted (English).

Catch-per-unit-effort data are presented from krill fishing operations in CCAMLR Subareas 48.1, 48.2 and 48.3 for the period 1975/76 to 1987/88. Comparisons are carried out between subareas in single years, between years on a subarea and area basis, and between oceanic and shelf regions. Results show that the CPUE may differ between subareas, years and shelf/oceanic regions. Obviously, a consistent pattern of CPUE values does not occur over time for the entire area. High average CPUE were observed in the years 1975/76 and 1980/81, whereas the lowest CPUE occurred in Subarea 48.3 in 1977/78. The validity of the CPUE index as an indicator for krill abundance/biomass is discussed and caution is expressed in this regard. Depending on the circumstances, a CPUE index may seriously under- or overestimate the amount of krill available in a statistical subarea. Overall length-frequency distributions from commercial fishing operations in general tend to show little interannual variation because several factors influence the representativeness of krill smaller than 35 mm in the catches.

WG-EMM-97/23

Reporting of fine-scale krill data in the 1995/96 season. CCAMLR Secretariat, 22 pp. (English, unpublished).

WG-EMM-97/24

A multi-frequency method for improved accuracy of *in situ* target strength measurements. D.A. Demer, M.A. Soule and R.P. Hewitt (Southwest Fisheries Science Center, PO Box 271, La Jolla, Ca. 92038, USA), 28 pp. (English, unpublished).

The effectiveness of a split-beam echosounder system to delineate single scatterers and accurately measure *in situ* target strengths (TS) is dramatically enhanced (98.2–99.4%) by combining synchronised signals from two or more adjacent split-beam transducers of different frequencies. The accuracy of the method was determined through controlled tank experiments using multiple standard spheres and 38 and 120 kHz split-beam transducers. Furthermore, by utilising the angular position information from one of the split-beam transducers, additional corresponding TS measurements can be collected with juxtaposed single-beam transducers. Both methods were utilised to extract *in situ* TS measurements of Antarctic scatterers simultaneously at 38, 120 and 200 kHz. Differences in the resulting TS measurements provided information

about the identity of constituents in a mixed-species assembly.

WG-EMM-97/25 Rev. 1
CEMP indices 1997: sections 1 to 3. CCAMLR Secretariat, 145 pp. (English, unpublished).

WG-EMM-97/26
Identification of squid echoes in the South Atlantic. C. Goss, P.G. Rodhouse, J.L. Watkins and A.S. Brierley (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 12 pp. *CCAMLR Science*, submitted (English).

During a research cruise of the British Antarctic Survey vessel RRS *James Clark Ross* in February 1996, a substantial number of the ommastrephid squid, *Martialia hyadesi*, were caught in a pelagic trawl near the Antarctic Polar Frontal Zone in CCAMLR Subarea 48.3. This paper describes acoustic data gathered during this haul and a survey of the immediate vicinity carried out in order to characterise an acoustic signature that may be used to identify this species of squid.

WG-EMM-97/27
Report of the workshop on predator–prey–fisheries interactions at Heard Island and McDonald Islands and at Macquarie Island. Australia, 38 pp. (English, unpublished).

WG-EMM-97/28
Important aspects of prey distribution for the formation of foraging areas of chinstrap penguins and Antarctic fur seals at Seal Island. T. Ichii, J.L. Bengtson, T. Hayashi, A. Miura, T. Takao, P. Boveng, J.K. Jansen, M.F. Cameron, L.M. Hiruki, W.R. Meyer, M. Naganobu and S. Kawaguchi (National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424 Japan), 24 pp. (English, unpublished).

Variables of prey availability between inshore and slope/offshore foraging areas were compared to evaluate important factors for the formation of foraging areas of chinstrap penguins (*Pygoscelis antarctica*) and Antarctic fur seals (*Arctocephalus gazella*) at Seal Island. Advantages of foraging inshore are: (i) proximity to breeding colonies and (ii) high krill (*Euphausia superba*) abundance, whereas those of foraging slope/offshore are: (iii) less patchy krill distribution; (iv) shallow krill distribution; (v) larger krill size; and (vi) occurrence of energy-rich bioluminescing myctophid fish at night. Chinstrap penguins foraged in two modes during the chick-brooding period: daytime-foraging chinstrap penguins foraged in the inshore region, while overnight-foraging penguins foraged in the slope region. It was suggested that an important factor for the formation of daytime foraging areas may be mainly (i), while those of overnight foragers may be primarily (iii) and secondarily (vi), considering chinstrap penguins may have difficulty in perceiving prey at night. Antarctic fur seals foraged mostly in the slope/offshore region during the pup-rearing period. It was suggested that the main important factors may be (iv) and (vi). In conclusion, feeding success may not necessarily be associated with dense aggregations of krill, but rather with distribution patterns of krill which enhance prey capture, and the availability of myctophid fish.

WG-EMM-97/29
Krill density, biomass, proportional recruitment and recruitment index in the Elephant Island region during the period 1977 to 1997. V. Siegel, V. Loeb and J. Gröger (Institut für Seefischerei, Bundes-forschungsanstalt für Fischerei, Palmaille 9, 22767 Hamburg, Germany), 11 pp. (English, unpublished).

The Elephant Island long-term dataset was updated for krill density and proportional recruitment. Krill biomass (from net sampling surveys) and absolute recruitment are introduced as additional indices for this time series. New survey results of the past two seasons indicate a very successful 1994/95 and an average 1995/96 krill year-class (below average for proportional recruitment, average for absolute recruitment). After a period of low krill density in the area for almost a decade, krill density and biomass have increased.

Caution is expressed regarding whether or not this observed increase represents a long-term recovery of the stock.

WG-EMM-97/30
AMLR 1996/97 field season report: objectives, accomplishments and tentative conclusions. Administrative Report LJ-97-09. Southwest Fisheries Science Center, La Jolla, Ca., USA, 1997, 14 pp. (English).

WG-EMM-97/31
ICES working group on fisheries acoustics science and technology (FAST): summary report of the meeting in Hamburg 18–19 April 1997. I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 9 pp. ICES CM 1997/B:5 (English, unpublished).

WG-EMM-97/32
How much is enough? Analysis of the net sampling effort in the Elephant Island area necessary to adequately assess and describe krill and zooplankton assemblages during summer. V. Loeb (Moss Landing Marine Laboratories, PO Box 450, Moss Landing, Ca. 95039-450, USA), 24 pp. (English, unpublished).

Data from US Antarctic Marine Living Resources (AMLR) program surveys conducted in the Elephant Island area from 1995 to 1997 are examined to determine the level of sampling effort required to assess adequately (i) the abundance and demographic structure of Antarctic krill and (ii) the relative abundance and inter-specific relations of krill, salps and other macrozooplankton taxa in the Elephant Island area during summer months. Both parametric and non-parametric techniques are used. Between-survey and between-year comparisons are made to examine possible changes in sampling adequacy resulting from ecological changes taking place on seasonal and interannual time scales. The results of these analyses indicate that minimal efforts such as eight-station transects are generally unreliable. Results from most analyses indicate that data from at least 55 stations are required to estimate adequately krill, salp and other zooplankton abundance, describe krill length-frequency and maturity stage composition, and assess the abundance relations of krill, salps and other zooplankton taxa in the Elephant Island area.

WG-EMM-97/33
Krill, salps and other dominant zooplankton taxa in the Elephant Island area during the 1997 austral summer. V. Loeb, D. Outram and K. Puglise (Moss Landing Marine Laboratories, PO Box 450, Moss Landing, Ca. 95039-450, USA), 16 pp. (English, unpublished).

Results from two net surveys conducted in the Elephant Island area during January to March 1997 indicated moderate krill abundance and lower recruitment success of the 1995/96 year class relative to that of 1994/95. These occurred after a relatively early spawning season in 1996 that, theoretically, should have promoted good krill recruitment. However winter 1996 was characterised by slightly below-average sea-ice conditions. These observations strongly suggest that winter sea-ice extent greatly affects larval survival and recruitment even when krill spawning is relatively early. Salp abundance values during March 1997 survey D were second only to those observed during February to March 1993 and, like in 1993, resulted from massive population growth during summer. This bloom, as did those in previous 'salp years', followed a winter with relatively low sea-ice development. The other zooplankton collected included a diverse taxonomic assemblage. Copepods, salps and postlarval *Thyanoessa macrura* were numerically dominant during both surveys. Day/night catch differences and inter-specific relationships among various zooplankton taxa observed during January to February 1997 survey A are described here.

WG-EMM-97/35
CPUE and proportional recruitment indices from Japanese krill fishery data in Subarea 48.1. S. Kawaguchi, T. Ichii and M. Naganobu (National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424 Japan), 21 pp. (English, unpublished).

Proportional recruitment indices and CPUE in Subarea 48.1 (Antarctic Peninsula region) from 1980 to 1996 were calculated based on logbook data from Japanese commercial krill trawlers. Proportional recruitment calculated from fisheries data was similar to that from scientific data (Siegel et al., 1997), and showed a close relationship to sea-ice indices. CPUE (catch/towing volume) in the Livingston Island area showed a decreasing trend during the study period. Changes in operational strategy in response to changes in product quality and a decrease in krill density in the area were considered as possible reasons for this. On the other hand, CPUE in the Elephant Island area showed greater interannual variation without any trend.

WG-EMM-97/36

CPUEs and body length of Antarctic krill during the 1995/96 season in the fishing grounds around the South Shetland Islands. S. Kawaguchi, T. Ichii and M. Naganobu (National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424 Japan), 10 pp. (English, unpublished).

This paper summarises Japanese krill catch data collected during the austral summer of 1995/96. The main fishing grounds throughout the season were consistently to the north of Livingston Island. CPUE in December was high, but from January to June CPUE was comparable to the value obtained for the Livingston Island area in the previous fishing season. From January to early May, the modal size of krill differed between the shelf area and the slope/outer shelf area. However, from mid-May to late June, no difference in length frequency and only a single component with modal size of 47 to 48 mm were observed.

WG-EMM-97/37

Interannual and seasonal variability of salp by-catch from Japanese krill fishery around the South Shetland Islands. S. Kawaguchi, T. Ichii and M. Naganobu (National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka, 424 Japan), 7 pp. *CCAMLR Science*, submitted (English).

Data on salp by-catch and green krill discoloured by active phytoplankton feeding were analysed based on logbook data of Japanese krill trawlers. Interannual and seasonal variability of the timing, duration and strength of salp bloom and green krill were analysed. Salp by-catch and occurrence of green krill seemed to show reverse correlation. Possibilities of competition for phytoplankton between krill and salps, and direct predation of krill on salps were discussed.

WG-EMM-97/38

The application of CCAMLR Ecosystem Monitoring Program (CEMP) standard methods in the Antarctic site inventory project. R. Naveen (PO Box 15259, Chevy Chase, Md. 20825, USA), 14 pp. (English, unpublished).

For three austral spring and summer field seasons (1994–97) the Antarctic Site Inventory project has collected data on Antarctic Peninsula visitor sites. It is intended that these data will assist in establishing baselines for: conducting future environmental assessments under the Antarctic Environmental Protocol; designing future monitoring programs to detect changes in fauna, flora, and other major features at these sites; and determining how best to minimise potential adverse impacts of human visitor activity. CEMP standard methods were used to establish the project's methodology, particularly with respect to counting penguin nests and chicks. At each site, investigators attempt to select prospective control (seldom disturbed) colonies and experimental (frequently disturbed) colonies to census. The intent is to carry out censuses regularly both near to and far from landing beaches where visitors access a site, allowing comparisons over time between areas subject to much human activity and those where there is no such activity. A power analysis indicates that the inventory's methodology fully conforms with sampling strategies recommended by the Working Group on Ecosystem Monitoring and Management (WG-EMM), enabling the inventory to detect a 10% or 20% change in a parameter with a significance level $\alpha \leq .01$ and a statistical power $P (= 1-\beta) \geq 0.8$.

WG-EMM-97/39
Serological evidence of the presence of infectious bursal disease virus in Antarctic penguins – possible implications for CEMP. Australia, 3 pp. (English, unpublished).

WG-EMM-97/40
Characterisation of the Antarctic Polar Frontal Zone to the north of South Georgia in summer 1994.
P.N. Trathan, M.A. Brandon and E.J. Murphy (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 21 pp. (English, unpublished).

