CCAMLR SCIENTIFIC ABSTRACTS
1993

Commission for the Conservation of
Antarctic Marine Living Resources

PO Box 213, North Hobart 7002, Tasmania, Australia
Telephone – 61 3 6231 0366; Facsimile – 61 3 6234 9965
Email – ccamlr@ccamlr.org
Website – www.ccamlr.org

Copies of this publication are available from the CCAMLR Secretariat at the above address.

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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 1993. It corresponds to the Twelfth 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 "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(iii) Scientific papers not intended for publication, which are listed as "unpublished"; and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-Krill-92/8 (document number 8 submitted at the 1992 meeting of the Working Group on Krill).

Unpublished papers must not be cited without written permission of the author(s).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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SC-CAMLR-XII/BG/4
An exploratory fishing expedition for *Dissostichus eleginoides* around the South Sandwich Islands, Antarctica. P.S. Rubilar, C.A. Moreno, J.R. Ashford and I. Everson (Instituto de Ecología y Evolución, Universidad Austral de Chile, Valdivia, Chile), 19 pp. (English, unpublished).

An exploratory fishing survey was undertaken around the South Sandwich Islands (Subarea 48.4), to establish the presence and abundance of the Patagonian toothfish, *Dissostichus eleginoides*, with a view to opening a new fishery under the auspices of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). The survey was undertaken by the Chilean longliner *Friosur V*, owned by the company Frioaysen S.A. Fishing was by bottom longline, and data were collected following guidelines set out in the *CCAMLR Scientific Observers Manual* and in a memorandum of understanding between the Governments of Chile and the UK. A new fishery in Subarea 48.4 was found not to be commercially viable due to an extremely low catch-per-unit of 5.37 g/hook. The low numbers of fish found may have been due to the close proximity of the southern edge of the geographic range of *D. eleginoides* or to an unfavourable environment. Incidental catch consisted largely of *Macrourus holotrachys* and *Raja (Amblyraja) georgiana*. Interactions between fishing operations and seabirds were also examined, with no incidental mortality witnessed, but data were inconclusive due to the low number of longline operations (N = 7) completed.

SC-CAMLR-XII/BG/5
SCAR-COMNAP proposal for an Antarctic data management system. CCAMLR Secretariat, 9 pp. (English).

SC-CAMLR-XII/BG/6
Entanglement of Antarctic fur seals *Arctocephalus gazella* in man-made debris at Bird Island, South Georgia during the 1992 winter and 1992/93 pup-rearing season. J.P.Y. Arnould and J.P. Croxall. (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 22 pp. (English, unpublished).

Surveys of Antarctic fur seals entangled in man-made marine debris were carried out for the third consecutive winter and fifth consecutive summer at Bird Island, South Georgia. In the 1992 winter an unprecedented number of 97 entangled seals were seen, a ten-fold increase on the previous two years and with twice as many seals suffering serious injuries. Almost all animals involved were juvenile males, the main element of the population seen ashore at Bird Island at this time of year. In the summer, 84 entangled seals were seen. This was a 75% increase from 1992 and contained more adult females than usual. Otherwise, the nature of the entangling debris (50% packaging bands, 25% fishing net), the categories of seal affected (60% juvenile males, 30% adult females) and the severity of injuries (40% serious) was similar to previous years. The increased incidence of entanglement in both

winter and summer is disturbing, particularly following two years of relatively low incidence. It cannot be accounted for by changes in the foraging ecology of fur seals at South Georgia nor by obvious changes in fishing practice, except possibly for the increase in vessels engaged in longline fishing, which uses bait boxes tied with packaging bands. CCAMLR needs to renew its vigilance with respect to marine debris and should consider requiring the use of packaging bands on fishing vessels to be phased out.

SC-CAMLR-XII/BG/7
Records of fishing hooks associated with albatrosses at Bird Island, South Georgia, 1992/93. J. Cooper (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom). *Mar. Orn.*, (in press): 9 pp. (English).

At least six instances of longline fishing gear (especially hooks) in association with breeding black-browed and wandering albatrosses were recorded at Bird Island, South Georgia in 1992/93. Although similar observations had been made in previous seasons, this is the highest incidence yet recorded in a single season.

SC-CAMLR-XII/BG/8 Rev. 1
Seabird interactions with longlining operations during an exploratory fishing cruise for *Dissostichus eleginoides* to South Sandwich Islands, Antarctica. J.R. Ashford, J.P. Croxall, P.S. Rubilar and C.A. Moreno (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom). *CCAMLR Science*, (in press): 21 pp. (English).

During seven operations involving the setting and hauling of longlines to catch *Dissostichus eleginoides* around the South Sandwich Islands (Subarea 48.4), actual and potential interactions with seabirds were assessed. Bird numbers increased rapidly after dawn and large numbers of Cape, giant and storm petrels and smaller numbers of white-chinned petrels and black-browed albatrosses were present during day hauling operations. No incidental mortality was seen and only one bird was caught on a hook; nevertheless these aggregations of birds are clearly potentially vulnerable to setting operations in daylight hours. Several species of seabirds present must have originated from South Georgia populations; however wandering and grey-headed albatrosses, whose populations are in serious decline at South Georgia were rare; their vulnerability to longlining operations in the South Sandwich Islands is therefore low. Anecdotal data and observations on longline vessels fishing around South Georgia, however, suggest that there may be significant catch rates of albatrosses; further detailed studies are needed.

SC-CAMLR-XII/BG/10
Southern Ocean Cephalopods Symposium. P.G. Rodhouse (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 32 pp. (English, unpublished).

SC-CAMLR-XII/BG/11
Fishing and conservation in southern waters. K.-H. Kock (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany). *Polar Record,* 30 (172): 3-22 (1994).

In the Southern Ocean, fishing for finfish began in 1969/70 and for krill in 1972/73. The Soviet Union was the most important fishing nation, taking 80 to 90% of the entire catch. More than three million tonnes of finfish were harvested prior to 1992/93, most of the catch coming from around South Georgia and Iles Kerguelen. After 15 years of exploitation, most fish stocks were heavily depleted. The krill catch from the Southern Ocean has been 4.9 million tonnes to date. More than 90% of this catch has originated from the Atlantic sector. Fifty to 90% is taken from the foraging range of land-based predators during the critical period of their breeding cycle when they raise their young. This creates the potential for direct competition between krill fisheries and krill-dependent predators. Potential impacts of krill and finfishing on the ecosystems of the Southern Ocean range from endangering recruitment due to the by-catch of juvenile fish in the krill fishery to incidental mortality of birds during longline operations and the entanglement of seals in fragments of discarded or lost fishing gear.

Most fish stocks had already been over-exploited before the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) came into force in 1982. Stringent conservation measures to halt the further decline of the stocks have been implemented only since 1989. There is evidence that some fish stocks have started to recover recently. Precautionary catch limits for krill of 1.5 million tonnes for the Atlantic sector (Statistical Area 48), and of 390 000 tonnes for Statistical Division 58.4.2 in the Indian sector, were set in 1991 and 1992, respectively. CCAMLR has implemented a number of conservation measures to safeguard other components of the marine ecosystems from fishing. CCAMLR adopted a system of inspection in 1989/90 and a scheme of international scientific observation in 1992. It is too early to judge the efficacy of these enforcement and data-gathering programs.

There is a growing recognition in CCAMLR of the need for preventative measures in circumstances of biological uncertainty. The development of multi-species management models appears to be remote at present. The way forward is likely to be a single-species model for the krill fishery, which needs to take implicit account of the demands of natural predators, particularly at small scales. If demersal fish stocks are able to recover to their maximum sustainable yield level, the fishery potential of the Southern Ocean is likely to be much larger than current catches. The fishery potential of krill and mesopelagic lanternfish is likely to exceed that of demersal fish stocks by an order of magnitude. By contrast with the 1970s and 1980s, when most fisheries were subsidised, economic considerations and market demands will be the primary determinants of the development of fishing in southern waters during the 1990s.

SC-CAMLR-XII/BG/12

FAO *ad hoc* consultation on the role of regional fishery agencies in relation to high seas fishery statistics. CCAMLR Secretariat, 5 pp. (English, unpublished).

SC-CAMLR-XII/BG/13

Observations on CCAMLR specifications for streamer lines to reduce longline by-catch of seabirds. S.R. Kalish and S. Tong (Ministry of Agriculture and Fisheries, PO Box 297, Wellington, New Zealand), 24 pp. (English, unpublished).

Abstract not available.

SC-CAMLR-XII/BG/14

Incidental capture of seabirds by Japanese southern bluefin tuna longline vessels in New Zealand waters 1988 to 1992. T.E. Murray, J.A. Bartle, S.R. Kalish and P.R. Taylor (New Zealand), 59 pp. (English, unpublished).

Fishery observers recorded incidental capture of seabirds during 785 days on Japanese bluefin tuna longline vessels around New Zealand between April and August each year 1988 to 1992. High numbers of albatrosses (*Diomedea* spp.) and petrels (*Procellaria* spp.) were caught on longline hooks during setting and drowned. Twelve seabird taxa were recorded, six of them breeding only in New Zealand. Most were breeding adults, except for grey-headed and black-browed albatrosses. No bias in sex ratio was evident except for grey petrels, of which nearly all were female. Winter-breeding species were most often caught. Birds were not caught randomly, but in a highly aggregated fashion suggestive of complex behavioural interactions with the fishery. Most albatrosses were caught by day in the south whereas most petrels were caught by night northeast of New Zealand. Highest capture rates occurred at dawn and dusk off northeast New Zealand in June to August. Very large catches at specific sites contributed disproportionately to the overall catch rate. The estimated minimum number of total seabirds caught in New Zealand waters declined from 3 652 in 1988 to 360 in 1992, probably as a result of mitigation measures introduced progressively by the industry and by government regulation. Use of tori lines to prevent birds seizing baits had an effect, as did setting in total darkness in the south. Considerably more work needs to be done on the development of improved mitigation measures. Greater observer coverage is required to accurately measure the mortality of individual seabird species on tuna longlines throughout the

Southern Ocean and to determine the effectiveness of mitigation measures.

SC-CAMLR-XII/BG/15
Oiled penguins observed at Bird Island, South Georgia, 1992/93. K. Reid (British Antarctic Survey, High Cross, Madingley Road, United Kingdom), 7 pp. (English, unpublished).

In the first observation of oiled seabirds at Bird Island, South Georgia since the station was opened in 1975, six freshly-oiled penguins (one chinstrap, five gentoos) were recorded ashore in July and August 1993. Because gentoo penguins feed very close inshore in winter they must have been contaminated near Bird Island from pollution originating nearby. Krill fishing boats, operating within 20 n miles of the Willis Islands (5 km west of Bird Island) from early July, are the most likely source of the oil. Large concentrations of penguins were seen in this area by a US research cruise in June 1993.

SC-CAMLR-XII/BG/16
The SCAR Antarctic digital topographic database. J.W. Thomson and A.P.R. Cooper (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom). *Antarctic Science*, 5 (3): 239-244, 1993 (English).

The Antarctic digital topographic database is the outcome of a truly international collaborative project between 11 nations. Data capture was coordinated in the UK, under the auspices of the Scientific Committee on Antarctic Research (SCAR), during a two-year period. Over 200 maps, at scales ranging from 1:200 000 to 1:5 000 000, were digitised for the project and reference was made to a similar number of satellite images (mostly Landsat photographic products). Editing and harmonisation of the data derived from the different sources has produced a seamless map of Antarctica which has the most up-to-date coastline now available. The topographic database created, to be published on one CD-ROM, will form the foundation for future GIS needs in Antarctic research. Products already derived from the database include digital elevation models and customised maps; the latter can be reproduced by research groups to meet their own mapping needs.