The Polar Front (PF) forms the southern boundary of the Polar Frontal Zone (PFZ) along the northern edge of the Antarctic Circumpolar Current (ACC). In a number of areas the position of the PF (and thus the PFZ) is known to be influenced by topographic steering, while local bathymetry has also been implicated in the movement and retention of various associated mesoscale features. In this paper we examine the structure and position of the PF as it passes over the rugged bathymetry to the north of the Scotia Sea. Results are presented from an oceanographic transect crossing the PF to the northwest of South Georgia and from a pair of shorter transects south of the PF but north and east of the first. Associated with the PF was a narrow, high-speed flow embedded in broader, slower-moving regions. This high-speed flow was found to have a geostrophic component of velocity that was slower than estimates for other regions of the PF. Comparisons with output from recent oceanographic models were found to be consistent with the physical observations. A second examination of the region after a period of 30 days suggested that the surface expression of the PF had shifted southward by approximately 35 km but that the PF was essentially in the same position over the southern edge of the Maurice Ewing Bank. An advanced very high resolution radiometer image taken during the cruise provided additional information about the position of the surface expression of the PF and the extent of mesoscale features that were present to the north of the study area. Immediately to the north of South Georgia, water in the eastward flow of the ACC meets colder, more saline water flowing west along the north coast of the island. The area where these two flows meet was found to be variable over the 30-day timescale of the cruise. This area is known to be of major biological significance, and variability in the local oceanography is possibly of crucial importance to many predator species breeding at the northern end of South Georgia.

WG-EMM-97/41
Analysis of trawl data from the South Georgia krill fishery.
P.N. Trathan, E.J. Murphy, I. Everson and G.B. Parkes (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 20 pp. *CCAMLR Science*, submitted (English).

Data from individual trawls carried out by vessels operating in the South Georgia krill fishery were examined and a range of descriptive measurements reflecting the fishery operation are produced. The measurements emphasise that the krill fishery at South Georgia was geographically focused, operating in a limited area along the shelf edge on the northern coast of the island. Each day a large number of trawls were undertaken by each vessel, with trawls being shorter in duration during the middle of the day. Daytime trawls were also generally deeper and produced a larger catch. Individual trawls were examined to establish the time required for each phase of the trawl operation. The times associated with shooting and hauling the net were usually short and showed little variation, whereas the time associated with the actual fishing period was longer and more variable. The time between consecutive trawls was almost as long as the fishing period and showed similar levels of variability. Distances moved between consecutive trawls were generally small, suggesting that little effort was spent searching for fishable swarms beyond the near neighbourhood. The range of measurements describing the fishery indicate that differences existed between years. Aspects of variability are discussed in relation to previous attempts to model fishereis data and to derive suitable abudance indices that are sensitive to changes in biomass. The focused nature of the fishery at South Georgia suggests that

some form of abundance index may be valuable for management purposes, and that further detailed analysis would be useful.

WG-EMM-97/42
Escapement of elephant seal prey in the Heard Island fishery for *Dissostichus eleginoides*. A.J. Constable, R. Williams, W.K. de la Mare and D. Slip (Australian Antarctic Division, Channel Highway, Kingston, Tasmania, 7050, Australia), 4 pp. (English, unpublished).

The Patagonian toothfish, *Dissostichus eleginoides*, has been reported as a prey species of elephant seals in the Heard Island region. The question was raised at SC-CAMLR-XV concerning what affect the fishery for toothfish in Division 58.5.2 might have on the abundance of the age classes of toothfish preyed on by these seals. This paper provides an updated analysis of the age of toothfish taken by elephant seals at Heard Island and uses the generalised yield model (Constable and de la Mare, 1996) to examine the level of escapement of fish preyed on by these seals under the current total allowable catch of 3 800 tonnes. Of 21 otoliths found in elephant seal stomachs at Heard Island that have previously been identified as being from *D. eleginoides*, 18 were from one stomach and, of these, only seven could be reliably identified as being from toothfish. There appeared to be three pairs among the seven identified otoliths, based on the similarities of size and erosion state. Estimates of age were obtained from these otoliths. The importance of *D. eleginoides* as a prey item of elephant seals at Heard Island is unclear given the small number of otoliths that are of sufficient quality to be identified reliably and related to a specific size class of fish. However, it seems that toothfish in the age range of two to six years are likely to be vulnerable, to some extent, to predation by elephant seals. The evaluation of escapement of young fish (ages 2–6 years old) under the current catch limit of 3 800 tonnes in the trawl fishery in Division 58.5.2 indicates that escapement in terms of biomass is more than 85%, well above the 75% level adopted by CCAMLR for other prey species such as krill (*Euphausia superba*) generally and icefish (*Champsocephalus gunnari*) at Heard Island.

WG-EMM-97/43
A comparison between the estimated density of krill from an acoustic survey with that obtained by scientific nets on the same survey. T. Pauly, S. Nicol, W.K. de la Mare, I. Higginbottom and G. Hosie (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia), 14 pp. (English, unpublished).

This work presents the initial comparative analysis of acoustic and net haul krill density estimates for the RMT8 oblique (0 to 200 m depth) trawls conducted from January to March 1996 as part of a hydroacoustic biomass survey of Antarctic krill in CCAMLR Division 58.4.1. The acoustic krill density estimates were consistently larger than the net estimates, otherwise no relationship was found between the two datasets. Several orders of magnitude were seen in the range of variation between acoustic and net krill density estimates. This variation was reduced by subsampling the dataset, excluding sites where krill represented less than 90% of the catch. This reduction in variation was thus largely attributed to the removal of the mixed species component of the samples.

WG-EMM-97/45
Bias in the estimation of krill yield from using a deterministic formulation of the median unexploited spawning biomass. A.J. Constable and W.K. de la Mare (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia), 4 pp. *CCAMLR Science*, submitted (English).

Two Monte Carlo simulation models are currently available to CCAMLR for estimating krill yields according to decision rules that relate spawning stock status to the median unexploited spawning biomass, SB_0. The first model, the krill yield model, has been developed specifically for krill while the second is a generalised yield model. The decision rules relate to the effects of a specified long-term annual yield

(γ) on (i) the probability of the spawning stock being reduced below a set proportion of SB_0 during a projection run (probability of critical depletion), and (ii) the median status of the spawning stock (as a proportion of SB_0) at the end of the projection run (level of escapement). The krill yield model uses a biased estimate of SB_0 with a method for correcting this bias in the level of escapement. The generalised yield model uses an unbiased estimate of SB_0 and requires no correction. This paper examines the implications for estimates of krill yield of using the biased estimate of SB_0 in the krill yield model compared to the unbiased estimate in the generalised yield model. The results show that the biased estimate of SB_0 results in a biased estimate of the probability of critical depletion while the level of escapement is not appreciably sensitive to the method of estimating SB_0. This bias in the krill yield model will result in the catch level (γ) given for a set probability of critical depletion being too high. The relationship between fishing season and spawning season will influence the sensitivity of the krill yield model to this bias. In this case, a greater overlap between fishing season and spawning season will result in less bias occurring.

WG-EMM-97/46

Net sample validation of acoustic techniques used to identify and size Antarctic krill. J.L. Watkins and A.S. Brierley (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 21 pp. (English, unpublished).

Acoustic surveys to estimate krill biomass require that sound backscattered by krill be distinguished from all other types of backscatter. Traditionally this has been achieved by sampling characteristic types of acoustic target with nets. More recently, partitioning of backscatter into species groups has been attempted using differences in echo strength at two acoustic frequencies (ΔMVBS). Here we compare net and acoustic data from two cruises carried out around South Georgia in 1996 in order to assess the functionality of acoustic target identification techniques. MVBS data at 120 and 38 kHz were collected with a Simrad EK500 echosounder, and net samples were collected with an RMT8. Around 80% of the targets thought to be krill on the basis of their appearance on echocharts were also identified as krill on the basis of their difference in backscatter at 38 and 120 kHz ($\Delta MVBS = MVBS_{120} - MVBS_{38}$; where ΔMVBS is between 2 and 12 dB). Biomass values estimated from krill identified using echochart appearance or dB difference were broadly similar (regression: dB classification = 0.94 visual classification, r^2 = 0.99). Krill size was predicted from scattering models using the two-frequency data and compared with that obtained in net hauls. This comparison revealed that a simplified bent-cylinder model was a better predictor of krill length (predicted length = 8.79 + 0.685 observed length, r^2 = 0.77) than a fluid-filled sphere model.

WG-EMM-97/47

Variation in the distribution of Antarctic krill (*Euphausia superba*) around South Georgia. J.L. Watkins, A.W.A. Murray and H.I. Daly (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 34 pp. (English, unpublished).

Between 1980 and 1997 British Antarctic Survey carried out 11 cruises in the region of South Georgia. Here we summarise the length-frequency distributions of krill caught during each of these cruises and look particularly at differences between krill taken from the eastern and western ends of the island. Cluster analysis revealed that the length-frequency distributions could be grouped into five main types with relatively simple biological characteristics: cluster 1 were medium-sized year 2+ krill (mean size 39.7 mm); cluster 2 were a mixture of year classes (mean size 37.7 mm); cluster 3 were large krill probably 3+ and older (mean size 49.5 mm); clusters 4 and 5 were small krill, mostly year 1+, either with or without some older size classes (mean sizes 27.2 and 24.5 mm respectively). Principle components analysis (PCA) provided good separation of these clusters using the first two axes (80% of the total variance). The PCA for all cruises combined showed that there were no obvious differences in the type of krill found at different depths, although there were some indications that differences did occur

between different water masses. Detailed inspection of the individual cruises revealed that the smallest krill were found in Weddell Sea water and that the length-frequency distributions at the western end of the island contained more large krill than those from the eastern end of the island. We consider such differences may arise because krill may originate from either the Weddell Sea or Bellingshausen Sea and may experience different conditions during transport to South Georgia and at either end of the island.

WG-EMM-97/48

Krill biomass estimates for South Georgia, December/January 1996/97. A.S. Brierley, J. L. Watkins and C. Goss (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 10 pp. (English, unpublished).

Stratified random acoustic surveys, each comprising 10 parallel transects, were conducted within two areas 80 x 100 km over the shelf-break to the northeast and northwest of South Georgia during December/January 1996/97. Netting suggested that the mean lengths of krill within the eastern and western survey boxes were 36.1 mm and 45.4 mm respectively. These lengths were used to derive box-specific krill target strength (TS) values of -38.89 and -38.59 dB kg^{-1}. Acoustic signals believed to be attributable to krill were identified on the basis of the difference between mean volume back-scattering strength at 120 and 38 kHz ($MVBS_{120kHz} - MVBS_{38kHz}$ between 2 and 12 dB indicative of krill). Mean volume backscattering strengths at 120 kHz were scaled by the appropriate TS value to determine mean krill biomass for each transect. Transect values were used to derive weighted mean (and variance) estimates of krill biomass within each survey area. The estimates were 58.28 g m^{-2} (56.31) and 25.17 g m^{-2} (18.44) for the eastern and western boxes respectively. These mean density values were similar to those obtained during the most recent surveys of krill biomass (January 1996) in these areas, but substantially higher than estimates derived from surveys there in January 1994.

WG-EMM-97/49

Krill biomass and distribution in Subarea 48.2 during summer 1996. S.M. Kasatkina, V.A. Sushin, M.I. Polischuk and A.M. Abramov (AtlantNIRO, 5 Dimitry Donskoy Street, Kaliningrad 236000, Russia), 30 pp. (English, unpublished).

The results of a hydroacoustic survey of krill biomass carried out in Subarea 48.2 (adjacent to Coronation Island) in February/March 1996 by RV *AtlantNIRO* are presented. Hydrorological conditions during surveys are also discussed, taking into account the close relationship between krill and oceanographic structure of water masses and currents. Average weighted krill density in the study area amounted to 17 g/m^2, obtained on the basis of diurnal surveys. Average weighted krill density in the daytime amounted to 30.4 g/m^2, which is comparable with density values observed in other areas of Scotia Sea. However, density values obtained seem to be underestimates and typical only for the late summer season, since in the early summer season krill density may be higher. The estimate of krill biomass (1.12 ± 0.093 million tonnes) in the acoustic survey area, which was obtained on the basis of average weighted density in daytime and night-time hauls, is relatively accurate (CV = 4.1%). However, this estimate is likely to be biased downwards due to systematic error caused by underestimation of krill abundance during night hauls. We consider that estimates of krill biomass based on average weighted krill density in the daytime (30.4 g/m^2) provide a more accurate value of krill abundance in the study area. Thus, biomass amounted to 2.00 ± 0.573 million tonnes with a coefficient of variance equal to 12.5%.