SC-CAMLR-XII/BG/17
Anthropic impact at Cape Shirreff, Livingston Island, Antarctica. D. Torres and A. Aguayo (Jefe Departamento Planes, Instituto Antártico Chileno, Luis Thayer Ojeda 814, Correo 9, Santiago, Chile). *Ser. Cient. INACH*, 43: 95-111, 1993 (Spanish).

The aim of this research is to present a summary account of the impact of human activities at Cape Shirreff (62°27'S 60°47'W), Livingston Island, based on historical facts and field observations. An arbitrary time division has been chosen: long-past, recent and current periods.

The first period relates to old shipwrecks, the remains of which are scattered along the beaches of the San Telmo Islands and Cape Shirreff. Among them it is possible to find remains of the Spanish vessel *San Telmo* that sank near the coast of Cape Shirreff, as well as other remains of seal boats and remnants from sealers' camps.

The second period refers mainly to a Russian station, the remnants of which are currently being examined. This station was dismantled, leaving behind the base of an antenna, fragments of food cans, electrical cables, broken tools, boots, nails, battery cells, etc. At this facility two Russian documents were discovered, describing the contents of a wooden box covered by a cairn. Our findings and the collection of various types of plastic debris spread over beaches, valleys and hills of Cape Shirreff (net fragments, buoys, containers for domestic use, plastic packing bands, etc.), which would have been disposed of accidentally or deliberately during the years of peak fishing in the Southern Ocean, are also mentioned.

The third period refers to human activities carried out from 1981 to the present. In this paper we describe found artefacts which relate to scientific work carried out at sea (findings of plastic cards or current meters) and in the field (handling and tagging of pups, recovery of lost plastic tags, etc.) between 1981 and 1993. The setting up of a dismountable module of fibreglass at the northeast coast of Cape

Shirreff; the ongoing beaching of plastic debris, especially containers for domestic use and the anecdotal evidence of Mexican coins from 1986 and 1987 found at the San Telmo Islands are also mentioned.

Special emphasis is given to the protection of the SSSI No. 32 (Site of Special Scientific Interest), at Cape Shirreff and in the San Telmo Islands, in particular while conducting work in the field.

As a comprehensive measure to protect the Southern Ocean as a whole and its related ecosystems, it is proposed that the Antarctic Treaty, through its subsidiary bodies, coordinate and support all action directed toward strengthening the Marpol Convention 73/78, by means of an active relationship with other international and national organisations with a view to establishing and consolidating the conservation of the Southern Ocean and related ecosystems. Moreover, a proposal is made for the establishment of a monitoring network to record, where possible, the impact of plastic debris in accordance with standard forms developed by CCAMLR, including the recording of bird and mammal entanglements as well as other impacts on the marine biota caused by this type of debris (described here for SSSI No. 32).

SC-CAMLR-XII/BG/18

Report on measures on board Russian vessels in 1992/93 to avoid incidental mortality of seabirds. Russia, 3 pp. (English, unpublished).

Abstract not available.

SC-CAMLR-XII/BG/19

Notes on management under uncertainty. Ukraine, 2 pp. (English, unpublished).

Abstract not available.

SC-CAMLR-XII/BG/21

Population dynamics of black-browed and grey-headed albatrosses *Diomedea melanophris* and *D. chrysostoma* at Bird Island, South Georgia. P.A. Prince, P. Rothery, J.P. Croxall and A.G. Wood (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 58 pp. (English, unpublished).

Population dynamics of black-browed and grey-headed albatrosses were studied at Bird Island, South Georgia for 17 consecutive years (1975 to 1991). Over this period almost all the grey-headed albatross colonies decreased, at an average rate of 1.8% per annum. Although the total black-browed albatross population increased (at 0.8% p.a.), 14 of the 23 colonies (including both study colonies) decreased. Black-browed albatrosses follow an annual breeding cycle, with over 80% of birds successful in rearing a chick and 75% of those failing to do so returning to breed the next year, 5 to 10% of both categories delaying one further year (even when still paired). Grey-headed albatrosses are essentially biennial, <1% of successful birds breeding the next year, 68% returning two years later, 11% the next and 5% not until the fourth year. In contrast, over 50% of birds failing to rear a chick breed the next year, 23% delaying for one further year. This largely reflects the fact that birds failing after March do not return the next year, whereas 80% of birds failing during incubation do breed the following year. Grey-headed albatrosses show higher (39%) and more consistent breeding success than black-browed albatrosses (29%, including four years of almost complete breeding failure); hatching success is similar in both species and fledging success is the main source of variation in black-browed albatross productivity. We link this to the dependence of this species on Antarctic krill, a variable resource largely absent in three of the four years of widespread failure. Modal age of first breeding is 10 and 12 years for black-browed and grey-headed albatrosses respectively. Overall, survival rates of juveniles to recruitment as breeding birds averaged 28% and 14% for 1960s and 1970s cohorts, respectively, of black-browed albatrosses; for grey-headed albatrosses similar values were 38% and 6%. Studies of immigration and emigration between colonies show that no breeding birds move, that philopatry of fledglings is generally high but that recruitment rates need to be increased by 1 to 3% to allow for juveniles returning to non-natal colonies. Annual survival of adults averages 93% (s.e. = 0.6) and 95% (s.e. = 0.8) for black-browed and grey-headed albatrosses

respectively; for sexed birds, rates are similar for grey-headed albatrosses but 2% higher for female black-browed albatrosses. With our data, lifetime productivity would be 30% higher for black-browed albatrosses but this could be offset by a change in adult survival rate of less than 1%. The proximate reason for the population decline in studied colonies is high juvenile mortality, which has increased since the 1960s. It is likely that this reflects incidental mortality associated with fisheries (particularly entanglement in longlines for tuna and collision with net monitor cables of trawlers) but data are few and mainly circumstantial. Many differences between grey-headed and black-browed albatrosses (e.g., the former showing later sexual maturity, less frequent breeding, higher and more consistent survival) probably relate to basic differences between annual and biennial breeding. Some differences (e.g., breeding success) probably relate to differences in diet; others (e.g., in juvenile survival) may reflect different at-sea distributions. Comparisons with other species reveal species and possibly site-specific differences rather than consistent patterns for annual and biennial breeders.

SC-CAMLR-XII/BG/22
Cooperative Mechanisms for the Conservation of Albatross. R. Gales (Division of Parks and Wildlife, 134 Macquarie Street, Hobart, Tasmania 7000, Australia). Australian Nature Conservation Agency, Australian Antarctic Foundation: 132 pp., 1993 (English).

SC-CAMLR-XII/BG/24
Cooperation with IWC. CCAMLR Secretariat, 5 pp. (English, unpublished).

SC-CAMLR-XII/BG/25
Towards the development of an international GLOBEC Southern Ocean program. SCAR Observer, 43 pp. (English, unpublished).

The Southern Ocean marine ecosystem is, in many respects, unique. It has an inner ring around the Antarctic continent with a sea-ice dominated regime, followed by a very large area of seasonally iced and de-iced region and finally, an outer ring of open oceanic water. Because of physical conditions, the surface water is very much isolated from the rest of the world oceans, while intermediate and deep water is in open communication with these. There is high primary productivity in the surface water, particularly close to the ice-edge during the time of ice retreat, but, in general, nutrients in the water are not depleted. What is limiting for the primary production is still not understood, but contributing factors are the deep mixing layer, grazing by zooplankton and possibly lack of some micro-nutrients (e.g., iron). Despite this lack of depletion, the system sustains a secondary production of enormous proportions, notably of one species of krill, the Antarctic krill (*Euphausiasuperba*), with a total estimated biomass of somewhere between 650 and 1 000 million tonnes (which is almost the double biomass of the human population on earth). The system is physically highly variable both seasonally and interanually - yet it is predictable within limits, and it is old enough for the biota to have adapted to the harsh conditions. Because of these special conditions and the role polar seas play in the discussions and in reality on global climate stability or change, the Scientific Steering Committee of the International Global Ocean Ecosystem Dynamics (SSC of GLOBEC International) decided that the Southern Ocean is a key geographical area for studies of the processes that govern and influence secondary production in its physical setting.

The SSC of GLOBEC International gratefully acknowledged the kind invitation to hold a meeting of its Southern Ocean Planning Group at the Center for Coastal Physical Oceanography of the Old Dominion University in Norfolk, Virginia USA. The meeting was sponsored by US GLOBEC for US participants and SCOR for many of the international members of the group. Others were paid for their participation by sources of their own countries. The meeting took place under excellent conditions and ground service from the host institution.

SC-CAMLR-XII/BG/26
Antarctic ozone depletion: impacts of elevated UV-B levels on the Southern Ocean ecosystem. ASOC Observer, 2 pp. (English, unpublished).

Abstract not available.

Working Group on Krill

WG-KRILL-93/4
Geographic aspects of *Euphausia superba* resources exploitation. R.R. Makarov (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia), 12 pp. (Russian, unpublished).

Data on the distribution and biomass of *E. superba* aggregations in the Atlantic sector and adjacent waters (areas outside the Scotia Sea being of particular interest) were collected. Aggregations of *E. superba* having the same order of density as aggregations in the Scotia Sea area were observed in several areas along the periphery of the Weddell Gyre and also in coastal areas of the Antarctic. Offshore aggregations of *E. superba* have an increased spatial irregularity. Any development of fisheries in these previously unfished areas should include preliminary studies of the distribution variability of *E. superba* aggregations. Additional multi-disciplinary studies which should be directed at the evaluation of *E. superba* flux as well as distribution variability of its aggregations in open waters. Exploitation of offshore aggregations of *E. superba* have to be linked with regular surveys prior to as well as during every fishing season.

WG-KRILL-93/5 Rev. 1
The preparation of recommendations and standard procedures for krill acoustic surveys. W.D. Tesler (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia), 14 pp. (English, unpublished).

Acoustic surveys are the most powerful tool for estimating krill abundance and mapping of krill distribution. Standard requirements and procedures for acoustic equipment, as well as survey design, data acquisition, processing, storing and analysis are required to conduct international cooperative surveys. In this paper, various aspects of the acoustic survey designs at different scales (macro, meso, micro) are reviewed. It is concluded that most standard and specific procedures could be elaborated based on existing experience in survey design and data analysis. This paper could be considered as a basis for further critical discussions by the CCAMLR Scientific Committee and its Working Groups.

WG-KRILL-93/6
Further analysis of target strength measurements of Antarctic krill at 38 and 120 kHz: comparison with deformed cylinder model and inference of orientation distribution. D. Chu, K.G. Foote and T.K. Stanton (Department of Applied Ocean Physics and Engineering, Woods Hole Oceanographic Institution, Woods Hole, Ma. 02543, USA). *J. Acoust. Soc. Am.*, 93 (5): 2985-2988, 1993 (English).

Data collected during the krill target strength experiment (*J. Acoust. Soc. Am.*, 1990, 87: 16-24) are examined in the light of a recent zooplankton scattering model where the elongated animals are modelled as deformed finite cylinders (*J. Acoust. Soc. Am.*, 1989, 86: 691-705). Exercise of the model under assumption of an orientation distribution allows absolute predictions of target strength to be made at each frequency. By requiring that the difference between predicted and measured target strengths be a minimum in a least-squares sense, it is possible to infer the orientation distribution. This useful biological quantity was not obtainable in the previous analysis which involved the sphere scattering model.

WG-KRILL-93/7
An assessment of the impact of krill fishery on penguins in the South Shetlands. T. Ichii, M. Naganobu and T. Ogishima (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, 424 Japan). *CCAMLR Science*, (in press): 11 pp. (English).

The competition for krill between the Japanese krill fishery and penguins during their breeding season (December to March) in the South Shetland Islands (Subarea 48.1) was assessed based on available information on the fishery, penguin biology

and krill biomass. The catches are normally very low in December followed by roughly equivalent catch rates (3 000 to 10 000 tonnes/10 days) for the following three months, during which increased catch rates are observed over the shelf and slope of Livingston and/or Elephant Island. In contrast, the food consumption by penguins is estimated to be large in the shelf and slope areas near King George Island (11 680 tonnes/10 days), but small near Livingston (2 570 tonnes/10 days) and Elephant (220 tonnes/10 days) Islands. Thus a small degree of overlap between the main fishing and krill foraging areas implies a less competitive relationship between the fishery and penguins. Estimated krill biomass varies considerably within the regular fishing areas due to the variability of krill flux across these areas, but high krill biomass (100 to 1 000 x 10^3 tonnes) is usually found there. Compared with the biomass (100 to 1 000 x 10^3 tonnes) and the degree of its variability (in the order of 100 x 10^3 tonnes/10-20 days), the present catch rate (≤ x10^3 tonnes/10 days) is smaller by one or more orders of magnitude within the localised areas. Hence, from the view point of the catch size as well, the present fishery is very unlikely to have an adverse impact on the local krill biomass and hence on penguins.

WG-KRILL-93/8
Status of the krill stock around Elephant Island in 1991/92 and 1992/93. V. Loeb and V. Siegel (Moss Landing Marine Laboratories, PO Box 450, Moss Landing, Ca. 95039, USA). *CCAMLR Science*, (in press): 26 pp. (English).

Krill stock composition and distribution patterns in the vicinity of Elephant Island during austral summers 1991/92 and 1992/93 are described and compared with information from previous years. The general distribution of krill length and maturity classes conformed to previous descriptions and appears to be a recurring and predictable aspect of the krill stocks in the Antarctic Peninsula region. The length frequency distributions and maturity stage composition reflected relatively good year class success from the 1990/91 spawning season but poor success from 1991/92. Year class success from these and other years appears to be associated with female maturity development and spawning during early summer months. The overall abundance, maturity stage composition and reproductive activity of krill appeared to be affected by dense salp concentrations during 1992/93 and 1989/90.

WG-KRILL-93/9
Fine-scale catches of krill in Area 48 reported to CCAMLR for the 1991/92 fishing season. CCAMLR Secretariat, 20 pp. (English, unpublished).

WG-KRILL-93/10
Krill catch distribution in relation to predator colonies 1987 to 1992. CCAMLR Secretariat, 8 pp. (English, unpublished).

The distribution of krill catches in relation to land-based predator colonies, calculated from CCAMLR fine-scale data, is shown for Subareas 48.1 and 48.2. The pattern of catches in 1992 is similar to that seen for other years, with 70% of the total catch from Subarea 48.1 being taken within 100 km of colonies and between the months of December to March inclusive (the 'critical period-distance'). Although data reporting was not complete for Subarea 48.2 in 1992, it was estimated that 38% of the total catch from this subarea was taken in the critical period-distance, compared to 5 to 78% in previous years. It is estimated that the catch in the critical period-distance was equal to 12 and 15% of the total exploitation of krill in these two subareas respectively.

WG-KRILL-93/11
Bibliography of Antarctic oceanography, hydrology and related aspects of krill (*Euphausia superba*) distribution and migration. CCAMLR Secretariat, 34 pp. (English, unpublished).

WG-KRILL-93/12
Estimating krill recruitment and its variability. W.K. de la Mare (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia). *CCAMLR Science*, (in press): 21 pp. (English).

A maximum likelihood method is developed for the decomposition of krill density-at-length data into the proportion of recruits in a population sampled in a net haul survey. Preliminary results from a series of five net haul surveys in the South Atlantic and the Indian Ocean sectors of the Southern Ocean give a mean recruitment rate for one-year-old krill of 0.339 with a standard deviation of 0.100. The corresponding results for two-year-old krill from nine surveys are 0.522 and standard deviation 0.074. A number of the assumptions needed for reliable results are discussed.

WG-KRILL-93/13
Modelling krill recruitment. W.K. de la Mare (Antarctic Division, Channel Highway, Kingston, Tasmania, 7050, Australia). *CCAMLR Science*, (in press): 9 pp. (English).

A method is developed for using observed values of the mean proportion of recruits and its variance to model recruitment in a krill population in terms of numbers of recruits. The method includes the calculation of natural mortality and other parameters consistent with the observed proportional recruitment parameters. A procedure is given for generating families of recruitment functions which are consistent with the statistical uncertainty in the observed recruitment parameters.

WG-KRILL-93/14
A preliminary model of krill fishery behaviour in Subarea 48.1. D.J. Agnew (CCAMLR Data Manager, 25 Old Wharf, Hobart, Tasmania 7000, Australia). *CCAMLR Science*, (in press): 17 pp. (English).

A simple model of the behaviour of the krill fishery in FAO Statistical Subarea 48.1 (South Shetland Islands and Antarctic Peninsula) is described. Parameters of the model are calculated from Chilean fishery data over the period from 1989 to 1992. The distribution of catches predicted by the model, which is restricted to the four months December to March, compares favourably with the historical distribution of catches in the subarea. A number of management scenarios are considered which involve the closure of (i) a radial zone 50 km offshore from the South Shetland Islands, and (ii) zones 100 km around Livingston and Elephant Islands. The model predicts that the management option of closing the zones around Livingston and Elephant Islands in alternate years would result in an average yearly catch similar to that at present. However, in this scenario, the catch would be more concentrated in foraging areas of land-based predators during alternate years.

WG-KRILL-93/15
Trophic ecology of demersal fish communities in waters to the south of Elephant Island, north of Livingston Island, north of the Antarctic Peninsula and east of Smith Island, with reference to the ecological role of krill. M. Takahashi (Japan Marine Fishery Resources Research Center, 3-4, Kioi-cho, Chiyoda-ku, Tokyo, Japan), 41 pp. (English, unpublished).

The trophic ecology of demersal fish communities in waters to the south of Elephant Island, north of Livingston Island, north of the Antarctic Peninsula and east of Smith Island was studied. In these three areas, excluding the area east of Smith Island, demersal fish communities at depths of around 100 m, 300 m and 500 m were sampled. To the east of Smith Island, the demersal fish community at a depth of around 800 m was sampled using bottom trawl. Krill (*Euphausia superba* Dana) and a wide range of benthic and benthopelagic organisms were the most important food for demersal fish communities in three areas, excluding the north of Livingston Island. Krill was also the most important food for communities to the north of Livingston Island. The importance of krill in the feeding of demersal fish communities increased in those communities distributed at depths of more than around 300 m. The significance of these results is discussed in relation to the vertical distribution of krill and the ecological role of krill in the food web of the demersal fish communities of these areas.

WG-KRILL-93/16
A review on the feeding conditions of the baleen whales in the Southern Ocean. A. Kawamura (Faculty of Bioresources, Mie University, 1515 Kamihama-cho, Tsu, 514 Japan),

39 pp. (English, unpublished).

Food habits of the southern baleen whales were reviewed, based on published and unpublished data since 1946. Retrospectively studied geographical distributions of krill in whale stomachs and the frequency occurrence of krill by size showed that large krill (>50 mm) occurs more frequently in stomachs sampled in International Whaling Commission (IWC) Areas II and III, then the size is medium (40 to 50 mm) in Areas IV and V, and small (<40 mm) frequents Areas I and VI. Assuming that some 76 x 10^4 minke whales feed mainly in the ice-associated waters of the southern latitudes, feeding grounds in Areas II and III would be beneficial for the feeding of blue, fin, humpback and for some right whales, because these areas are possibly not disturbed by feeding of minke whales. No clear evidence of any inter- and/or intra-specific competitions for food is known hitherto. However, the high density of minke whales could be considered as the most probable cause of interfering the feeding of blue whales through unfavourable disturbances of krill swarms by their frequent feeding bouts. More process-oriented *in situ* observations relating to behavioural relationships among baleen whale species are needed especially in the Weddell Sea area before drawing any conclusions.

WG-KRILL-93/17

Distribution of salps near the South Shetland Islands; their ecological significance in the area. J. Nishikawa, M. Naganobu, T. Ichii and K. Kawaguchi (Oceanic Research Institute, University of Tokyo, Minamidai 1-15-1, Nakano-ku, Tokyo, 164 Japan), 15 pp. (English, unpublished).

Distribution and abundance of salps were studied near the South Shetland Islands during the summer of 1990/91. Total salp biomass ranged between 0.1 and 2021.3 mg • m^{-3} (wet weight) and was nearly equal to krill biomass in the area. Two species, *Salpa thompsoni* and *Ihlea racovitzai*, were found and the former was dominant. Horizontal distribution of salps and krill did not overlap. Krill occurred abundantly at the high chlorophyll *a* area, in contrast, salps exhibited high biomass in the area of low chlorophyll *a* concentration.

WG-KRILL-93/18

Comparison of the distribution of particulate matters and the composition of particulate organic matter in surface waters between the coastal and oceanic areas off the northern South Shetland Islands in summer. A. Shiomoto and H. Ishii (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, Shizuoka, 424 Japan), 27 pp. (English, unpublished).

Biogenic silicon (BSi), lithogenic silicon (LSi), particulate organic carbon (POC) and nitrogen (PON), and chlorophyll *a* (Chl*a*) were measured in the surface waters (<100 m) off the northern South Shetland Islands in summer. Higher concentrations of BSi were frequently observed in the oceanic area, and those of LSi in the coastal area. However, the regional differences were not observed in POC, PON and Chl*a* concentrations. The mean BSi/POC atomic ratio (±SD) in the oceanic area (0.27 ± 0.17) was six-times higher than that in the coastal area (0.045 ± 0.020), and nearly equal to the higher values (0.30 to 0.65) reported until today in the Antarctic Ocean. In contrast, POC/PON ratio was nearly constant throughout all the stations (mean ±SD = 5.4 ± 1.7). The results show that although the Antarctic particulate organic matter is uniquely very siliceous in the oceanic area, this is not the case in the coastal area.

WG-KRILL-93/19

Some idea of numerical model for assessment of *Euphausia superba* biomass. M.J. Kishi and M. Naganobu (Oceanic Research Institute, University of Tokyo, Minamidai 1-15-1, Nakano-ku, Tokyo, 164 Japan), 2 pp. (English, unpublished).

A numerical model is being developed for assessment of *Euphausia superba* in Antarctic Ocean which consists of: (1) calculation of three-dimensional current field using CCSR version (developed by Dr Yamanaka of Center of Climate System Research, University of Tokyo) of the three-dimensional primitive equation for the ocean circulation developed originally at the GFDL, Princeton, NJ; (2) calculation of spatial distribution of DIN (Dissolved Inorganic Nitrogen); (3) calculation of

spatial distribution of DON (Dissolved Organic Nitrogen); (4) calculation of spatial distribution of Chl*a*; and (5) calculation of spatial distribution of *E. superba*. Our model will be capable of calculating the detailed spatial distribution of *E. superba* by dividing the Antarctic Ocean into many grid points. It also takes into consideration the effects of fisheries.