WG-EMM-97/50

Distribution of the Soviet commercial krill fishing fleet around the South Orkneys (Subarea 48.2) during 1989/90. V.A. Sushin (AtlantNIRO, 5 Dimitry Donskoy Street, Kaliningrad 236000, Russia), 11 pp. *CCAMLR Science*, submitted (English).

The results of analysis of haul-by-haul catch statistics of the Soviet commercial

fleet for the 1989/90 season (3 614 hauls for the period from 1 November 1989 to 12 June 1990) are presented. Over the entire season fishing vessels worked in one fishing ground off the northwestern edge of Coronation Island. Incidentally, CPUE shows regular intraseasonal variations from a minimum in November (3.2 tonnes/hour) to a maximum in February and March (9.6 tonnes/hour and 11.0 tonnes/hour respectively), with a subsequent decrease to 6.9–7.1 tonnes/hour in May/June. The stability of the fishing ground is governed by hydrodynamic features, such as a stationary doubling current around the islands and a high level of water disturbance caused by topogenic factors. No temporally or spatially sustained fishable krill aggregations are likely to form outside the main area (excluding November 1989). In November the commercial fleet fished oceanic krill aggregations formed in the major current which transports krill northeastwards. A drift of the fleet fishing the above aggregation was observed. A maximum CPUE (3.8 tonnes/hour) was observed in the beginning of the period with a gradual subsequent decrease to a level unacceptable to the fleet (2.5 tonnes/hour) towards the end of November. Following the break-up of that aggregation, which had existed for about 25 days, commercial vessels returned to Coronation Island. Krill drift velocity, estimated on the basis of fishing ground shift velocity, amounted to 7.4 km/day or 8.7 cm/sec. This velocity is comparable to the drift velocity off Elephant Island (11–13 cm/sec) obtained earlier (Sushin and Myskov, 1992).

WG-EMM-97/51

Assessment of krill catch rates in Subarea 48.2 during the 1989/90 season. V.I. Ivanova, S.M. Kasatkina and V.A. Sushin (AtlantNIRO, 5 Dimitry Donskoy Street, Kaliningrad 236000, Russia), 16 pp. (English, unpublished).

The aim of this research program was to assess the impact of fishing on the krill population during the months December to March, which are critical to dependent species. Estimates of catch rates are calculated on the basis of haul-by-haul commercial statistics for the Russian fleet (data of 2 900 trawls are used) operating in the South Orkneys area from December 1989 to March 1990. In the above period the total krill catch amounted to 88 900 tonnes, which constitutes the upper limit of seasonal catch rates (2 700 to 88 900 tonnes) obtained for the same four months during the period 1984 to 1993 (CCAMLR, 1994). Therefore, the critical months to dependent species (December to March 1989/90) were considered to be the months of the highest fleet pressure over the entire period from 1984 to 1993. Krill fishing was concentrated in the area to the north of Coronation Island. During the period considered the average monthly catch per haul ($\bar{Q}$) of those vessels was 30 tonnes. The highest variability was observed in haul duration ($\bar{\tau}$) and catch per hour of hauling ($\bar{q}$). Coefficients of variation of the average monthly estimates of those parameters during the period studied were: CV ($\bar{Q}$) = 5.7%, CV ($\bar{\tau}$) = 46%, CV ($\bar{q}$) = 36.2%. During the period from December 1989 to March 1990 catch rates in each month critical to dependent species did not exceed 10% of the initial krill stock at the beginning of each month over the entire area of fishing. On the fishing grounds where most vessels operated, the above estimate did not exceed 15%. Taking into account the estimation method used, those values are considered to be in the upper range of a theoretically calculated limit. Taking into account the major fishing ground location within the zone of regular krill recruitment, it may be assumed that competition between the fishing fleet and dependent predators for krill resources in that area is insignificant, therefore, the probable negative impact via trophic chain is low.

WG-EMM-97/52

Variation in echosounder calibration with temperature, and some possible implications for acoustic surveys of krill biomass. A.S. Brierley, C. Goss, J.L. Watkins and P. Woodroffe (British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom), 9 pp. *CCAMLR Science*, submitted (English).

Accurate estimation of krill biomass by acoustic techniques is dependant upon a number of factors including, fundamentally, accurate echosounder calibration.

The Simrad EK500 scientific research echosounder used aboard RRS *James Clark Ross* is regularly calibrated at South Georgia before and after krill surveys, and exhibits acceptable temporal stability in the system gain settings. Between Antarctic seasons, this echosounder has additionally been calibrated in temperate European waters and, under these conditions, calibrated gain settings differ markedly from those applied in the Antarctic, even after appropriate adjustments for differences in sound speed between locations have been made. Here we present results from multiple Antarctic and European calibration events which suggest that echosounder transducer performance is dependant upon ambient water temperature. Highly significant differences in S_V and TS transducer gains were detected at both 38 and 120 kHz between calibrations conducted at the two locations. At 120 kHz, required S_V transducer gains were on average 1.4 dB less at South Georgia (sea temperature 2.0˚C) than in European waters (7.3˚C), and a similar trend was detected at 38 kHz. If European calibrationparameters were to be employed on surveys around South Georgia, and no account were taken of the differences in gain settings, then integrated 120 kHz echo signals would be under-reported by 2.8 dB, leading in turn to an underestimation of krill biomass by 52.5%. Every effort should therefore be made to ensure that echosounders are calibrated at a location as close as possible to the area in which surveys are to be conducted. In addition, the implications of temperature variation across a survey area for biomass estimation should be considered carefully.

WG-EMM-97/53

Spatial and temporal distribution of krill (*Euphausia superba*) biomass in the Ross Sea (1989/90, 1994/95). M. Azzali and J. Kalinowski (National Research Council, Institute for Marine Fishery, Molo Mandracchio, 60100 Ancona, Italy), 34 pp. (English, unpublished).

This paper, based on the results of Italian expeditions to the Ross Sea (December 1989 to January 1990 and November to December 1994), describes and quantifies spatial and temporal distribution of krill biomass. Hydroacoustic observations were carried out when the study area was practically covered by pack-ice (November to mid-December) or immediately after the ice had receded (end of December to January). The ice began to melt in mid-November, near the Ross Ice Shelf (so-called polynia area) and moved northwards. All research was carried out in the daytime. Krill were observed in aggregations both below the ice and in ice-free water, but below the ice krill were dispersed. On many occasions individual krill were observed on pieces of ice broken up by the icebreaker, therefore it can be assumed that below-ice krill occurred mainly in scattered forms very close to the surface. Aggregations of krill were observed mainly in the part of the Ross Sea between 70° and 75°S, although in November and the beginning of December they were closer to 75°S while towards the end of December and January they were observed closer to 70°S. It may be suggested that, temporally, krill migrated horizontally northwards, parallel to the receding ice. It is also possible that parts of observed aggregations were not the result of migration, but rather created from krill previously dispersed below the ice. The biomass density of krill was calculated per nautical mile. In order to compare the biomass from different years, the whole study area was divided in rectangles of 1.0° x 0.5°. The results of calculations indicate that krill biomass in the western part of the Ross Sea (east of longitude 180°), estimated during late spring and at the beginning of the austral summer in 1994, was about 3 million tonnes. The study area measured approximately 30 000 n miles^2 and the mean biomass density was about 100 tonnes/n miles^2. The highest value of biomass density (51 761 tonnes/n miles^2) was recorded on 23 November 1997 at position 174°36'S, where a so-called superswarm was observed. In November 1994, 80 to 100% of the study area was covered by ice. The abovementioned superswarm was recorded in a small area of ice-free water. It may be assumed that below-ice krill occurred mainly in scattered forms (as mentioned above), and when the environmental conditions are favourable krill aggregations can be formed very quickly. During the 1989/90

expedition hydroacoustic observations were carried out at the end of December and in January in ice-free water. During the first part of an echo survey (at the end of December and at the beginning of January) in an area of 13 000 n miles^2, a total biomass of 426 000 tonnes was estimated (mean biomass density approximately 32 tonnes/n miles^2). During the second part of the hydroacoustic survey (January), in an area measuring about 22 000 n miles^2, the estimated biomass was 847 000 tonnes (mean biomass density approximately 39 tonnes/n miles^2). The highest value of biomass density (1 041 tonnes/n miles^2) was found in January at position 175°40'E, 70°45'S. The results of the Italian expeditions indicate that, contrary to previously stated opinions, biomass density of *E. superba* in the Ross Sea (Pacific Sector), is similar to values calculated for the Atlantic and Indian sectors.

WG-EMM-97/54

Acoustic discrimination of Southern Ocean zooplankton. A.S. Brierley, P. Ward, J.L. Watkins and C. Goss. *Deep-Sea Research*, Bioacoustical Oceanography special issue, submitted (English).

Acoustic surveys in the vicinity of the sub-Antarctic island of South Georgia revealed the existence of a number of horizontally extensive yet vertically discrete scattering layers in the upper 250 m of the water column. These layers were fished with a Longhurst-Hardy plankton recorder (LHPR) and a multiple-opening 8 m^2 rectangular midwater trawl (RMT8). Analysis of catches suggested that each scattering layer was composed predominantly of a single species of either the euphausiids *Euphausia frigida* or *Thysanöessa macrura*, the hyperiid amphipod *Themisto gaudichaudii*, or the eucalaniid copepod *Rhincalanus gigas*. Instrumentation on the nets allowed their trajectories to be reconstructed precisely, and thus catch data to be related directly to the corresponding acoustic signals. Discriminant function analysis of differences between mean volume backscattering strength at 38, 120 and 200 kHz separated echoes originating from each of the dominant scattering layers, and other signals identified as originating from Antarctic krill *Euphausia superba*, with an overall correct classification rate of 77%. We therefore demonstrate that with the use of echo intensity data alone, gathered using hardware commonly employed for fishery acoustics, it is possible to discriminate *in situ* between several zooplanktonic taxa, taxa which in some instances exhibit similar gross morphological characteristics and have overlapping length-frequency distributions. Acoustic signals from the mysid *Antarctomysis maxima* could additionally be discriminated once information on target distribution was considered, highlighting the value of incorporating multiple descriptors of echo characteristics into signal identification procedures. The ability to discriminate acoustically between zooplankton taxa could usefully be applied to provide improved acoustic estimates of species abundance, and to enhance field studies of zooplankton ecology, distribution and species interactions.

WG-EMM-97/55

Breeding distribution and population sizes of three species of penguin at sub-Antarctic Marion Island. R.J.M. Crawford, B.M. Dyer, M. Greyling, J. Hurford, D. Keith, M.A. Meyer, L. Upfold and A.C. Wolfaardt (Sea Fisheries Research Institute, Private Bag X2, Roggebaai 8012, South Africa), 18 pp. (English, unpublished) (Abstract not available).

WG-EMM-97/56

Breeding biology and diet of pintado petrels (*Daption capense*) at Bouvetøya during the summer of 1996/97. O. Huyser, B.M. Dyer, K. Isaksen, P.G. Ryan and J. Cooper (Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7700, South Africa), 23 pp. (English, unpublished).

A study on the breeding biology and diet of pintado petrels (*Daption capense*) was conducted at Nyrøysa, Bouvetøya, South Atlantic, from December 1996 to February 1997. Overall breeding success for the total 300 pairs of breeding pintado petrels at Nyrøysa was 59%. Three study colonies were marked out and monitored intensively; in one colony overall breeding success was only 4% owing to predation by sub-

Antarctic skuas (*Catharacta antarctica*) on unattended chicks, but in another colony the success rate was 85%. Rates of failure were higher during the chick stage than in the egg stage for both of these two study colonies. The mean hatching date in these colonies was 11 January, and the first and last hatching 6 and 18 January respectively. The mean period when chicks were permanently attended by parents (guard period) was 14 days. The length of the guard period was negatively related to the date of hatching (expressed as the number of days since the first egg hatched, i.e. 6 January). Growth of chicks in the third study colony was similar to that recorded for other populations of pintado petrel, as was the diet of chick-rearing adults – dominated by euphausiids, especially krill (*Euphausia superba*). Whole female krill occurred more frequently (and were larger) than male krill in the diets of chick-rearing pintado petrels at Nyrøysa. It is estimated that during the nestling stage the entire Bouvetøya population of pintado petrel chicks consumes 6 500 kg of krill.