WG-KRILL-93/20

Report of an examination of the acoustic data from RV *Eduardo L. Holmberg* collected during the FIBEX study. I. Everson and A.O. Madirolas (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom). *CCAMLR Science*, (in press): 4 pp. (English).

Data from the *Eduardo L. Holmberg* FIBEX survey have been re-examined for incorporation into the BIOMASS Database in the approved standardised format. The results indicate the krill were concentrated at the western end of the South Orkney Islands. Density values are consistent with those from other FIBEX surveys.

WG-KRILL-93/21

Prediction of krill target strength by liquid prolate spheroid model. M. Furusawa and Y. Miyanohana (National Research Institute of Fisheries Engineering, Ebidai Hasaki-machi, Kashima-gun Ibaraki-ken, 314-04 Japan), 17 pp. (English, unpublished).

A theoretical prolate spheroid liquid model is applied to predict the target strength (TS) of krill. Scattering patterns are shown to demonstrate orientation dependence of krill TS. Length-to-wavelength ratio (L/λ) dependencies of reduced (normalised by body length squared) target strength are shown for some orientation distributions. The model results can explain results of well-organised experiments. The krill TS variability is large where L/λ is larger than one. Therefore, a frequency around 70 kHz is superior to 120 kHz which had been ordinarily used for krill surveys.

WG-KRILL-93/22

Hydrographic flux in Statistical Area 58 of CCAMLR in the Southern Ocean. M. Naganobu (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, Shizuoka, 424 Japan), 13 pp. (English, unpublished).

This document submits basic information on the hydrographic flux in Statistical Area 58, including data on surface geostrophic flow in the whole of Statistical Area 58, and vertical distributions of geostrophic flow along 37°E, 75°E, 114°E and 155°E.

WG-KRILL-93/23

Chlorophyll distributions around the South Shetland Islands. H. Ishii, T. Ichii and M. Naganobu (Tokyo University of Fisheries, 4-5-7, Kounan, Minato-ku, Tokyo 108, Japan), 6 pp. (English, unpublished).

Chlorophyll distribution patterns around the South Shetland Islands are briefly described based on data collected during the Antarctic survey of RV *Kaiyo Maru* from 13 December 1990 to 11 January 1991 (Leg I) and from 16 January to 11 February 1991 (Leg II). To the north of Livingston Island, high chlorophyll *a* concentration and low POC/Chl*a* ratio in Leg II and low chlorophyll *a* concentration in Leg I suggest that phytoplankton bloom occurred in this area for about one month.

WG-KRILL-93/24

Orientation of Antarctic krill in an aquarium. Y. Endo (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, Shizuoka, 424 Japan). *Nippon Suisan Gakkaishi*, 59 (3): 465-468, 1993 (English).

Acoustic methods appear to be the best way to estimate Antarctic krill abundance directly. Information on krill body orientation, however, is needed to obtain reliable values of krill acoustic target strength (TS), since TS varies with body orientation. Krill body orientation was measured in an aquarium aboard the RV *Kaiyo Maru*. Average body orientation was 45.6° (SD = 19.6°, N = 67), which was slightly less than that when animals were hovering, 49.7° (SD = 7.5°, N = 50). Such an acute angle of elevation would tend to reduce the reflected echo intensity when compared to animals swimming horizontally.

Although mature females with marked swelling of the cephalothorax were not

included in the experiment, the centre of mass was found to be situated more to the anterior than in males and immature females. The hovering orientation, which is close to average body orientation, of mature males and mature females was estimated on the basis of Kils' model. Mature females with swollen cephalothorax demonstrated large tilt angles relative to the horizontal plane than did males, as the centre of mass is positioned more to the anterior and the pleopods are less developed in females. It is concluded that the orientation, and therefore TS, may differ according to the maturity stage composition of individual aggregations.

WG-KRILL-93/25
CPUEs and body length of Antarctic krill during 1991/92 season in the fishing grounds north of Livingston Island. T. Ichii (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, 424 Japan), 20 pp. (English, unpublished).

This paper summarises Japanese krill catch data for the austral summer of 1991/92. Main catches were consistently taken north of Livingston Island. CPUEs show the highest catches at the height of summer (late January to late March). Krill with modal lengths of 41 to 45 mm were dominant in catches, about 5 mm smaller than in the previous season.

WG-KRILL-93/26
Note on relationship between the Antarctic krill and annual variation of ice edge during 1979 to 1992. M. Naganobu and S. Kawaguchi (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, Shizuoka 424, Japan), 9 pp. (English, unpublished).

The relationship between the size of Antarctic krill and the extent of the sea-ice in the sea area around the South Shetland Islands are described for the period from 1979 to 1991. Mean size of krill near the coastal zone appeared to be small in years with extensive ice coverage. This implies that strong recruitment of small-sized krill had occurred just after the ice retreat in years with extensive ice coverage. Interannual fluctuations of the ice extent are known to be related to the strength of the Antarctic circumpolar trough. Therefore, it could be suggested that climate and ecology of krill populations are closely related.

WG-KRILL-93/27
Note on maturity of krill in relation to interannual fluctuations of food environment in the seas around the South Shetland Islands. M. Naganobu and S. Kawaguchi (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, Shizuoka, 424 Japan), 11 pp. (English, unpublished).

Relationship between food environment and maturity of krill around the South Shetland Islands is discussed. Data collected during the 1991/92 austral summer show that when chlorophyll concentration in the phytoplankton of the size fraction larger than 2 μm was high, feeding activity of krill was also high. Five years' data from commercial krill trawler indicates that percentage of occurrence of gravid females were high when the feeding activity of krill was high throughout the season. Therefore, interannual fluctuations in krill maturity are related to the food environment, namely to the biomass of the phytoplankton of the size fraction larger than 2 μm.

WG-KRILL-93/28
Estimates of primary productions by ice algae and phytoplankton in the coastal ice-covered area near Syowa Station, Antarctica. H. Satoh K. Watanabe and T. Hoshiai (Tokyo University of Fisheries, 5-7, Konan 4-chome, Minato-ku, Tokyo, 108 Japan). *Nankyoku Shiryô (Antarctic Record)*, 35 (1): 30-38, 1991 (English).

Annual primary production of ice algae and phytoplankton under fast ice near Syowa Station (69°00'S, 39°35'E), Antarctica, was estimated. Mean daily production in each month from February 1983 to January 1984 was calculated using a mathematical model based on measured parameters of solar radiation, day length, reflection coefficients of snow, ice and water, chlorophyll *a* concentration, quantum yield for photosynthesis etc. Solar radiation measured at Syowa Station ranged from 0 E m^{-2} h^{-1} in June to 13.3 E m^{-2} h^{-1} in December. Relative light intensity estimated at the bottom of sea-ice during the year ranged from 0 to 6.5% of

incident solar radiation, due to reflection from snow and ice. Maximum daily production of ice algae (34 $mgCm^{-2}$ day^{-1}) and phytoplankton (450 $mgCm^{-2}$ day^{-1}) was reached in December and in February, respectively. The estimated annual production of ice algae and phytoplankton was 3.5 and 17 gCm^{-2}, respectively. These results indicate that summer phytoplankton production contributed remarkably to the primary production in the coastal ice-covered area near Syowa Station.

WG-KRILL-93/29
Environmental gradients of Antarctic krill (*Euphausia superba* Dana) in the whole of the Antarctic Ocean. M. Naganobu and Y. Komaki (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, Shizuoka, 424 Japan), 21 pp. (English, unpublished).

The relationship between a regional and circumpolar distribution of Antarctic krill, *Euphausia superba* Dana, and its summer environmental gradients was considered. In order to find out the relationship between the geographical distribution of *E. superba* and its oceanographical gradients, an environmental index $\overline{Q}_{200}$ was introduced. The environmental index represents the integrated value of water temperature from the surface to 200 m at bottom depth Z. It was found that the area of high concentrations of *E. superba* coincided with the area of low values of $\overline{Q}_{200}$ chiefly falling in the range from 0°C to -1.5°C. This range corresponds with the thick layer of winter water, especially in the slope and the shelf areas south of the Antarctic Divergence Zone.

WG-KRILL-93/30
Winter gut contents of Antarctic krill (*Euphausia superba* Dana) collected in the South Georgia area. Y. Nishino, A. Kawamura (Faculty of Bioresources, Mie University, 1515 Kamihama-cho, Tsu, 514 Japan), 15 pp. (English, unpublished).

Foregut content of Antarctic krill, *Euphausia superba* Dana, collected in the South Georgia area in austral winter, 12 July to 4 August 1992 was analysed. A total of 130 specimens (78 adults, 49 sub-adults and 3 juveniles) collected from krill trawl catches from various depths were examined in this study. In 77 samples, the foregut content consisted of various fragments of crustacean zooplankton. Among the fragments a portion of the pereiopods of krill was found in all specimens examined. Although the obtained materials were geographically confined to South Georgian waters, which were free from fast-ice throughout the year, the results might imply that krill seemed to seasonally switch between available food sources. Krill demonstrated herbivorous feeding habits during the rich phytoplankton bloom, but might change to carnivorous habits in the autumn and winter. Strong cannibalistic feeding habits during austral winter observed in this study are considered to be important aspects for the population dynamics studies of krill.

WG-KRILL-93/31
Status of the FIBEX acoustic data from the West Atlantic. P.N. Trathan and I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom). *CCAMLR Science*, (in press): 12 pp. (English).

Data from the FIBEX acoustic survey in the West Atlantic sector have been re-examined to check the consistency of krill abundance estimates derived from different survey vessels. There is a good level of consistency between the results from four of the vessels, *Itzumi, Eduardo L. Holmberg, Odysee* and *Walther Herwig.* While there is an error factor due to the combination of data collected at 50 kHz (*Walther Herwig* survey) with data collected at 120 kHz (all other vessels), it is concluded that this does not significantly affect the estimated biomass. The data from the *Professor Siedlecki* survey do not provide estimates that are consistent with the other surveys. The authors can find no explanation for this difference.

WG-KRILL-93/32
An address to citizen's marine summit. I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 5 pp. (English, unpublished).

The main aims of CCAMLR are reviewed in an essay which discusses the advances in the effectiveness of harvesting, arising from

developments in science and technology in comparison with the requirements of science to provide information for rational management. It is concluded that cooperation is essential between fishermen and scientists to ensure the provision of the data needed to test hypotheses related to the functioning of the Southern Ocean ecosystem. Although currently cooperation is fairly good it would be improved by an increased spirit of trust between the various parties.

WG-KRILL-93/33
A note on chlorophyll measurement by satellite remote sensing in the Antarctic Ocean. T. Ogishima, M. Naganobu and S. Matsumura (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, 424 Japan), 7 pp. (English, unpublished).

This paper describes the usefulness of satellite ocean colour remote sensing in the Antarctic Ocean by making a comparison between CZCS chlorophyll images and ship-measured chlorophyll concentrations in open waters off Enderby Land, Antarctica. In addition, some characteristics of the chlorophyll distribution in the Antarctic Ocean are briefly explained using composite images averaged for three months (January to March).

WG-KRILL-93/34
Peak mortality of krill, fished with midwater trawls and feasible criteria of krill trawls ecological safety. Yu.V. Kadilnikov (AtlantNIRO, 5 Dimitry Donskoy Street, Kaliningrad 236000, Russia), 32 pp. (English, unpublished).

The mathematical model of fishery-targeted objects contacting trawl meshes while escaping a trawl is described. Model equations are given to calculate the rate of the object elimination probability caused by catch and fishery-related mortality. The coefficient of the trawl ecological safety is proposed, which is represented by the ratio of the objects caught and the objects escaping through the net during trawling and subsequently dying. The equations are presented to estimate the gross removal of objects by the fishing fleet. An input of data from the krill fishery was used to test the model. In this test, the calculated gross removal of objects based on commercial data for December 1984 in the South Shetland area exceeded the catch rate only in the range of 1.5 to 26%, depending on the fishing intensity, i.e., it was within the range of stock estimate bias.

WG-KRILL-93/35
Krill distribution and biomass variability within Subarea 48.3 in June 1991. S.M. Kasatkina, E.N. Timokhin, P.P. Fedulov and K.E. Shulgovsky (AtlantNIRO, 5 Dimitry Donskoy Street, Kaliningrad 236000, Russia), 12 pp. (English, unpublished).

Temporal and spatial variability of krill distribution characteristics was investigated in an 8 x 6 miles survey area, where eight consecutive hydroacoustic surveys were carried out. Krill aggregations occurred as fields of small swarms whose spatial distribution characteristics (size and density of swarms, swarm field density, number of swarms per mile) varied considerably from tack to tack within each survey. The maximum horizontal extension of swarms was 120 m, although about 70% of swarms were of 30 m in length, with density up to 200 g/m^3. About 75% of all swarms had biomass less than one tonne. Average statistical parameters of swarms in the survey area varied insignificantly from survey to survey, while the swarm number varied from 1 918 to 7 000. Krill biomass in the survey area varied stochastically within the range of 1 091 to 6 085 tonnes. Krill distribution variability revealed in the survey area suggests an irregular import and export flux of krill across the area due to transport by currents. Additionally, in the upper layer of 0 to 50 m, swarm number was almost constant, and krill redistribution due to transport by currents and diurnal migrations took place in the layer of 50 to 150 m. Estimated velocity of krill swarm displacement corresponded to the estimated water transport velocity in the area, suggesting that so-called passive migration of krill had occurred.

WG-KRILL-93/36
Growth of krill around the South Orkney Islands in 1989/1990. V.I. Latogursky (AtlantNIRO, 5 Dimitry Donskoy Street, Kaliningrad 236000,

Russia), 12 pp. (English, unpublished).

Samples collected by biologists-observers on board krill fishing vessels from October 1989 to June 1990 near South Orkney Islands were analysed to study the growth of krill males and females by size groups. Six size groups both for males and females were distinguished. A period of intensive growth for males was from December to April, and for females from November to February. An increment between size groups was 7 to 10 mm for males and 8 to mm for females. The rate of growth for the males was higher among the small specimens and vice versa for the females. Growth rates are similar to those observed in 1984/1985 in the South Orkneys and in Admiralty Bay (King George Island).

WG-KRILL-93/37

On the problem of natural subdivision of the area of Antarctic krill habitat (an application to the monitoring of fishing). R.R. Makarov and L.L. Menshenina (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia), 14 pp. (English, unpublished).

The possibilities of natural regionality of the area of Antarctic krill habitat with emphasis on the distribution of fisheries are considered, on the basis of existing data on the spatial structure of the area of krill habitat. More than 43% of the area of krill habitat where concentrations of krill are usually present (this percentage includes all recent fishing areas) lays inside the secondary water fronts. These fronts are taken as natural boundaries of krill stocks (sub-populations). In the case of crustaceans, such position of areas of increased abundance inside secondary fronts creates difficulties when attempting to identify stocks. This problem may be solved if new multidisciplinary surveys are undertaken. These surveys should obtain information on spatial structure of waters, ways of krill drift as well as information on the main biological characteristics of all crustaceans. These surveys should cover fairly large areas which must include corresponding areas as well as other areas of increased abundance of krill and also areas of low abundance of krill. Seasonal and annual variability increases the necessity to repeat these observations over several years, which is very expensive and not feasible at present. Therefore, in the meantime, information obtained by observers on commercial trawlers as well as data from research vessels is very useful.

WG-KRILL-93/38

Factors influencing Antarctic krill distribution in the South Shetlands. T. Ichii, H. Ishii and M. Naganobu (National Research Institute of Far Seas Fisheries, Orido 5-7-1, Shimizu, Shizuoka, 424 Japan), 36 pp. (English, unpublished).

The influences of environmental, biological and physical factors on krill (*Euphausia superba*) distribution were studied in the area north of South Shetland Islands during the 1990/91 austral summer. In mid-summer, krill distribution had a distinct offshore-inshore heterogeneity in terms of abundance and maturity stages: abundance was low in the oceanic zone (8.5 g/m^2), higher in the slope frontal zone (37.3 g/m^2), and highest along the shelf break (135.1 g/m^2) in the inshore zone; krill were reproductive in the oceanic and frontal zones, whereas non-reproductive in the inshore zone. The following factors were considered to be responsible for this characteristic distribution of krill. Diatoms were the main food of krill, and a spatial correlation between distributions of krill and diatoms were observed. Hence, higher diatom biomass may be one of the factors forming krill concentrations in the inshore and frontal zones. The water flow was sluggish in the inshore zone (3.2 km/day), while meandering in the oceanic zone (7.9 km/day) and moving in one direction in the frontal zones (13.8 km/day). Especially, in the inshore zone, convergent complex eddies were generated along the shelf break, where krill were densely aggregated. Hence, the mechanical accumulation may be another factor concentrating non-reproductive krill there. The frontal zones were considered to be a favourable spawning ground for krill: not only because of the greater depth (which prevents krill embryos from being predated by benthic animals) and of the presence of warm Circumpolar Deep Water (which helps the development of the embryo) but also because of the higher chance of larvae to be transported to their nursery grounds.

Based on the abovementioned factors, we further discussed why the change in spatial distribution of krill occurs from early to late summer.

WG-KRILL-93/39
Estimation of chlorophyll distributions obtained from satellite images (Nimbus-7/CZCS) in the Antarctic Ocean. N. Kimura, Y. Okada, S. Matsumura and Y. Sugimori (Marine Science and Technology, Tokai University, 3-20-1 Orido, Shimizu, Shizuoka, 424 Japan), 9 pp. (English, unpublished).

Previous studies have established that ocean colour information from Nimbus-7/CZCS (Coastal Zone Colour Scanner) could be related to distribution of phytoplankton pigment (Chlorophyll *a* + pheopigments) concentrations. CZCS data from polar regions have been utilised to only a limited extent because of many problems such as cloud cover, large solar zenith angles, bio-optical algorithm and other logistic constraints. This paper discusses the characterisation of phytoplankton pigment concentrations.

WG-KRILL-93/40
Krill length and age at maturity. V. Siegel and V. Loeb (Institut für Seefischerei, Palmaille 9, D-22767 Hamburg, Germany), 11 pp. (English, unpublished).

Data from several summer surveys to the Antarctic Peninsula region were analysed to calculate length and age at maturity for the Antarctic krill *Euphausia superba*. L_{50} values of 34.62 to 35.90 mm for female krill are the best estimates for the high spawning season. Males attain sexual maturity later at a length between L_{50} = 43.33 and 43.79 mm. Length-at-maturity and length-at-first spawning are identical for krill. Comparisons with length-at-age data show that females mature in the third year of the life cycle (age class 2+), while males reach maturity in the fourth year as age class 3+. Both sexes show knife-edge maturity.

WG-KRILL-93/41
Abundance of *Euphausia superba* in the western Bransfield Strait region during the KARP cruise in the 1992/93 summer. S.-M. Choi and S. Kim (Korea Ocean Research and Development Institute, Ansan PO Box 29, Seoul 425-600, Republic of Korea), 5 pp. (English, unpublished).

The cruise on the Sixth Korea Antarctic Research Program (KARP) of 1992/93 was designed to examine physical and biological processes that give rise to high biological productivity in the vicinity of the Antarctic Peninsula and to look for a post "bloom" effect. The cruise took place during the late summer from 5 February to 15 February 1993 in the Bransfield Strait area. During the cruise, samples were collected aboard the RV *Onnuri*. A total of 80 stations was selected for samples from the coastal shelf, the continental shelf break, island shelves, the Bellingshausen Sea-Weddell Sea confluence, and a portion of the Drake Passage. Although a number of previous studies had sampled at or near the Bransfield Strait area, a little mesoscale study had investigated the coupling between the physical processes and the interactions among bacteria, phytoplankton, zooplankton, krill and benthos within the Bransfield Strait coastal ecosystem. The cruise focused on a small, but representative geographic region, with a research plan for high-resolution sampling. A new understanding of ecosystem dynamics and the mesoscale upper-ocean circulation can emerge only from intensive study of a more restricted geographic region.

Copepods were the major components of epipelagic zooplankton in numbers, accounting for 55.4% of total zooplankton abundance. *Calanoides acutus*, small calanoides and cyclopoids dominated the zooplankton samples. Salps and euphausiids were the next most abundant groups, accounting for 26.4% and 12.9%, respectively. Chaetognaths, amphipods, polychaetes, ostracods and fish larva were also important zooplankton groups observed during this study period. In samples collected by a MOCNESS net, major groups of species were apparently actively migratory species.

The distributional pattern and abundance of *Euphausia superba* in the western Bransfield Strait region showed that the highest abundance was found in the middle of one Bransfield area with 205l ind./$10^3 m^3$. *Euphausia superba* in

juvenile stages were dominant in most krill samples. The overall range of abundance in the study area was from 14 ind./10^3m^3 near Brabant Island to 205l ind./10^3m^3 in the Bransfield Strait region. Adult *E. superba* appeared negligible during the Sixth KARP cruise in February. They were only found in the northern part of Bransfield (Drake Passage area) and a station in the Antarctic Peninsula, ranging from 26 ind./10^3m^3 to 132 ind./10^3m^3 respectively. The distribution and abundance of krill in different life stages suggest that krill in early stages of development originated from coastal waters of Gerlache Strait.

WG-KRILL-93/42

Further computations of the consequences of setting the annual krill catch limit to a fixed fraction of the estimate of krill biomass from a survey. D.S. Butterworth, G.R. Gluckman, R.B. Thomson and S. Chalis (Department of Applied Mathematics, University of Cape Town, Rondebosch 7700, South Africa). *CCAMLR Science*, (in press): 33 pp. (English).

The results of Butterworth *et al.* (1992) relating potential krill yield to a pre-exploitation survey estimate of krill biomass are extended to incorporate most of the amendments specified by the Third and Fourth Meetings of the Working Group on Krill. The most important of these extensions is integration over the ranges of uncertainty for a number of the model parameters. Results are provided for the probability of spawning biomass falling below various fractions of its median pre-exploitation level (K_{sp}), as a function of the fraction of the biomass estimate which is set as the catch for a 20-year period. Three alternative fishing seasons are considered. The model extensions requested by the Third Meeting make little difference to the results of Butterworth *et al.* (1992). Winter fishing is marginally preferable to a summer harvest. However, the imposition of an upper bound of 1.5 yr^{-1} on the effective annual fishing mortality, as specified by the Fourth Meeting, results in marked reductions in the probabilities of krill spawning biomass falling below specified fractions of K_{sp}.