WG-EMM-97/57
Draft Standard Method A3b. P. Wilson (Manaaki Whenua, Landcare Research, Private Bag 6, Nelson, New Zealand), 3 pp. (English, unpublished).

WG-EMM-97/58
Diet and prey consumption of Antarctic petrels (*Thalassoica antarctica*) at Svarthamaren, Dronning Maud Land and at sea outside the colony. S. Lorentsen, N. Klages, N. Røv (Norwegian Institute for Nature Research, Tungasletta 2, N-7005 Trondheim, Norway), (Norwegian Antarctic Research Expeditions 1991/92 and 1993/94) (English).

The diet of the Antarctic petrel *Thalassoica antarctica* was studied during two years at Svarthamaren, an inland colony situated in Dronning Maud Land, Antarctica and in the pack-ice outside Svarthamaren. The analyses showed that the most important food (wet weight) at Svarthamaren was crustaceans (68%), followed by fish (29%) and squid (3%), whereas individuals collected in the pack-ice took mostly fish (95%), followed by crustaceans (5%). The prey composition and length found in this study is comparable to what is found in other diet studies. Estimates of food consumption for birds breeding at Svarthamaren (c. 250 000 pairs) indicate that they take approximately 6 600 tonnes of crustaceans, 2 600 tonnes of fish and 485 tonnes of squid during the breeding season. Furthermore, their annual consumption is estimated to 34 800 tonnes of crustaceans, 13 800 tonnes of fish, and 2 600 tonnes of squid. Satellite telemetry studies indicate that Antarctic petrels from Svarthamaren may fly more than 3 000 km during one foraging trip and may thus cover a huge ocean area.

WG-EMM-97/59
Population structure of the Antarctic krill (*Euphausia superba*) populations in CCAMLR Division 58.4.1 during January to March 1996. S. Nicol, J. Kitchener, R. King, G. Hosie and W.K. de la Mare (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 37 pp. (English, unpublished).

This report summarises some of the results of krill studies from a large-scale survey of CCAMLR Division 58.4.1 conducted from January to March 1996. Krill varied in mean size across the survey area and the various maturity stages showed some longitudinal and latitudinal trends. Growth rate measurements resulted in figures comparable to other studies carried out in the Indian Ocean sector and these results have been examined in conjunction with the size measurements to examine seasonal and geographic differences. The relationship between mean krill and salp abundance per transect and average annual ice cover was investigated and the results of this voyage seem to suggest some degree of geographic linkage between these parameters.

WG-EMM-97/60
The diet of the Antarctic fur seal (*Arctocephalus gazella*) at Harmony Point, Nelson Island, South Shetland Islands. R. Casaux, A. Baroni and A. Carlini (Dirección

Nacional del Antártico, Cerrito 1248, 1010 Buenos Aires, Argentina), 12 pp. (English, unpublished).

The diet of juvenile and non-breeding male Antarctic fur seals (*Arctocephalus gazella*) was investigated at Harmony Point, Nelson Island, South Shetland Islands, by analysing 18 and 33 scats collected during the 1995/96 and 1996/97 summer seasons respectively. Overall, fish were the most frequent prey (74.5%) and predominated by mass (54.4%), whereas krill did by number (94.2%). This pattern coincides well with that observed in 1996/97, but in 1995/96 krill was also the most important prey by mass (50.2%). The importance of the remaining taxa represented in the samples (octopods, hyperiids and bivalves) was negligible. Among fish, myctophids represented 85.2% of the fish mass, the main prey being *Gymnoscopelus nicholsi* and *Electrona antarctica*. These two species also predominated in 1996/97, whereas *Cryodraco antarcticus* and *Gobionotothen gibberifrons* did in 1995/96. The importance of myctophids as prey of the Antarctic fur seal is discussed.

WG-EMM-97/61

On the accuracy of the pellet analysis method to estimate the food intake in the Antarctic shag (*Phalacrocorax bransfieldensis*). R. Casaux (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 13 pp. (English, unpublished).

The accuracy of correction factors used to compensate for digestion and loss through the gastrointestinal tract of fish otoliths found in pellets of the Antarctic shag (*Phalacrocoraxbransfieldensis*) was tested at two localities of the South Shetland Islands. For this purpose, results from the analysis of 226 and 115 pellets collected throughout the breeding season at Harmony Point and at Duthoit Point respectively were corrected for the abovementioned factors. The estimates indicated that the daily food intake increased from November to January (pre-laying to late-rearing) and decreased slightly in February. These estimates are generally in line with those previously obtained for other colonies and/or shags by different methods, which suggests that the use of pellets is an acceptable way of quantifying the diet of the Antarctic shag.

WG-EMM-97/62

Population size and distribution of *Pygoscelis antarctica* and *P. papua* at Cape Shirreff, Livingston Island, Antarctica (1996/97 season). R. Hucke-Gaete, D. Torres and V. Vallejos (Universidad Austral de Chile, Facultad de Ciencias, Instituto de Zoología, Casilla 567, Valdivia, Chile), 10 pp. (English, unpublished) (Abstract not available).

WG-EMM-97/63

Population size and distribution of *Arctocephalus gazella* at SSSI No. 32, Livingston Island, Antarctica (1996/97 season). R. Hucke-Gaete, D. Torres, V. Vallejos and A. Aguayo (Universidad Austral de Chile, Facultad de Ciencias, Instituto de Zoología, Casilla 567, Valdivia, Chile), 14 pp. (English, unpublished) (Abstract not available).

WG-EMM-97/64

Adélie penguins' foraging behaviour and krill abundance along the Wilkes and Adélie Land coasts, Antarctica. B.C. Wienecke, R. Lawless, D. Rodary, C. Bost, R. Thompson, T. Pauly, G. Robertson, K. Kerry and Y. Lemaho, (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 22 pp. (English, unpublished).

The foraging behaviour of Adélie penguins (*Pygoscelis adeliae*) was studied simultaneously at Shirley Island (SI) near Casey Station and at Petrel Island (PI) at Dumont d'Urville during the 1995/96 breeding season. The study took place in conjunction with a ship-based krill survey in CCAMLR Division 58.4.1 (south of 55°S, 80–150°E) to determine the extent of overlap between penguin foraging areas and krill distribution. The maximal distances travelled by penguins from Shirley Island were significantly greater than those by penguins from Petrel Island (SI 68–113 km; PI about 37 km). Foraging trip durations and total distances travelled were also significantly different between colonies (duration: SI 55–113 hours, PI 25–32 hours; total distance: SI 182–352 km, PI 86–100 km). All penguins foraged over the continental shelf and not in oceanic waters. The percentage distribution of dive depths

was similar at both colonies; nearly 70% of all dives were to <35 m. Trawls from the ship contained *Euphausia superba* and *E. crystallorophias* near Shirley Island, but only *E. superba* near Petrel Island. The diet of the Shirley Island penguins consisted mainly of *E. crystallorophias* (47–51%), while penguins from Petrel Island ingested large amounts of both euphausiids (27-38% *E. superba*, 22–39% *E. crystallorophias*). At Shirley Island, the remainder of the diet consisted of fish, mainly *Pleuragramma antarcticum* (20–40%) and amphipods (<3%). The study took place in parallel to a ship-based krill survey in CCAMLR Division 58.4.1 (south of 55˚S, 80-150˚E). Acoustic and trawl data were collected near both study sites, albeit at the end of the Adélie breeding season.

WG-EMM-97/65
Horizontal flux of secondary production in the Southern Ocean food web: current velocity data and the transport of krill in the South Georgia ecosystem. E.J. Murphy, I. Everson and P.N. Trathan (British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom), 19 pp. (English, unpublished).

The transport of secondary production in the Southern Ocean food web was investigated using a combination of physical model data and biological data collected from vessels. The physical current velocity dataset was from FRAM and was used to derive a mean velocity field for the upper 250 m of the water column. These data have been combined with estimates of krill density and standing stocks to consider the flux of krill through the South Georgia area and estimate residence times. These data have been considered with estimates of local predator demand to consider the implications for calculating precautionary catch levels suitable for the region. The study suggests that catch levels in this area have in the past been of the same order as the calculated potential yield. The work highlights the need for improved information on spatial food web connections, krill flux and residence times.

WG-EMM-97/66
Environmental variability effects on marine fisheries: four case histories. E.E. Hofmann and T.M. Powell (Center for Coastal Physical Oceanography, Old Dominion University, Norfolk, Va. 233529, USA), 34 pp. (English, unpublished).

The changing nature of marine fisheries requires management approaches that recognise and include ecosystem and environmental effects. Therefore, we review some examples of exploited fish stocks in which environmental control is a major contributor to structuring the abundance and distribution of the stock. Four examples (ranging from Antarctic krill to oysters) are given that clearly illustrate environmental control of the fishery. From these examples, we argue that future management strategies for exploited fisheries must include the effects of environmental variability. In particular, management strategies must be flexible enough to include delayed responses to environmental variations that result from the transfer of perturbations from larger to smaller scales and vice versa. This capability requires an understanding of where linkages between the physical environment and the species of interest occur. Development of this knowledge requires input from a variety of disciplines, coordinated research programs, and considerable cooperation at national and international levels.

WG-EMM-97/67
Structure of the Antarctic circumpolar current in the South Atlantic with implications for biological transport. E.E. Hofmann, J.M. Klinck, R.A. Locarnini, B. Fach and E.J. Murphy (Center for Coastal Physical Oceanography, Old Dominion University, Norfolk, Va. 233529, USA), 16 pp. (English, unpublished) (Abstract not available).

WG-EMM-97/68
Hydrography and circulation of the Antarctic continental shelf: 150°E eastward to the Greenwich Meridian. E.E. Hofmann and J.M. Klinck. In: A.R. Robinson and K.H. Brines (Eds). *The Sea, The Global Coastal Ocean;*

Regional Studies and Synthesis, Vol. 11, in press. John Wiley and Sons. (English) (Abstract not available).

WG-EMM-97/69

Pursuit of polynyas in the Antarctic Peninsula area. M. Naganobu, K. Shibazaki, N. Kimura, Y. Okada and S. Matsumura (National Research Institute of Far Sea Fisheries, 5-7-1 Orido, Shimizu, Shizuoka 424, Japan), 12 pp. (English, unpublished).

Polynyas accelerate oceanic and atmospheric processes. Moreover, we consider that polynyas influence biological activity. We observed the daily transition of coastal polynyas in the Antarctic Peninsula area from 1978 to 1995 using microwave satellite images of sea-ice concentrations. A typical polynya existed off the tip of the Peninsula in 1987 and 1991. In those years, sea-ice cover developed extensively. Conversely, the years of narrow sea-ice cover were 1988, 1989, 1990 and 1993. In those years, polynyas did not exist. The typical polynya (nearly 500 x 200 km) in 1987 was observed from 1 August to 20 October. The shape of the polynya changed remarkably over several days. We speculated that annual variability of sea-ice cover and, consequently, polynyas is mainly caused by westerly winds.

WG-EMM-97/70

Further krill-predator model calculations. R.B. Thomson and D.S. Butterworth (Sea Fisheries Research Institute, Private Bag X2, Rogge Bay 8012, South Africa), 22 pp. (English, unpublished).

Thomson and Butterworth (1996) developed a krill–predator model and applied this to an Antarctic fur seal dataset. These calculations are extended here. The level of krill fishing intensity required to halve the fur seal population (γ_{half}) is between 0.08 and 0.09, slightly lower than that estimated previously. Tests of the estimation procedure indicate that γ_{half} estimates are likely to be biased upwards. The estimator is not robust to incorrect specification of the assumed form of the functional relationship between krill availability and survival rates, and especially not to the assumption of the size of the maximum growth rate which the population can achieve. Refinements are introduced to the process of applying this approach to the black-browed albatross dataset, but calculations to estimate γ_{half} for this species have yet to be completed. The results quoted above are for the deterministic models; stochastic calculations await finalisation.