WG-KRILL-93/43

Possible effects on predators of different levels of krill fishing - some initial modelling attempts. D.S. Butterworth and R.B. Thomson (Department of Applied Mathematics, University of Cape Town, Rondebosch 7700, South Africa). *CCAMLR Science*, (in press): 28 pp. (English).

An initial attempt is made to develop the modelling framework suggested by the joint meeting of CCAMLR's WG-Krill and WG-CEMP in 1992, to address this issue. First, estimates are made of the parameters of predator survival rates as functions of krill abundance, by considering a krill dynamics model incorporating recruitment fluctuations together with information on adult survival and breeding success patterns for certain krill predator species. A "one way" interaction model is developed, in which krill abundance fluctuations impact the predator population, but not *vice versa.* Computations based on this model indicate that variability in the annual recruitment of krill results in predator populations being less resilient to krill harvesting than deterministic evaluations would suggest. However, the analyses also raise a number of questions about the proper interpretation of the available predator population dynamics information in the context of the models developed, and about the modelling of the predator survival rates as functions of krill abundance. It is suggested that these questions merit discussion at the forthcoming WG-Krill and WG-CEMP meetings. A formalism for a "two-way" interaction model (including also the effect of differing predator consumption levels on krill) is developed, but computations based on this approach are deferred pending clarification of the questions raised above at the WG-Krill and WG-CEMP meetings.

WG-KRILL-93/44

Natural mortality rates of the Antarctic krill *Euphausia superba* Dana in the Indian sector of the Southern Ocean. E.A. Pakhomov (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine). *Polar Biology*, (in press): 12 pp. (English).

Data on the size and age composition of *Euphausia superba* were collected in the

Sodruzhestva and Cosmonavtov Seas from 1985 to 1990. The coefficients of instantaneous natural mortality of *E. superba* in the Indian sector of the Southern Ocean were calculated according to Alverson-Carney's (1975), Richter-Efanov's (1977) and Beverton-Holt's (1958) methods. Values varied from 0.72 to 0.87, from 0.41 to 0.59 and from 0.94 to 2.30, respectively. The estimation of the annual extinction rate of *E. superba* was obtained using the method of Zikov and Slepokurov (1982) and results were best fitted by a parabolic equation. The coefficients of natural mortality of *E. superba* derived with this method range from 0.49, during the maturation period, to 1.17 and 3.22 during the first and last years of life, respectively.

WG-KRILL-93/45
Antarctic krill, *Euphausia superba* Dana, demography studies in the seas of Sodruzhestva and Cosmonavtov (Indian Ocean sector of Antarctica). E.A. Pakhomov (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine). *Mar. Ecol. Prog. Ser.*, (in press): 29 pp. (English).

Materials on *Euphausia superba* biological state and size composition in the Indian Antarctic seas for the period from 1985 to 1990 are analysed to study its growth, life duration, as well as about the interannual variability in the above parameters. According to our data, duration of *E. superba* life cycle somewhat exceeds five years in the Cosmonavtov Sea and six years in the Sodruzhestva Sea. *E. superba* growth rate ranges from 0.126 to 0.133 mm per day in the first year of life to 0.028 to 0.041 mm per day in the fifth year having assumed that *E. superba* growth takes place during 180 days each year. Bertalanffy growth curves calculated for different areas are close to those obtained by Australian researchers (Hosie *et al.*, 1988) for the Prydz Bay using data obtained in the years 1981 to 1985. Based on longterm observations, relations are noted between *E. superba* age composition and its spawning efficiency in coastal areas of the Sodruzhestva and Cosmonavtov Seas. The presence of relatively independent (self-reproducing) grouping of *E. superba* is assumed in these areas.

WG-KRILL-93/46 Vacant

WG-KRILL-93/47
Penguin foraging behaviour in relation to the distribution of prey. D.A. Croll, R.P. Hewitt, D.A. Demer and J.K. Jansen (Institute of Marine Science, University of California, Santa Cruz, Ca. 95064, USA), 18 pp. (English, unpublished).

The diving behaviour of seven chinstrap penguins (*Pygoscelis antarctica)* (N = 12 171 dives) was measured concurrently with a hydroacoustic assessment of the vertical distribution and abundance of their primary prey, krill (*Euphausia superba*) in the vicinity of Seal Island, South Shetland Islands, Antarctica between 19 January and 10 March 1992. Krill was found to show a distinct diel migration pattern, being dispersed in the upper portion of the water column at night and more concentrated and deeper during the day. Penguin foraging effort was found to be concentrated around noon and midnight, with a reduction in effort around dawn and dusk (local apparent time). The mean and maximum depth of chinstrap penguin dives was found to follow the diel migration pattern of the krill. On average, chinstrap penguins dove to the shallow limit of the distribution of krill. The maximum depth of penguin dives did not exceed the maximum depth distribution of krill. These patterns in diving behaviour may result from diel changes in the methods used by penguins to locate and capture prey. Our results suggest that penguins do not require extremely dense aggregations of prey in order to successfully capture sufficient krill to meet their energetic needs. We hypothesise that the diel migration pattern found in krill which has been found to be variable in different study locations at different times may in part be determined by the intensity of predation pressure by predators which feed in the upper portion of the water column (i.e., seabirds and marine mammals).

WG-KRILL-93/48
Bias in acoustic biomass estimates of *Euphausia superba* due to diel vertical migration. D.A. Demer and R.P. Hewitt (Scripps Institution of Oceanography, La Jolla, Ca. 92039, USA),

22 pp. (English, unpublished).

The diel vertical migration of Antarctic krill (*Euphausia superba*) can greatly bias the results of qualitative and quantitative hydroacoustic surveys which are conducted with a down-looking sonar and independent of the time of day. To demonstrate and quantify these negative biases on both the estimates of biomass distribution and abundance, a time-depth-density analysis was performed. Data for this study were collected in the vicinity of Elephant Island, Antarctica, during the austral summer of 1992. The data include five surveys conducted from mid-January to mid-March. The first and fourth surveys covered a 105 x 105 n mile study area centred on Elephant Island; the second and third surveys covered a 60 x 35 n mile area immediately north of Elephant Island; the fifth survey covered a 1 n mile^2 area centred on a large krill swarm to the west of Seal Island. Average krill volume densities were calculated for each hour as well as for three daily time periods; day, twilight and night; these data were normalised and presented as a probability of daily average density. A function was fit to the probability of average daily biomass versus local apparent time. This function was used to create a temporal compensation function (TCF), for upwardly adjusting acoustic biomass estimates due to diel vertical migration. The TCF was then applied to the original survey data; the resulting biomass estimates are 2.3 to 99.6% higher than those calculated disregarding biases due to diel vertical migration.

WG-KRILL-93/49

Acoustic estimates of krill biomass in the Elephant Island area: 1981 - 1993. R.P. Hewitt and D.A. Demer (Southwest Fisheries Science Center, La Jolla, Ca. 92038, USA). *CCAMLR Science*, (in press); 4 pp. (English).

Acoustic estimates of krill biomass in the vicinity of Elephant Island for the years 1981 to 1993 (with the exception of 1982 and 1986) are presented. Estimates for 1981 to 1991 are based on previous reports adjusted for the recently proposed definition of krill target strength. Biomass estimates range from 81 x 10^3 tonnes (March/April 1985) to 4 880 x 10^3 tonnes (January 1993) and areal biomass densities range from 2.5 g/m^2 to 134.5 g/m^2. Average biomass and average areal density over the 13-year period was 1 692 x 10^3 tonnes and 52.8 g/m^2.

WG-KRILL-93/50

Fishes in pelagic catches in the vicinity of the South Shetland Islands during the 6th Antarctic expedition of RV *Kaiyo Maru*, 1990/91. T. Iwami, T. Ichii, H. Ishii and M. Naganobu (Laboratory of Biology, Tokyo Kasei Gakuin University, 2600 Aihara, Machida, Tokyo, 194-02 Japan), 6 pp. (English, unpublished).

During the Sixth Antarctic Expedition of RV *Kaiyo Maru* (1990/91), observations on the occurrence and abundance of fishes in a total of 102 pelagic hauls for Antarctic krill were made. Of the 102 net hauls, a total of 104 fishes belonging to four families and 16 species were captured in 25 tows. Juvenile *Lepidonotothen larseni* was the most abundant (46 individuals; 44.2% in number) and post-larval *Cryodraco antarcticus* was the next (14 individuals; 13.5% in number). The standard length of *L. larseni* ranged from 41.4 to 50.9 mm (average 46.8 mm; mean 46.6 mm). Among the notothenioid fishes collected, only two adults (one specimen of *Gobionotothen gibberifrons* and one channichthyid fish - specimen lost on board) were included. Bottom depths of the stations where notothenioid post-larvae and juveniles were caught were less than 1 000 m deep. On the contrary, bathypelagic groups of the Myctophidae and Paralepididae were collected at the 11 offshore stations at which bottom depths were deeper than 2 000 m. In contrast with other previous data, present results (less than 36 individuals per 0.5 hour haul) show relative low abundance in pelagic catches for this region.

WG-KRILL-93/51

Fishes caught along with Antarctic krill in the vicinity of South Georgia Island during the austral winter months of 1992. T. Iwami (Laboratory of Biology, Tokyo Kasei Gakuin University, 2600 Aihara, Machida,

Tokyo, 194-02 Japan), 4 pp. (English, unpublished).

Observations on the abundance of by-catch fishes were made during the austral winter months of 1992 (from 9 July to 3 August) on board FV *No. 3* and *No. 5 Chiyo Maru* in the vicinity of South Georgia Island. Among 74 net hauls examined, a total of 66 specimens of fishes belonging to three species were found in 20 trawl catches. Among by-catch fishes, juvenile *Lepidonotothen larseni* was the most abundant (62 specimens; 93.9% in number; 58.9% of total weight of by-catch fish). Standard length (SL) of *L. larseni* varies from 32.4 to 52.1 mm (average 44.5 mm; mean 45.3 mm). Three specimens of juvenile *Champsocephalus gunnari* (ranging 80.5 to 88.3 mm SL) and one adult specimen of *Electrona antarctica* (72.1 mm SL) were also found, but no other fish species was recognised in our by-catch samples. The abundance of fish in our krill catches was relatively low (less than 52 individuals and 43.68 g per 100 kg of krill) in comparison with some data reported previously.

Working Group for the CCAMLR Ecosystem Monitoring Program

WG-CEMP-93/4
Parameters for a model of the functional relationships between krill escapement and crabeater seal demographic performance. P.L. Boveng and J.L. Bengtson (National Marine Mammal Laboratory, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, Wa. 98115, USA), 5 pp. (English, unpublished).

Estimates are provided for crabeater seal life-history parameters, to be incorporated into a simple model of the functional relationships between krill escapement and crabeater seal demographic performance. The crabeater seal parameters were estimated from seals collected near the Antarctic Peninsula between 1964 and 1990. Average annual survival rate of adults was estimated to be 0.93. Age at sexual maturity was estimated to be 3.8 years. Of 44 annual estimates of historical cohort strength, 16 were judged to represent 'good' years for demographic performance, 18 as 'poor' years, and 10 as 'bad' years.

WG-CEMP-93/5
Draft Management Plan for the Protection of Cape Shirreff and the San Telmo Islands, South Shetland Island, as a site included in the CCAMLR Ecosystem Monitoring Program. Chile and USA, 16 pp. (English, unpublished).