WG-EMM-97/71

Australia's contribution to CEMP 1996/97: summary and notes. Australia, 8 pp. (English, unpublished).

WG-EMM-97/72

Fish by-catch in the Japanese commercial krill fishery to the north of the South Shetland Islands in February 1997. T. Iwami, M. Naganobu, T. Ichii and S. Kawaguchi (Laboratory of Biology, Tokyo Kasei Gakuin University, 2600 Aihara, Machida, Tokyo 194-02, Japan), 3 pp. (English, unpublished).

Scientific observations of fish by-catch in krill catches taken by FV *Niitaka Maru* from 1 to 23 February 1997 to the north of the South Shetland Islands. In the 80 hauls examined, a total of 61 specimens belonging to four families and seven species, *Electrona antarctica* (50 specimens), *Electronacarlsbergi* (4), *Protomyctophum tenisoni* (1), *Gymnoscopelus opisthopterus* (1), *Notolepis coatsi* (3), *Benthalbella elongata* (1) and *Neopagetopsis ionah* (1), were taken as by-catch in 16 hauls. Except for one channichthyid juvenile *Neopagetopsis ionah*, by-catch fish belonged to the bathypelagic families, Myctophidae, Paralepididae and Scopelarchidae. The myctophid *Electrona antarctica* was the most abundant by-catch species. This species was found in 12 hauls, and its estimated frequency was 20 to 380 individuals per tonne. The by-catch data obtained did not demonstrate a clear relationship between the abundance of by-catch fish and krill CPUE. This observation differs from those made in previous studies. In the present survey, the abundance of by-catch was well correlated to the time zone of trawling, which is thought to be the result of the large amount of bathypelagic fishes in the catches.

WG-EMM-97/73
Effects of sea-ice extent and krill or salp dominance on the Antarctic food web. V. Loeb, V. Siegel, O. Holm-Hansen, R.P. Hewitt, W.R. Fraser, W. Trivelpiece and S. Trivelpiece. *Nature*, 387: 897–900, 1997 (English).

Krill (*Euphausia superba*) provide a direct link between primary producers and higher trophic levels in the Antarctic marine food web. The pelagic tunicate *Salpa thompsoni* can also be important during spring and summer through the formation of extensive and dense blooms. Although salps are not a major dietary item for Antarctic vertebrate predators, their blooms can affect adult krill reproduction and survival of krill larvae. Here we provide data from 1995 and 1996 that support hypothesized relationships between krill, salps and region-wide sea-ice conditions. We have assessed salp consumption as a proportion of net primary production, and found correlations between herbivore densities and integrated chlorophyll-*a* that indicate that there is a degree of competition between krill and salps. Our analysis of the relationship between annual sea-ice cover and a longer time series of air temperature measurements indicates a decreased frequency of winters with extensive sea-ice development over the last five decades. Our data suggest that decreased krill availability may affect the levels of their vertebrate predators. Regional warming and reduced krill abundance therefore affect the marine food web and krill resource management.

WG-EMM-97/74
Echo integration in low signal-to-noise regimes: methods of noise estimation and removal. I. Higginbottom and T. Pauly (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 13 pp. (English, unpublished).

The results of acoustic surveys, especially in low signal-to-noise regimes, are sensitive to the method used to exclude the contribution of background noise from the acoustic data. The use of thresholds to reject weak signals during data collection is inappropriate because the noise contribution to the above threshold-signal cannot later be removed in post processing. The only solution is to log unthresholded data and to correct for noise in post processing. Integrated data collected at 120 kHz with a Simrad EK500 are presented to demonstrate the highly variable nature of background noise. A dynamic method to determine background noise for individual integration intervals was found to be better than several methods that apply a single background noise level to a dataset. The dynamic technique requires that logged data have high resolution in both depth and distance. It can be applied so long as some integration layers in each integration interval include only noise. Further, it is recommended that the physically meaningful quantity 'noise power', being the apparent received power (dB/1W) at the transducer due to noise, be used to describe background noise levels.

WG-EMM-97/75
Laboratory target strength measurements of free-swimming Antarctic krill (*Euphausia superba*). T. Pauly and J.D. Penrose (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia), 40 pp. (English, unpublished).

Target strength measurements of free-swimming krill at 120 kHz were made using a single-beam monostatic system in a laboratory tank with a volume of 10 m^3. Krill (grouped according to length classes) swam freely in the tank, triggering the data acquisition system when generating a back scattering signal larger than a threshold, determined by the system noise level. Dorsal and ventral target strength estimates were calculated indirectly by deconvolution of the cumulative probability function of echo ensembles of single-animal insonifications. For mean length classes in the range [29.6, 36.2] mm the median single-animal target strengths are in the range [-76.7, -71.8] dB. Monte Carlo computer simulations were used to evaluate the effects of varying the ratio of largest to smallest echo amplitudes for a given ensemble, thus enabling the estimation of threshold-induced bias in the target strength estimates. The threshold-induced bias was then determined for each ensemble of experimental data and used to determine corrections which were in the range of

[-0.84, -0.33] dB. An error analysis of the target strength estimates detailing the components due to measurement accuracy and precision, and the indirect signal-processing techniques used are also presented.

WG-EMM-97/77
Synthesis of activities carried out at SSSI No. 32 and the CEMP site 'Cape Shirreff and San Telmo Islands' during the Antarctic season 1996/97. D. Torres (Departamento Científico, Instituto Antártico Chileno, Luis Thayer Ojeda 814, Correo 9 Santiago, Chile), 5 pp. (English, unpublished).

WG-EMM-97/78
Summary of monitoring and research activities at Svarthamaren, Dronning Maud Land. N. Røv, S. Lorentsen and T. Tveraa (Norwegian Institute for Nature Research, Tungasletta 2, N-7005 Trondheim, Norway), 11 pp. (English, unpublished).

Data obtained from monitoring Antarctic petrel (*Thalassoica antarctica*) population and demography at Svarthamaren, Dronning Maud Land, from five field seasons between 1991/92 and 1996/97 are presented. The results of population monitoring show that the number of pairs with chicks or eggs varied between 55 387 and 178 240 (mean 119 000). Assuming that about 10% of the colony is situated in inaccessible parts outside the area covered by the monitoring system, the mean number of pairs producing a chick each year is about 132 000. On average 52% of the reproductive fraction of the population breeds each year, indicating that the total number of reproductive birds attached to the colony is approximately 510 000 individuals. Annual survival rates varied between 0.871 and 0.954 (mean 0.924). Our results suggest that a monitoring program for breeding Antarctic petrels should include estimation of mortality rates and breeding frequency in addition to the numbers of birds breeding.

WG-EMM-97/79
Proposal for the second international symposium on krill. M. Mangel, S. Nicol, J. Cuzin-Roudy, Y. Endo, D. Miller and J.L. Watkins (Section of Evolution and Ecology, University of California, Davis Ca. 95616, USA), 5 pp. (English, unpublished).

Working Group on Fish Stock Assessment

WG-FSA-97/4
International observer program, Convention for the Conservation of Antarctic Marine Living Resources: Protocol – randomised sampling designs for use in sampling *Dissostichus eleginoides* in a longline fishery. J. Ashford and G. Duhamel (Applied Marine Research Laboratory, Old Dominion University, 1034 West 45th Street, Norfolk, Va. 23529, USA), 16 pp. (English, unpub-lished).

WG-FSA-97/5
Natural mortality rate in the mackerel icefish (*Champsocephalus gunnari)* around South Georgia. I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 23 pp. *CCAMLR Science*, submitted (English).

Information on natural mortality rates of the mackerel icefish (*Champsocephalus gunnari*) from the period prior to large-scale commercial harvesting is discussed. The methods used are based on population age structure and growth parameters. It is concluded that only in the three earliest years, 1951, 1964 and 1966, do the data reflect an unexploited population. The best estimate of M from analyses of the data from these seasons is 0.3 for age 3 and 4 but increases to 0.7 for fish greater than age 5. It is suggested that results from 1967 and 1968 may have been affected by large-scale fishing prior to the reported commencement of commercial fishing in 1970.

WG-FSA-97/6
Report on the assessment of reduced incidental mortality of seabirds in Division 58.5.1 (Kerguelen Islands) during the 1996/97 fishing season. A.S. Petrenko and A.M. Vertunov

('YUGRYBPOISK', 5 Kozlov Street, Kerch 334500, Crimea, Ukraine), 4 pp. (English, unpublished).

WG-FSA-97/7
Report on fisheries activities of Ukrainian longliners in Division 58.5.1 (Kerguelen Islands) during 1996/97. A.S. Petrenko and A.M. Vertunov ('YUGRYBPOISK', 5 Kozlov Street, Kerch 334500, Crimea, Ukraine), 3 pp. (English, unpublished).

WG-FSA-97/8
Meteorological conditions during 1996/97 fishing campaign for toothfish in the waters of Kerguelen Islands. A.S. Petrenko ('YUGRYBPOISK', 5 Kozlov Street, Kerch 334500, Crimea, Ukraine), 3 pp. (English, unpublished) (Abstract not available).

WG-FSA-97/9
An assessment of measures mitigating seabird mortality in longlining operations for *Dissostichus eleginoides* around South Georgia, March–May 1997. J. Ashford and J.P. Croxall, (Applied Marine Research Laboratory, Old Dominion University, 1034 West 45th Street, Norfolk, Va. 23529, USA), 34 pp. *CCAMLR Science,* submitted (English).

Interactions of seabirds with longlining operations for *D. eleginoides* off South Georgia and the effectiveness of measures employed to mitigate seabird mortality were assessed. In this study 61 lines were set during April and May, all at night, using the Spanish double-line method with extra weights on the line and all deck-lights extinguished. Data were recorded during hauling using a randomised cluster sampling method, which has been developed to allow representative data to be collected when 100% observer coverage could not be achieved. Thirteen seabird deaths were recorded, all during setting operations and all but one during April, giving an average mortality rate of 0.018 birds/1 000 hooks, and 0.099 birds/1 000 observed hooks. Bird deaths were as follows: nine white-chinned petrels, two black-browed albatrosses and one unidentifiable bird caught on hooks; and one giant petrel killed which flew into the side of the vessel. Few birds were generally seen following the vessel during setting operations. However, during April large numbers of white-chinned petrels were seen occasionally, and observed to dive; large numbers of black-browed albatrosses were seen when the moon was full, but were observed to dive on only one night. Live birds were observed to become caught on hooks during hauling on 23 occasions; no mortalities resulted, birds being released apparently unharmed. Black-browed albatrosses concentrated on taking returning bait off the line and accounted for eighteen birds caught; giant petrels concentrated on taking discarded offal, and accounted for five birds caught. An experiment to assess the effectiveness of streamer lines in mitigating bird mortality found that a streamer line made no significant difference when used during night setting of correctly weighted longlines, with all deck lights extinguished.

WG-FSA-97/10
Fishery for the squid *Martialia hyadesi* at South Georgia conducted by the Korean-registered vessel *Ihn Sung 101* (June/July 1997): Scientific observer's report. S.P. Harding (Polar Regions Section, Foreign and Commonwealth Office, King Charles Street, London SW1A 2AH, United Kingdom), 15 pp. (English, unpublished).

WG-FSA-97/11
Correspondence between Drs Everson, Vorobyov and Sushin relating to the acoustic survey conducted by RV *Atlantida* in February 1996. I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 9 pp. (English, unpublished).

WG-FSA-97/12
A comparative study of the size composition of catches of *Dissostichus eleginoides* taken during the 25th expedition of the RV *Akademic Knipovich* in January 1990 (Subarea 48.3). VNIRO (17a V. Krasnoselskaya, Moscow 107140, Russia), 17 pp. (Russian, unpublished).

Patagonian toothfish (*Dissostichus eleginoides)* was found in catches of 25 trawls in waters off South Georgia, and in catches from 13 trawls carried out on the Shag Rocks shelf. It was caught in all depth strata, but the most abundant catches were at depths of 260 to 320 m. On the whole, catches of Patagonian toothfish consisted of juveniles 21 to 37 cm in length, immature fish 41 to 78 cm in length and mature fish 80 to 88 cm in length. Never-theless, there were differences in the length range and the modal lengths of fish taken from different parts of the South Georgia shelf and the Shag Rocks shelf.