WG-CEMP-93/6
Population dynamics of black-browed and grey-headed albatrosses *Diomedea melanophris* and *D. chrysostoma* at Bird Island, South Georgia. P.A. Prince, P. Rothery, J.P. Croxall and A.G. Wood (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom). *Ibis*, 136: 50-71, 1994 (English).

Population dynamics of black-browed and grey-headed albatrosses were studied at Bird Island, South Georgia for 17 consecutive years (1975 to 1991). Over this period almost all the grey-headed albatross colonies decreased, at an average rate of 1.8% per annum. Although the total black-browed albatross population increased (at 0.8% p.a.), 14 of the 23 colonies (including both study colonies) decreased. Black-browed albatrosses follow an annual breeding cycle, with over 80% of birds successful in rearing a chick and 75% of those failing to do so returning to breed the next year, 5 to 10% of both categories delaying one further year (even when still paired). Grey-headed albatrosses are essentially biennial, <1% of successful birds breeding the next year, 68% returning two years later, 11% the next and 5% not until the fourth year. In contrast, over 50% of birds failing to rear a chick breed the next year, 23% delaying for one further year. This largely reflects that birds failing after March do not return the next year, whereas 80% of birds failing during incubation do breed the following year. Grey-headed albatrosses show higher (39%) and more consistent breeding success than black-browed albatrosses

(29%, including four years of almost complete breeding failure); hatching success is similar in both species and fledging success is the main source of variation in black-browed albatross productivity. We link this to the dependence of this species on Antarctic krill, a variable resource largely absent in three of the four years of widespread failure. Modal age of first breeding is 10 and 12 years for black-browed and grey-headed albatrosses respectively. Overall, survival rate of juveniles to recruitment as breeding birds averaged 28 and 14% for 1960s and 1970s cohorts, respectively, of black-browed albatrosses; for grey-headed albatrosses similar values were 38 and 6%. Studies of immigration and emigration between colonies show that no breeding birds move, that philopatry of fledglings is generally high but that recruitment rates need to be increased by 1 to 3% to allow for juveniles returning to non-natal colonies. Annual survival of adults averages 93% (s.e. = 0.6) and 95% (s.e. = 0.8) for black-browed and grey-headed albatrosses respectively; for sexed birds, rates are similar for grey-headed albatrosses but 2% higher for female black-browed albatrosses. With our data, lifetime productivity would be 30% higher for black-browed albatrosses but this could be offset by a change in adult survival rate of less than 1%. The proximate reason for the population decline in studied colonies is high juvenile mortality, which has increased since the 1960s. It is likely that this reflects incidental mortality associated with fisheries (particularly entanglement in longlines for tuna and collision with net monitor cables of trawlers) but data are few and mainly circumstantial. Many differences between grey-headed and black-browed albatrosses (e.g., the former showing later sexual maturity, less frequent breeding, higher and more consistent survival) probably relate to basic differences between annual and biennial breeding. Some differences (e.g., breeding success) probably relate to differences in diet; other (e.g., in juvenile survival) may reflect different at-sea distributions. Comparisons with other species reveal species and possibly site-specific differences rather than consistent patterns for annual and biennial breeders.

WG-CEMP-93/7

A miniature storing activity recorder for seabird species. V. Afanasyev and P.A. Prince (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom). *Ornis Scand.*, 24: 243-245, 1993 (English).

An activity recorder weighing 24 g with on board data storage, designed to record data relating to seabird activity and behaviour at sea, is described. The principles, the design specification and the circuit description of the device are presented, together with data from field tests on wandering albatrosses *Diomedea exulans* to illustrate performance.

WG-CEMP-93/8

Population change in gentoo penguins *Pygoscelis papua* at South Georgia: potential roles of adult survival, recruitment and deferred breeding. J.P. Croxall and P. Rothery (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom). In: Dann, P., I. Norman and P. Reilly (Eds). *Penguin Biology*, 2: 21 pp. (English).

Data on breeding population size and breeding success in gentoo penguins at Bird Island, South Georgia from 1977 to 1992 are used, in conjunction with empirical (and some hypothetical) data on survival and recruitment rates, to model the fluctuations in breeding populations, taking account of variations introduced by good and bad years (as classified on the basis of breeding success). There is generally good agreement between observed and predicted breeding populations, except in four years, when major population changes (large decreases followed by substantial increases) occurred. Three of these years were associated with reduced availability of krill, one with very cold winter and spring conditions. Comparing model and reality indicates that deferred breeding could account for the discrepancy in one year, and for part of the differences in two other years, when mortality rates must also have been higher. In the remaining year, when

the increase in population greatly exceeded the preceding decrease, it is likely that some immigration occurred. Detailed field studies from 1987 to 1991 established that the population decline in 1988 was indeed attributable to substantial deferred breeding coupled with higher rates of adult mortality. Emigration was most unlikely to be involved; no data are available on immigration. Gentoo penguin population dynamics are disproportionately affected by the consequences of infrequent bad years; any increase, natural or artificial, in the frequency of such events might have serious consequences for population trends.

WG-CEMP-93/9
Factors affecting the growth rate and mass at weaning of Antarctic fur seal pups at Bird Island, South Georgia. N.J. Lunn, I.L. Boyd, T. Barton and J.P. Croxall (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom). *Journal of Mammalogy*, 74: 908-919, 1993 (English).

We studied the influence of sex of pup, maternal age, birth date of pup, number of foraging trips, and the mean duration of both foraging trips at-sea and nursing visits ashore on the growth and mass at weaning of pups of Antarctic fur seals (*Arctocephalusgazella*) during the austral summers from 1988 to 1990. Although growth and mass at weaning were highly correlated, they were not related to maternal characteristics in 1988 or 1989. However in 1990 there was a negative relationship between growth of pup and mean duration of foraging trips. Growth rates of male and female pups varied considerably between 1972 and 1991 and appeared to decline from 1984 through 1990. Methods used to collect and weigh the pups influenced the nature and magnitude of sex differences in estimated growth rates. Growth rates of male and female pups did not differ when weighed serially (same individuals weighed throughout lactation), but males grew faster than females when weighed cross-sectionally (different individuals weighed throughout lactation). Based on our results of pairs of mothers and pups followed over the lactation period, maternal investment was greater in sons than daughters because males were heavier at birth and older at weaning than females and not because of any differential growth between the sexes. Mothers appear to have to work longer but not harder to wean male pups than female pups. Under the favourable feeding conditions that normally exist, individual differences in the growth of pups are most likely influenced by variation in foraging efficiency of mothers.

WG-CEMP-93/10
Reproductive performance of female Antarctic fur seals: the influence of age, breeding experience, environmental variation and individual quality. N.J. Lunn, I.L. Boyd and J.P. Croxall (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom). *Journal of Animal Ecology*: 43 pp. (English).

The reproductive performance of female Antarctic fur seals was examined in relation to age, breeding experience and environmental variation over 10 consecutive years (1983 to 1992) at Bird Island, South Georgia. Age at primiparity varied from three to six years, although over 90% gave birth for the first time at three or four years. We found no evidence that age at primiparity had significant effects on subsequent reproduction but 3-year-old primiparae were less likely to be seen in subsequent years than 4-year-old primiparae which may indicate a cost, in terms of survival, for females that first give birth at an early age. Age-specific reproductive rates increased rapidly from ages two to six years, reached a peak of 0.80 at seven to nine years, remained above 0.75 until 11 years and then began to decline with increasing age. The mean duration of foraging trips in the current year (which was used as a measure of the availability of food resources) consistently improved models of the likelihood of pupping and of weaning success. When these trips were long (indicating reduced local food resources), females returned to the breeding beaches later, fewer females pupped, they gave birth to lighter pups and weaning success was reduced. The reproductive performance of older, experienced Antarctic fur seals was greater than that of younger, inexperienced animals because they had higher natality rates, gave

birth to heavier pups earlier in the season, had greater weaning success and were more likely to pup the next season.

WG-CEMP-93/11

Tooth growth in male Antarctic fur seals (*Arctocephalus gazella*) from South Georgia: and indicator of long-term growth history. I.L. Boyd and J.P. Roberts (British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom). *J. Zool., Lond*., 229: 177-190, 1993 (English).

Growth of upper canine teeth of male Antarctic fur seals (*Arctocephalus gazella*) which died of natural causes at Bird Island, South Georgia, was quantified from measurements of annual layers in longitudinal sections of teeth. Mean age at death was 7.69 ± 0.07 years and this showed a small but significant increase through the period when samples were collected (1972/73 to 1988/89). There were significant correlations between morphometrics of teeth and those of seals, suggesting that tooth growth provided an indication of body growth. Tooth growth rate was lowest in seals which died early (age four years) and increased with age at death. Changes in the growth pattern of teeth suggested that fur seals which became sexually mature early also died early. Tooth growth layers deposited in each calendar year were compared with the expected layer depth based on a linear relationship between layer depth and age at which each layer was deposited. There was significant variation in the depth of tooth growth layers deposited in different years, suggesting that growth was greater in some years than others. No trends in cohort strengths were detected, but particularly poor years for growth were closely related to years in which reproductive performance was also observed to be low. Variations in growth from 1967/68 to 1987/88 were correlated significantly ($P < 0.008$) with the Southern Oscillation Index of climatic variation.

WG-CEMP-93/12

Distributions and predator-prey interactions of macaroni penguins, Antarctic fur seals, and Antarctic krill near Bird Island, South Georgia. G.L. Hunt Jr, D. Heinemann and I. Everson (Department of Ecology and Evolutionary Biology, University of California, Irvine, Ca. 92717, USA). *Mar. Ecol. Prog. Ser.*, 86: 15-30, 1992 (English).

We studied the distributions, abundances and interactions of macaroni penguins *Eudyptes chrysolophus*, Antarctic fur seals *Arctocephalus gazella*, and their zooplankton prey, in particular Antarctic krill *Euphausia superba*, near Bird Island, South Georgia, South Atlantic Ocean, in February 1986. Simultaneous surveys of marine birds, Antarctic fur seals and Antarctic krill were conducted along a series of transects radiating from the breeding colonies of the vertebrate predators. We examined the relationships between the distributions of predators and their prey with respect to the abundance of krill in the water column and marine habitats near the colonies. Antarctic fur seals and macaroni penguins showed positive correlations with Antarctic krill density across a wide range of spatial scales. Because krill was abundant close to the colony and predator densities decreased with distance due to geometry, distance from colony was a confounding variable. When the influences of distance and direction on predator abundance were factored out, we were able to demonstrate an additional influence of Antarctic krill abundance at measurement scales between 10 and 100 km for Antarctic fur seals and for macaroni penguins at the scale of 70 to 100 km. Water depth was an important correlate of Antarctic krill and Antarctic fur seal abundances but not of the abundance of macaroni penguins. We found no evidence that the fur seals or macaroni penguins were concentrating their foraging for krill in the vicinity of the shelf-break.

WG-CEMP-93/13

Aggregation patterns of pelagic predators and their principal prey, Antarctic krill, near South Georgia. R.R. Veit, E.D. Silverman and I. Everson (Department of Zoology NJ-15, University of Washington, Seattle, Wa. 98195, USA). *Journal of Animal Ecology*, 62, 1993 (English).