WG-FSA-97/13
Some observations on seabird by-catch from Australian longline fishing vessels: 1994–1996. W. Whitelaw (CSIRO Division of Marine Research, PO Box 1538, Hobart, Tasmania 7001, Australia), 4 pp. Submitted to the second meeting of CCSBT Ecologically Related Species Working Group. (English, unpublished) (Abstract not available).

WG-FSA-97/14
Recent information related to seabird by-catch on the high seas. G. Tuck, A. Betlehem and T. Polacheck (CSIRO Division of Marine Research, PO Box 1538, Hobart, Tasmania 7001, Australia), 4 pp. Submitted to the second meeting of CCSBT Ecologically Related Species Working Group. (English, unpublished) (Abstract not available).

WG-FSA-97/15
Japanese longline seabird by-catch in the Australian fishing zone: April 1995 – March 1997. N. Klaer and T. Polacheck (CSIRO Division of Marine Research, PO Box 1538, Hobart, Tasmania 7001, Australia), 10 pp. Submitted to the second meeting of CCSBT Ecologically Related Species Working Group. (English, unpublished) (Abstract not available).

WG-FSA-97/16
The influence of environmental factors and mitigation measures on by-catch rates of seabirds by Japanese longline fishing vessels in the Australia region. N. Klaer and T. Polacheck (CSIRO Division of Marine Research, PO Box 1538, Hobart, Tasmania 7001, Australia), 16 pp. Submitted to the second meeting of CCSBT Ecologically Related Species Working Group. (English, unpublished) (Abstract not available).

WG-FSA-97/17
Trends in tuna longline fisheries in the southern oceans and implications for seabird by-catch: 1997 update. G. Tuck and T. Polacheck (CSIRO Division of Marine Research, PO Box 1538, Hobart, Tasmania 7001, Australia), 10 pp. Submitted to the second meeting of CCSBT Ecologically Related Species Working Group. (English, unpublished) (Abstract not available).

WG-FSA-97/18
Toothfish of the genus *Dissostichus* – geographic range of distribution. V.L. Yukhov (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine), 8 pp. (English and Russian, unpublished).

All the material presented in this paper was collected by the author during expeditions of the whaling factory ship *Sovetskaya Ukraina* to the Antarctic from 1966 to 1976. Analyses of sperm whale stomach contents have indicated that toothfish (*Dissostichus*) occur both near the shores of the Antarctic continent and in the open waters of the adjacent seas in all three sectors of the Southern Ocean. The material on the Patagonian toothfish (*D. eleginoides*) and the Antarctic toothfish (*D. mawsoni*) confirms the hypothesis that their ranges do not coincide. Whereas the former occurs in temperate and sub-Antarctic waters and is confined to insular and continental slopes as well as to the waters above sea-bottom elevations, the latter is a high-latitude form ranging from the shores of the Antarctic continent into the vast expanse of the adjacent seas.

WG-FSA-97/19
Some data pertaining to the distribution of Antarctic toothfish (*Dissostichus mawsoni*) juveniles in the Indian Ocean sector of the Antarctic. E.A. Roshchin (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine), 3 pp. *CCAMLR Science*, submitted (English).

This paper presents available YugNIRO data on the distribution of Antarctic toothfish juveniles in the Indian Ocean sector of the Southern Ocean. In the austral summer (January–March) juvenile *D. mawsoni* from 4–9 to 30–75 cm in length were regularly recorded in catches made using pelagic and bottom trawls in all the coastal seas studied from 12 to 144°E.

WG-FSA-97/20
On the distribution of different species of toothfish (*Dissostichus*). V.G. Prutko (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine), 2 pp. *CCAMLR Science,* submitted (English).

According to the results of longterm studies (1967–1991) carried out during expeditions to the sub-Antarctic and Antarctic waters of the Indian Ocean sector of the Southern Ocean, areas of distribution of the Patagonian and Antarctic toothfish are clearly defined. It was concluded that the ranges of distribution of these toothfish species did not overlap in the study area.

WG-FSA-97/21
Incidental mortality of seabirds and marine mammals during longline fishing around the Falkland/Malvinas Islands. Z. Cielniaszek and J.P. Croxall (The Fisheries Department, Falkland Island Government, Stanley, Falkland Islands), 5 pp. (English, unpublished).

Data on incidental mortality of seabirds and marine mammals associated with longline fishing around the Falkland/ Malvinas Islands between August 1996 and May 1997 are briefly summarised. For seabirds, the overall average rate of incidental mortality was 0.34 birds per 1 000 hooks; when one set was excluded, during which 87 birds were caught, the average was 0.05 birds per 1 000 hooks. Black-browed albatrosses comprised 90% of birds caught.

WG-FSA-97/22
Breeding distribution and population status of the northern giant petrel (*Macronectes halli*) and the southern giant petrel (*M. giganteus*). SCAR, 33 pp. (English, unpublished).

WG-FSA-97/23
Bird communities: extract from a management plan for the Prince Edward Islands, 1995. South Africa, 6 pp. (English, unpublished).

WG-FSA-97/24
Underwater longline setting device and artificial bait. Extract from *Mustad Longline News*, Summer 1997, Norway, 2 pp. (English).

WG-FSA-97/25
Comments on the *Scientific Observers Manual*. J. Ashford (UK-designated CCAMLR scientific observer), 1 p. (English, unpublished).

WG-FSA-97/26
Trends in incidental mortality of seabirds caused by Chilean vessels fishing for *Dissostichus eleginoides* (Subarea 48.3). A. Benavides, P.S. Rubilar and C.A. Moreno (Instituto Antártico Chileno, Departamento Cientifico, Casilla 16521, Correo 9, Santiago, Chile), 6 pp. (English and Spanish, unpublished).

The incidental mortality of birds in the fishery for *Dissostichus eleginoides* was analysed for the Chilean fleet fishing in Subarea 48.3 during 1996 and 1997. In 1996, 533 birds were killed and in 1997, 478. The most vulnerable species was *Diomedea melanophrys* representing 41% of the total number of birds killed in both years, followed by *Procellaria aequinoctials* comprising 10% of birds killed in 1996 and 33% of birds killed in 1997. The BPUE (birds killed per 1 000 set hooks) was calculated for 1995, 1996 and 1997, and showed no significant differences between fishing seasons.

WG-FSA-97/27
Changes in the fish biomass around Elephant Island (Statistical Subarea 48.1) from 1976 to 1996. K.-H. Kock (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany), 28 pp. *CCAMLR Science*, submitted (English).

Finfish stocks in the Antarctic Peninsula region (CCAMLR Statistical Subarea 48.1)

were exploited from 1978/79 to 1988/89, with most of the commercial harvesting taking place in the first two years of the fishery. Results of bottom trawl surveys conducted by Germany in the vicinity of Elephant Island in the 1980s showed that stocks of *Champsocephalus gunnari*, *Notothenia rossii*, *Gobionotothen gibberifrons* and *Chaenocephalus aceratus* were considerably affected by fishing. Stocks of *G. gibberifrons* and *C. aceratus* had apparently recovered to a large extent by the second half of the 1980s, while stocks of *C. gunnari* remained at a low level. The status of *N. rossii* is still unclear, although some recovery was apparent from length compositions obtained in the 1980s. The Antarctic Peninsula region has been closed for finfishing since 1989/90. Results of the first bottom trawl survey carried out after the closure of the area in November–December 1996 suggest that the standing stock biomass of fish had further declined. Given the low abundance of *C. gunnari* and other species and the difficulties in managing fisheries which exploit mixed-species assemblages, there appears to be little prospect at present of reopening the fishery around Elephant Island.

WG-FSA-97/28

Albatross populations: status and threats. R. Gales. In: G. Robertson and R. Gales (Eds). *The Albatross Biology and Conservation*. Surrey Beatty and Sons, Chipping Norton: 20–45, 1997 (English).

The population and conservation status of the world's albatrosses are reviewed within the framework of recent taxonomic changes. The latest estimates of size of breeding populations (pairs) at all known localities of each of the 24 proposed species are presented; population trends are assessed where sufficient data are available. Despite increased efforts in population monitoring, the status (i.e., population trends) of two-thirds of the world's ca. 150 albatross populations remain unknown. For those that are known, almost half are decreasing. The threats currently facing each species are briefly reviewed. The best available evidence indicates that longline fishing is the most serious threat facing albatrosses today. Twenty-one of the 24 species are known to be killed on longline hooks, including rare and endangered species. Widespread implementation of appropriate mitigation measures is urgently required.

WG-FSA-97/29

An assessment of the mackerel icefish (*Champsocephalus gunnari)* off Heard Island. W.K. de la Mare, R. Williams and A.J. Constable (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia), 28 pp. *CCAMLR Science*, submitted (English).

Assessments of the abundance and potential yield of mackerel icefish (*Champsocephalus gunnari)* populations at Heard Island are developed from the results of four scientific surveys conducted in 1990, 1992, 1993 and 1997. The assessments include estimates of all the parameters required, based on the data collected during the surveys, including growth curves, natural mortality, ages and sizes at maturity and a weight/length relationship. The results show that characteristics of icefish populations on the Heard Plateau are sufficiently different from those on Shell Bank for them to be managed separately. Precautionary catch limits calculated using the generalised yield model are found to be 180 tonnes for the plateau and 18 tonnes for Shell Bank. An assessment based on the results of a survey conducted at the end of the 1997 fishing season would allow for a catch limit on the Heard Plateau of 900 tonnes in the 1997/98 season and 600 tonnes in 1998/99.

WG-FSA-97/30

Assessments of by-catch in trawl fisheries at Heard and McDonald Islands. A.J. Constable, R. Williams and W.K. de la Mare (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia), 11 pp. *CCAMLR Science*, submitted (English).

This paper provides an assessment of the longterm annual yield for three species caught as by-catch in the commercial trawl fisheries in the Heard Island area (Statistical Subarea 58.5.2): *Channichthys rhinoceratus*, *Lepidonotothen squamifrons* and skates (*Bathyraja* spp.). These assessments were undertaken with the aim of examining the potential for the

commercial trawl fisheries to significantly affect the spawning biomass of these stocks in the longer term. The long-term annual yields for each of the three species were estimated using the generalised yield model developed for WG-FSA, based on survey data obtained from the region in 1990 to 1993. Values for missing input parameters were obtained from the literature. The second part of the analysis examined the amount of each species caught in the commercial operations, the nature of the trawl operations in which they were caught and the effectiveness of CCAMLR's current by-catch provisions to ensure that the status of these species is not affected by these fisheries. The estimates of longterm annual yields for *Channichthys rhinoceratus*, *Lepidonotothen squamifrons* and skates were 69 to 97 tonnes (average 80 tonnes), 7 to 911 tonnes (average 325 tonnes) and 50 to 210 tonnes (average 120 tonnes) respectively. It should be noted that the by-catch in 1997 did not exceed the lowest estimates of yield for each species. The results indicate that the current commercial trawl fisheries around Heard Island are unlikely to be affecting these stocks negatively. It is notable that the large majority of infringements of the 5% by-catch rule in CCAMLR were caused by very small amounts of by-catch. This occurs, especially when a vessel is in prospecting mode and the catch of target species is low, and hence the amount of by-catch which can trigger the 5% rule is also very low. Most infringements were caused by less than 100 kg of by-catch. While the basic role of the by-catch provisions is to protect the by-catch species from over-exploitation while protecting them from being targeted by commercial operations, the current 5% by-catch rule excludes many areas from prospecting. In order to enable prospecting for commercial aggregations of icefish or toothfish to be carried out while protecting the by-catch species from excessive fishing effort, the by-catch rule could be modified for the Heard Island area to allow catches of by-catch species of up to 100 kg in any one haul. However, if this level is exceeded by any one of the by-catch species then the 5% rule should be enforced.

WG-FSA-97/31
A proposed research plan for an exploratory fishery for *Dissostichus* spp. in Division 58.4.3. R. Williams (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia), 12 pp. (English, unpublished).

A new fishery was declared for *Dissostichus* spp. in Division 58.4.3 for the 1996/97 season. Results of a brief survey by an Australian vessel are presented, but catches were very low. A new proposal for an exploratory fishery in Division 58.4.3 is presented. This involves a random stratified trawl survey to be undertaken in parallel with commercial exploration, and the collection of a comprehensive dataset from both the survey and commercial operations.

WG-FSA-97/32
Dataset user guide: fisheries C2 longline (draft). CCAMLR Secretariat, 41 pp. (English, unpublished).

WG-FSA-97/33
Resources available to WG-FSA-97. CCAMLR Secretariat, 3 pp. (English, unpublished).

WG-FSA-97/34
Scientific observations of trawl and squid jigging operations during 1997. CCAMLR Secretariat, 6 pp. (English, unpublished).

WG-FSA-97/35
Overview of biological reference points and their use in fisheries management. CCAMLR Secretariat, 17 pp. (English, unpublished).

WG-FSA-97/36 Rev. 3
IMALF data analysis in 1997. CCAMLR Secretariat, 13 pp. (English, unpublished).

WG-FSA-97/37
Catch and effort data for the longline fishery in Subarea 48.3 – comparison of data reported to CCAMLR and data acquired by the UK between 1994 and 1996.

D.J. Agnew, J. Pearce and G.B. Parkes (Renewable Resources Assessment Group, Imperial College, 8 Prince's Gardens, London SW7 1NA, United Kingdom), 7 pp. (English, unpublished).

Haul-by-haul data acquired by the UK from longline fishing operations targeting *Dissostichus eleginoides* around South Georgia were compared with data reported to CCAMLR and held in CCAMLR's longline database (database C2). Some instances of incomplete reporting were identified, where blocks of data appear to be missing from the CCAMLR database. In one instance, multiple hauls had been submitted as single records. A number of hauls yielding zero catches, present in the data acquired by the UK, have not been reported to CCAMLR. In 1996 less than 10% of the hauls showed large discrepancies between the two datasets, with many of the records for individual fields being identical. The number of discrepancies between the CCAMLR database and the data acquired by the UK declined from 1994 to 1996. However, there were a considerable number of discrepancies between the CCAMLR data and those acquired by the UK where reporting of by-catch and incidental mortality of birds was concerned.

WG-FSA-97/38
Management of *C. gunnari* in Subarea 48.3. D.J. Agnew, I. Everson, G.P. Kirkwood and G.B. Parkes (Renewable Resources Assessment Group, Imperial College, 8 Prince's Gardens, London SW7 1NA, United Kingdom), 21 pp. *CCAMLR Science*, submitted (English).

The management of *Champsocephalus gunnari* at South Georgia is complicated by the likelihood of substantial periodic variation in natural mortality rates. These may be associated with an increase in the consumption of icefish by Antarctic fur seals in years of poor krill availability. Thus natural mortality of icefish may, in some years, increase by a large factor (assumed here to be four) declining to normal levels again when krill return. A scheme is elaborated that would use information from studies of krill and predators undertaken as part of CEMP to interpret or modify information from commercial fisheries and research surveys leading to estimates of stock biomass. An extension of this scheme would use predictions of coming periods of krill scarcity as early warnings of increased natural mortality of icefish. This scheme would require greater quantitative knowledge of food web dynamics within the South Georgia ecosystem than we have at present. There is therefore a need for an interim approach to setting precautionary catch limits for this fishery. A description is given of an approach based on the general yield model that can be used to calculate an appropriate proportion of an estimate of B_0 which could be taken by fishing, under conditions where M is assumed to be highly variable from year to year.

WG-FSA-97/39
Preliminary reports of UK fish survey: Subarea 48.3. United Kingdom, 6 pp. (English, unpublished).

WG-FSA-97/40
Determination of stock structure and movement-at-age in Patagonian toothfish (*Dissostichus eleginoides*) through laser-based analysis of otoliths: report on progress 1996/97. J. Ashford, C. Jones and I. Everson (Applied Marine Research Laboratory, Old Dominion University, 1034 West 45th Street, Norfolk, Va. 23529, USA), 2 pp. (English, unpublished).

WG-FSA-97/41
An assessment of longlining operations for *Dissostichus eleginoides* on board the Chilean-registered longliner BF *Cisne Verde* during March–May 1997 around South Georgia (Subarea 48.3). J. Ashford and I. Everson (AppliedMarine Research Laboratory, Old Dominion University, 1034 West 45th Street, Norfolk, Va. 23529, USA), 25 pp. (English, unpublished).

Longlining operations from a single vessel fishing for *Dissostichus eleginoides* off South Georgia (Subarea 48.3) were

assessed over 48 days during April and May. All lines were set at night using the Spanish double-line method with extra weights on the line and all deck lights extinguished to reduce bird mortality. Data were recorded during hauling using a randomised cluster sampling method; the known number of coils laid during a night's setting operations provided the sampling frame, and the sampling units consisted of lengths of line between marked connecting lines. Previous catch rates were used to set daily sampling effort, and accurately achieved a CCAMLR sampling target of 60 fish/day. The method was further developed to integrate different, and varying, levels of effort at two observation stations into one daily sampling schedule. Data on total length, maturity and sex were taken. Mean total length of females caught was higher than it was for males, and length at first maturity was also greater. The proportion of mature fish in the male population sampled was 52.0%, but was only 24% for the female population. The mean daily loss rate of toothfish observed at the hauling point was only 0.8% of the mean daily catch rate; total by-catch by numbers was less than 5%. Consistent CPUE by numbers between catches in 1994 and 1997, despite a reduction in CPUE by weight, indicated that exclusion effects may be important in determining the catch taken by longlines. Continuing decreases in the size of fish caught relative to the length at first maturity of females indicate that 'reproductive' over-exploitation may become a threat.

WG-FSA-97/42
Technical data on the Patagonian toothfish, *Dissostichus eleginoides*. C.A. Moreno, P.S. Rubilar and A. Zuleta (Instituto de Ecología y Evolución, Universidad Austral de Chile, Casilla 567, Valdivia, Chile), 16 pp. (Spanish, unpublished).

The technical information used in the stock assessment of the Patagonian toothfish (*Dissostichus eleginoides*) in different parts of the world has been summarised in this document in order to facilitate future research and management of this species.

WG-FSA-97/43
Trends in Patagonian toothfish (*Dissostichus eleginoides*) biomass in Subarea 48.3 (1992–1997). P.S. Rubilar, C.A. Moreno, A. Zuleta and Z. Young (Instituto de Ecología y Evolución, Universidad Austral de Chile, Casilla 567, Valdivia, Chile), 16 pp. (Spanish, unpublished).

The size of the stock of *Dissostichus eleginoides* in Subarea 48.3, between the split-years 1992 and 1997, was estimated using the Sequential Population Analysis (SPA) model based in the catch-at-age data. The model was tuned by the standardised CPUE. For this last process GLIM was used and for the application of SPA the non-lineal function the Microsoft Excel solver tool was used. The results show decreasing trends in total, fishable and spawning biomass. This last part of the population is actually (1997) very close to the 20% of the initial (1992) spawning biomass. An approximation of the future TAC was made using the Thompson and Bell model of yield per recruit.

WG-FSA-97/44
Variations in the stock of *Champsocephalus gunnari* observed in four recent surveys around South Georgia Island. E.R. Marschoff, B. Gonzalez and J. Calcagno (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 13 pp. (English, unpublished).

The densities of *Champsocephalus gunnari* observed in four successive surveys, conducted from 1994 to 1997 on the shelf around South Georgia are analysed on a site-by-site basis using an incomplete block ANOVA design. The significant sum of squares due to sites obtained in the analysis is considered to be a result of the existence of regular patterns in the distribution of *C. gunnari* which continue from year to year. Comparisons of successive years showed significant increases between 1994/95 and 1995/96. Analysis of age compositions demonstrated that the 1994 values are anomalous. No increase was observed between 1996 and 1997, a fact that remains unexplained, but this may be attributable to variability in

recruitment. The fact that observed mortalities are larger than expected may be explained either by predator pressure or as an artefact due to the rebuilding of the stock.

WG-FSA-97/45
Spatial distribution of *Champsocephalus gunnari* size and age are related to depth. E.R. Marschoff, B. Gonzalez, J. Calcagno and J.A. Serra, (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 11 pp. (English, unpublished).

The results of four fish surveys (*Dr Eduardo L. Holmberg*, 1994 to 1997) were analysed to detect relationships between size and age class of *Champsocephalus gunnari* and size of *Gobionotothen gibberifrons, Notothenia rossii, Pseudochaenichthys georgianus, Chaenocephalus aceratus* and *Dissostichus eleginoides* and depth of catch, as well as within *C. gunnari* age classes. Except for *D. eleginoides*, median sizes of all species bore a close relationship to depth, directly in the case of *C. gunnari* and *N. rossii* and inversely for the remaining species. A weaker relationship with depth is observed in *C. gunnari* as the fish grow older, indicating that spatial separation is controlled by depth. The accumulated catches of age 1- show the greatest difference, with the older age classes at about 150 m, a result which might be used to fish different age groups of the populations, thus regulating the age composition of the catches.

WG-FSA-97/46 Rev. 1
Interim report of activities of the WG-FSA correspondence group on fish by-catch in krill fisheries. CCAMLR Secretariat, 6 pp. (English, unpublished).

WG-FSA-97/47
Results of *Dr Eduardo L. Holmberg* 1997 fish survey in Subarea 48.3. E.R. Marschoff, B. Gonzalez, J. Calcagno and B. Prenski (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 34 pp. (English, unpublished).

The survey comprised 51 bottom trawl hauls taken in Subarea 48.3. Of these, one was discarded due to net damage. About 80% of the hauls were taken on the shelf of South Georgia Island (41) and the remainder in the Shag Rocks area (9); 64% of the hauls were intended to duplicate the position of hauls in the previous cruises. Mean densities were obtained taking into account the spatial aggregation of stations in a nested ANOVA model. No significant changes were observed in the mean densities of several species, including *Champsocephalus gunnari* on the South Georgia shelf. The age and size structure of this species throughout Subarea 48.3 is dominated by younger fish (less than two years old). Four years and below: 99.07% at South Georgia Island and 98.57% at Shag Rocks.

WG-FSA-97/48
Analysis of the diet of *Champsocephalus gunnari* in Subarea 48.3, in late summer of the years 1994–97, *Dr Eduardo L. Holmberg* surveys. E. Barrera-Oro, R. Casaux and E.R. Marschoff (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 24 pp. *CCAMLR Science*, submitted (English).

The diet composition of mackerel icefish (*Champsocephalus gunnari*) caught in Subarea 48.3 in late summer of the years 1994–1997 was analysed using frequency of occurrence (F%) and coefficient 'Q' (%) methods. Krill (*Euphausia superba*) followed by the amphipod hyperiid *Themisto gaudichaudii* was the main food item around South Georgia and Shag Rocks in the period investigated, except in 1994 when the order of importance of these two organisms in the diet was reversed. The consumption of other prey items such as mysids and *Thysanoessa* spp., which are known to be important as alternative food in years of krill and fish scarcity, was only occasional or in negligible amounts, showing interannual variation. The spatial distribution of the main prey items in the diet as well as of the proportions of stomachs with/without food in the study area did not show a consistent pattern from year to year. Likewise, in the four *Holmberg* surveys carried out from 1994 to 1997, high proportions of fish exhibited empty stomachs, a phenomenon for which no consistent explanation was found. The

variation in diet with respect to *C. gunnari* length did not show a selectivity pattern for any of the prey items. The availability of krill in Subarea 48.3 in the period investigated can be defined as low in 1994, corresponding to years of krill scarcity; intermediate in 1995, less than in years of historical high abundance; and high in 1996 and 1997, as in krill-rich years. This information agrees well with independent information from acoustic surveys and krill-dependent species monitored in the CCAMLR Ecosystem Monitoring Program.

WG-FSA-97/49
Biological characteristics of Patagonian toothfish (*Dissostichus eleginoides*) relevant to the exploitation of this species in the Argentinian Exclusive Economic Zone and in adjacent oceanic waters. B. Prenski and S.M. Almeyda (Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), C.C. 175, 7600 Mar del Plata, Argentina), 40 pp. (English, unpublished).

This paper aims to study the distribution, length composition by depth, first maturity stage, length/weight relationship, and length/girth relationship, of Patagonian toothfish (*Dissostichus eleginoides*) in the Argentine Sea, and attempts some explanation of its distribution by analysing its diet. The distribution of Patagonian toothfish extends between 36˚30'S and 55˚S from 80 to 2 500 m depth. Areas of highest concentration were found to the south and northeast of the Falkland/Malvinas Islands, and on the shelf break off Buenos Aires province and between Burdwood Bank and State Island, this last-mentioned place being where the studies were carried out. Bottom temperatures ranged from 2˚C to 12˚C. Minimum and maximum values of sizes were between 12 and 227 cm, and most of the adult sizes (>80 cm) were found at depths greater than 900 m. In respect of selectivity the girth should be greater than 46 cm. The new length at 50% maturity was 78.27 cm for males, 87.06 cm for females and 82.16 cm for both together. The indices of length/weight relationship for males were: a = 5E-06; b = 3.186; for females: a = 5E-06; b = 3.161; and for both: a = aE-06; b = 3.187. The distribution of adults and juveniles can be explained partially by cannibalism and the size of the available prey at different depths. Based on the data analysed, it is recommended that both longline and trawl fishing in various sectors including the Convention Area be carried out at depths of at least 900 m in the area south of 54°S, at a minimum of 1 000 m in the area between 38°S and 48°S, and that in the area as a whole, these fisheries operate at a conservative depth of 1 000 m.

WG-FSA-97/50
Redefining the boundary between CCAMLR Statistical Subareas 58.6 and 58.7. (Delegation of South Africa), 4 pp. (English, unpublished).

WG-FSA-97/51
Seabird mortality in the longline fishery for Patagonian toothfish in the Prince Edward Islands: 1996–1997. P.G. Ryan, C. Boix-Hinzen, J.W. Enticott, D.C. Nel, R. Wanless and M.G. Purves (FitzPatrick Institute, University of Cape Town, Rondebosch 7701, South Africa), 15 pp. (English, unpublished).

Longline fishing for Patagonian toothfish (*Dissostichus eleginoides*) commenced in the Prince Edward Islands in October 1996, but unsanctioned fishing commenced some months before this date. This paper summarises the mortality of seabirds associated with this fishing during the year July 1996–June 1997. Data on seabird by-catches were obtained from fishery observers aboard 10 of 12 sanctioned fishing trips. Some 3.2 million hooks were observed during the period November–June, representing 84% of the estimated 3.8 million hooks set by permit-holders in the South African Exclusive Economic Zone (EEZ). However, the total fishing effort is estimated, based on landings, to be between 20 and 50 million hooks. The average bird by-catch rate was 0.289 birds per 1 000 hooks set. However, there was considerable variance between vessels (range 0.004 to 1.468 birds per 1 000 hooks) as a function of fishing season, time of setting, distance from the Prince Edward Islands, mitigation measures employed, and type of fishing gear used. Observers reported 923 birds of 10 species killed. The species most affected

were white-chinned petrels (*Procellaria aequinoctialis*) (73% of the total killed), grey-headed (*Diomedea chrysostoma*) and yellow-nosed albatrosses (*D. chlororhynchos*) (together 23%), and giant petrels (*Macronectes* spp.) (4%). Extrapolating to the total fishery suggests that between 5 000 and 20 000 birds were killed during 1996/97. This excludes birds killed that were not hauled aboard vessels. Ten toothfish hooks were found in birds or in bird pellets on Marion Island during 1996/97. Almost all birds killed were breeding adults, and there was a significant bias towards males in at least three species. More than 1% of four or five local breeding seabird populations were killed during the 1996/97 season. Given the low reproductive rate of these species, these levels of mortality (exacerbated by mortality in other longline fisheries) are not sustainable, and will result in local population declines. Bird mortality can largely be avoided by setting lines only at night, using a CCAMLR-approved bird-scaring (tori) line during setting, and not fishing during the main summer breeding season (or at least fishing >200 km from the breeding islands during this period). These measures were largely disregarded during most of the 1996/97 season. Unfortunately, the necessity for a presence around the islands to reduce the impact of uncontrolled fishing renders the last option impractical in the short term. It is important that observers continue to be placed aboard all vessels to monitor catches of both fish and birds, and to ensure compliance with regulations aimed at reducing bird by-catch.

WG-FSA-97/52

Foraging movements of the shy albatross *Diomedea cauta* breeding in Australia: implications for interactions with longline fisheries. N. Brothers, R. Gales, A. Hedd and G. Robertson. *Ibis*, 140, in press (English).

Satellite telemetry was used to identify the foraging zones of shy albatrosses (*Diomedeacauta*) breeding at two sites off Tasmania, Australia, (Albatross Island in western Bass Strait and Pedra Branca to the south) to assess their level of interaction with longline fisheries. Adult birds from both colonies fed locally both in and outside the breeding season. Breeding birds from Albatross Island foraged over the Australian continental shelf or slope waters off northwest Tasmania, while those from Pedra Branca foraged between the colony and the southeastern edge of the continental shelf. The distances travelled by the birds and the duration of their foraging trips varied during the breeding cycle and tended to decrease as eggs approached hatching. Adults which were tracked near the end of the breeding season (March–April, n = 7 birds) deserted their chicks prematurely, and while dispersing further than incubating or brooding birds, they remained over the continental shelf and slope waters off southeast Australia. Home range analyses indicated 41% overlap between foraging zones of birds during successive breeding stages. Dispersal during the postbreeding period extended the foraging zones with less overlap between individuals (10% for Albatross Island and 19% for Pedra Branca). The recent contraction of the Japanese southern bluefin tuna longline fishery to the south and east coasts of Tasmania has resulted in extensive overlap with adult shy albatrosses from Pedra Branca, but appears to pose a minimal threat to adult birds from Albatross Island. Coupled with the concomitant increase in the Australian domestic tuna longlining industry, adult shy albatrosses from southern Tasmania (Pedra Branca and the Mewstone) are vulnerable to incidental capture throughout their annual cycle.

WG-FSA-97/53

Underwater setting methods to minimise the accidental and incidental capture of seabirds by surface longliners. (Report on a prototype device developed by Ackroyd Walshe Ltd). P. Barnes and K.A.R. Walshe. *Science for Conservation*, 66. Department of Conservation, New Zealand. (English).

The accidental/incidental capture of seabirds by longline gear may be causing a significant decline in the numbers of some species – most notably albatross (*Diomedea* spp.) – in the Southern Oceans. In response to the seabird problem, the New Zealand Department of Conservation commissioned a program funded by the fishing industry through the Conservation

Services Levy in 1996 to develop a device to set baits underwater on commercial surface longliners. Trials on two U tube devices developed by Akroyd Walshe Ltd are described. A device with the tube opening facing forward was unsuccessful in flushing bait to the setting depth; however, a backward facing U tube succeeded in flushing the bait on all trials to the setting depth of 1.5 m. A second trial was undertaken with the backward facing U tube. On all trials the U tube successfully flushed the baits to the required 3 m depth. The U tube is a simple mechanical device requiring only one additional item of equipment – a deckhose. The device requires minimal operator skill, and is easy to build and maintain. The U tube has the potential to set baits at greater than 3 m. However, this capability has not been tested. Further study is required to test the device under commercial tuna vessel operating conditions and to assess the effectiveness of the device in thwarting seabirds from capturing the baits underwater.

WG-FSA-97/54

Development of an underwater setting method for surface longliners, to minimise the accidental capture of seabirds. Final report on CSL Project No. 95/9004. M. Smith and N. Bentley (MS Engineering, PO Box 125, Warkworth, New Zealand), 5 pp. (English, unpublished).

In response to the Department of Conservation's concerns regarding the accidental capture of seabirds by surface longliners and subsequent contract 95/3004, several ideas for bait placement devices were evaluated. Two methods were selected for further in- depth evaluation. The first consisted of a towed paravane with an endless cable used to transport and release the bait at the depth to which the paravane was set. Although practical bait-carrying devices were designed, retrieval of the endless cable and paravane proved problematical. At this point this concept was abandoned. The second concept was a transportation capsule which clamps the baited snood until the capsule reaches its determined depth, at which point the carry-over action of the capsule and retrieval action would release the bait. This design concept proved worthy of construction and trial. Sea trials of this device proved successful with a 100% bait release rate achieved.

WG-FSA-97/55

The impact of the hake *Merluccius* spp. longline fishery off South Africa on procellariiform seabirds. K.N. Barnes, P.G. Ryan and C. Boix-Hinzen. *Biological Conservation*, 82: 227–234, 1997 (English).

In 1994, an experimental longline fishery for hake *Merluccius* spp. commenced in the shelf waters off South Africa. Participants were required to record any birds caught, and these data were supplemented by ship-based observers on several vessels. Longlines are set at night and the white-chinned petrel *Procellaria aequinoctialis* was the only seabird species caught while attempting to scavenge bait during gear setting. Small numbers of great shearwaters *Puffinus gravis* and pintado petrels *Daption capense* were killed during hauling operations. The hake longline fishery is estimated to kill 8 000 ± 6 400 white-chinned petrels a year in South African waters at a rate of 0.44 birds per 1 000 hooks. This represents <1% of the global white-chinned petrel population, but is cause for concern given: (1) the slow reproductive rate among procellariiform seabirds; (2) the projected growth in the longline hake fishery; and (3) the increasing numbers of white-chinned petrels being killed in other longline fisheries. Light intensity was the most important factor for explaining variation in the number of petrels caught during setting; when line shooting was completed prior to the increase in white-chinned petrel activity (c. 2.5 h before sunrise), few birds were caught. Measures to reduce excessive seabird by-catch include: (1) the introduction of bird lines on all vessels; (2) restricting the setting of lines to times of least bird activity; (3) minimum use of deck lighting during setting; and (4) ensuring that baited hooks sink as fast as possible when deployed. Hauling mortalities can be reduced by diverting offal outlets to the opposite side of the vessel to where the longline is being hauled.

WG-FSA-97/56

Research and conservation: a future for albatrosses? J.P. Croxall. In: G. Robertson and R. Gales (Eds). *The Albatross Biology and Conservation*. Surrey Beatty and Sons, Chipping Norton: 267–288, 1997 (English).

The major recent advances in studies of albatross biology, ecology and conservation are reviewed. In addition to highlights arising during the first Albatross Conference, pioneering research on topics little covered therein (e.g behaviour, moult, diet, physiology) are summarised. Important topics and opportunities for future research are suggested. The major historical and current threats to albatrosses are reviewed and the priority initiatives needed to tackle the latest – and greatest – threat, that of incidental mortality associated with longline fisheries, summarised.

WG-FSA-97/57

Intersessional work on the incidental mortality of seabirds in longline fisheries in the 1996/97 intersessional period. CCAMLR Secretariat, 18 pp. (English, unpublished).

WG-FSA-97/58

Report on marine debris and entanglement at Palmer Station, Antarctic Peninsula, 1992–1997. W.R. Fraser (Polar Oceans Research Group, Department of Biology, Montana State University, Bozeman, Montana 59717, USA), 4 pp. (English, unpublished).

WG-FSA-97/59

An assessment of the conservation status of albatrosses. J.P. Croxall and R. Gales. In: G. Robertson and R. Gales (Eds). *The Albatross Biology and Conservation*. Surrey Beatty and Sons, Chipping Norton: 46–65, 1997 (English).

The conservation status of albatrosses has been re-evaluated using the recent suggested taxonomic revisions of albatrosses and the new IUCN criteria for identification of threatened taxa. The evaluations of threat status and categories were prepared by independent albatross specialists before being critically reviewed and endorsed by Birdlife International. This evaluation reveals albatrosses to have the highest proportion of threatened species in any bird family that comprises more than a single species. Of the 24 albatross species recognised in the new taxonomy, two species (Amsterdam Albatross and Chatham Albatross) are Critically Endangered, two species (Northern Royal Albatross and Tristan Albatross) are Endangered, and 16 species are classed as Vulnerable. Currently only the two most abundant albatross species, the Black-browed Near-threatened, and Laysan Albatrosses are classified as Lower Risk. For two species (Light-mantled Albatross and Atlantic Yellow-nosed Albatross) the present level of knowledge regarding population trend and status provides an inadequate basis for classification and these are assessed as Data Deficient. Albatrosses are currently the most threatened and vulnerable group of all seabirds, and their protection both on land and at sea is an urgent requirement.

AUTHOR INDEX