We examined the spatial distributions of pelagic seabirds and fur seals near South Georgia, and asked to what extent the

distributions of these predators were influenced by the spatial distribution of their principal prey, Antarctic krill (*Euphausia superba* Dana). One novel aspect of our analysis is an explicit consideration of the separation in space between swarms of krill and aggregations of predators that feed upon krill. Our data were collected in February 1986, during a systematic shipboard survey of the waters surrounding Bird Island, South Georgia. Predator abundance was estimated visually using strip transects, and krill abundance was simultaneously estimated using a hull-mounted echosounder. We approached the difficult analytical problems associated with spatial distributions of organisms by using spatial autocorrelation and cross-correlation analysis, regression models with spatial terms, and randomisation tests. The randomisation tests involved repeated simulations of predator distributions, and subsequent estimation of spatial association between predators and prey. Pelagic birds and seals were distributed in a strikingly non-random fashion at sea near South Georgia; their distributional patterns were strongly influenced by the distribution of krill swarms. Differences between predators in their spatial distribution and in their response to krill swarms suggest interspecific differences in foraging strategies.

WG-CEMP-93/14

Selecting sampling frequency for measuring diving behaviour. I.L. Boyd (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom). *Mar. Mamm. Sci.*, 9: 424-430, 1993 (English).

The use of time-depth recorders has revolutionised knowledge of diving activity of marine animals to the point where very detailed studies of variation in diving behaviour and performance between individuals, seasons and years are possible. The degree to which the sampling interval selected affects detection of dives and statistics of diving behaviour is investigated, using data from Antarctic fur seals and southern elephant seals - representative of the extremes of diving in pinnipeds.

For both species the proportion of surface intervals recognised incorrectly (i.e., real dives artificially concatenated) increased monotonically as sampling interval increased. Effects were especially marked for fur seals: an increase in interval from 5 s to 15 s resulted in 20% of dives being unrecognised, a 38% increase in mean maximum dive depth, a 29% increase in mean dive duration and a 12% increase in duration of surface interval. In elephant seals, an increase in interval from 10 s to 100 s produced changes of 10, 5, 13 and 18% respectively. Choice of sampling interval can therefore create significant biases, especially for species with diving characteristics similar to fur seals; critical comparisons should be confined to data collected using similar sampling intervals.

WG-CEMP-93/15

CEMP indices: sea-ice data. CCAMLR Secretariat, 13 pp. (English, unpublished).

The position of the sea-ice edge around the Antarctic continent was digitised into MAPINFO GIS software from the Joint Ice Center weekly charts of sea-ice distribution. The digitised images were then used to calculate the distance of the ice edge from CEMP sites throughout the year. These data are used to construct several of the indices associated with CEMP Environmental Monitoring Method F2: Sea-ice cover as viewed from the colony.

WG-CEMP-93/16

CEMP indices and trends 1993. CCAMLR Secretariat, 21 pp. (English, unpublished).

Indices of predator reproductive status are calculated for CEMP parameters such as penguin weight, penguin chick weight, foraging duration, chick diet, and fur seal pup growth rates (Methods A1 - A9, B1 - B2 and C1 - C2) using data held at the CCAMLR Data Centre. Preliminary statistical and graphical analyses of the trends shown by the indices are also presented.

WG-CEMP-93/17

Dive bouts of chinstrap penguin at Seal Island, Antarctica. Y. Mori (Department of Zoology, Faculty of Science, Kyoto University, Kitashirakawa, Sakyo-ku, Kyoto 606-01 Japan), 17 pp. (English, unpublished).

Diving behaviour of chinstrap penguins (*Pygoscelis antarctica*) was recorded continuously by time-depth recorders from two adults breeding chicks. Their diving behaviour could be split into bouts by using log frequency method. Organisation of dive bouts does not differ within each individual between days on which dives are recorded but differed between individuals, suggesting that ecological and physiological restrictions differed between the two individuals.

WG-CEMP-93/18
Analysis of data from time-depth recorders and satellite-linked time-depth recorders: report of a technical workshop. 20 to 22 September, 1992. W. Testa, Convener (Institute of Marine Science, University of Alaska Fairbanks, Fairbanks, Ak. 99775-1080, USA), mimeo: 30 pp. (English, unpublished).

WG-CEMP-93/19
The effects of CEMP monitoring procedures on Adélie penguin colonies. J.R. Clarke and K.R. Kerry (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia). *CCAMLR Science*, (in press): 17 pp. (English).

The effects of flipper bands, implanted tags, gastric lavage and external instrument attachment on the performance of Adélie penguins were investigated over three seasons at Béchervaise Island, Mac. Robertson Land, Antarctica. The return rates of birds carrying bands and/or implanted electronic transponders were compared to investigate the contribution of bands to bird mortality and to determine rates of band and tag loss. There was a reduction in return rates of birds banded for more than one season, but no evidence of band or tag loss over a single winter. The attachment of satellite tracking devices during the incubation period or for several consecutive trips during chick rearing resulted in increased foraging trip durations and reduced breeding success. Attachment for a single foraging trip post-hatching caused no significant increase in foraging trip durations. No reduction in fledging rates of chicks from nests of stomach lavaged birds was detected over two breeding seasons. The implications of these findings for the CCAMLR Ecosystem Monitoring Program are discussed.

WG-CEMP-93/20
Report: Workshop on Researcher-Seabird Interactions, 14-18 July, 1993 Monticello, Minnesota (Draft). W.R. Fraser and W.Z. Trivelpiece, Conveners (Polar Oceans Research Group, Department of Biology, Montana State University, USA), mimeo: 56 pp. (English).

WG-CEMP-93/21
Preliminary estimates of CPUE trends for the Chilean krill fishery in Subarea 48.1 from 1987 to 1993. V. Marín (Depto. Cs. Ecológicas, Facultad de Ciencias, Universidad de Chile, Casilla 653, Santiago, Chile), 2 pp. (English, unpublished).

WG-CEMP-93/22
Antarctic pack ice seals: indicators of environmental change and contributors to carbon flux. An international research program coordinated by the SCAR Group of Specialists on Seals, mimeo: 12 pp. (English).

WG-CEMP-93/23
Preliminary study on the breeding of chinstrap and gentoo penguins at Barton Peninsula, King George Island. H.-C. Shin and S. Kim (Polar Research Center, Korea Ocean Research and Development Institute, Ansan PO Box 29, Seoul 425-600, Republic of Korea), 15 pp. (English, unpublished).

A preliminary survey of two species of penguins, chinstrap and gentoo, was made in the penguin rookery on Barton Peninsula near King Sejong Station during the 1992/93 breeding season based on CCAMLR standard methods. A total of 96 nests for chinstraps and 121 nests for gentoos were monitored to document breeding chronology and give a measure of breeding success. The nests to be monitored were selected from several locations scattered in the colony. The nests were visited at two to three day intervals and the change in the nest content were followed. Chicks were hatched out at 50% of the monitored nests on 18 December and

25 December respectively for gentoos and chinstraps. The number of chicks per nest which were raised successfully to the creche stage was used as a measure of breeding success. Of the total number of nests which had been checked from the beginning of the observation, 1.45 chinstrap chicks and 1.32 gentoo chicks were raised to the creche stage. Of the nests which were active until the conclusion of the breeding success measurement, 1.67 chinstrap chicks and 1.54 gentoo chicks reached the creche stage. The growth of chicks was measured from the beginning of January to the beginning of February. Chinstraps grew from 0.61 to 3.43 kg and gentoos from 0.56 to 4.59 kg during the measurement period. After the chicks entered the late creche stage, they were banded to determine the survival and return rates in the following years. Some suggestions for further research in this rookery are also mentioned.

WG-CEMP-93/24
Censuses analysis of *Arctocephalus gazella* on the Site of Special Scientific Interest No. 32, Livingston Island, Antarctica. A. Aguayo and D. Torres (Instituto Antártico Chileno, Luis Thayer Ojeda 814, Correo 9, Santiago, Chile). *Ser. Cient. INACH*, 43, 1993 (Spanish).

This paper examines available information on four extensive censuses of the Antarctic fur seal, *Arctocephalus gazella*, as proposed at the meeting of the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP) that took place in Viña del Mar in August 1992. These censuses were carried out at Cape Shirreff and the San Telmo Islands during the 1965/66 and 1991/92 seasons, with the aim of determining the population increase over that time.

The results indicate that over these 26 years the population increased from 50 animals counted in January 1966 to 10 768 individuals counted in January 1992. It is advisable that in future counts animals from the San Telmo Islands be considered together with the population in Cape Shirreff since they form part of one population and also because these islands belong to the Site of Special Scientific Interest No. 32, established by the Parties at the XVth Antarctic Treaty Consultative Meeting.

WG-CEMP-93/25 Rev. 1
Blue-eyed shags as indicators of changes in littoral fish populations. R. Casaux and E. Barrera-Oro (Dirección Nacional del Antártico, Cerrito 1248, 1010 Buenos Aires, Argentina), 6 pp. (English, unpublished).

The analysis of components of regurgitated casts of blue-eyed shags as an appropriate technique to monitor the abundance of littoral fish populations is presented for consideration by the Working Group for the CCAMLR Ecosystem Monitoring Program. The method is based on the very good agreement found between the composition of fish species identified by the examinations of otoliths present in regurgitated casts and those regularly sampled with trammel nets in the same area. A list of publications supporting this proposal is also provided.

WG-CEMP-93/26 Rev. 1
The diet of the blue-eyed shag, *Phalacrocorax atriceps* Bransfieldensis at the west Antarctic Peninsula. R. Casaux and E. Barrera-Oro (Dirección Nacional del Antártico, Cerrito 1248, 1010 Buenos Aires, Argentina), 13 pp. (English, unpublished).

The diet of the Antarctic blue-eyed shag *Phalacrocoraxatricepsbransfieldensis* was analysed based on the identification of prey items in 50 regurgitated casts collected at Duthoit Point, Nelson Island, in February 1991. Benthic organisms, chiefly fish, were found to be the main components. Fish remains occurred in 100% of the casts and represented 68% by number and 90% by weight of the total number of prey items. From a total of 2 112 otoliths found, 1 176 fish specimens were identified belonging to four demersal-benthic species: *Harpagifer antarcticus*, *Notothenia neglecta*, *Nototheniops nudifrons* and *Trematomus newnesi*. For populations of these species in the study area, equations to estimate total length and weight of fish from otolith length are provided. *H. antarcticus* was the most frequently found species (92% by

number) and *N. neglecta* were the most important species (66% by weight). The number of cephalopod beaks found in the samples indicate that benthic octopods were the second important group in the diet of blue-eyed shags. Other invertebrates such as polychaetes, gastropods, bivalves and crustaceans were found only occasionally. The presence of algae and stones in the casts are also discussed and it is suggested that they were ingested accidentally. Our results are in general agreement with those published for other Antarctic localities which indicate that *P. atriceps* is a benthic coastal feeder, with fish as its main food item.

WG-CEMP-93/27
AMLR 1992/93 field season report: Objectives, accomplishments and tentative conclusions. *Administrative Report LJ-93-08,* Southwest Fisheries Science Center, La Jolla, Ca., USA, 1993, 109 pp. (English).

WG-CEMP-93/28
The autumn foraging range of Adélie penguins from Béchervaise Island, Antarctica. K.R. Kerry and J.R. Clarke (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia), 10 pp. (English, unpublished).

Abstract not available.

WG-CEMP-93/29
Southern Ocean GLOBEC. Chairman of the SCAR Sub-committee on Bird Biology, 11 pp. (English, unpublished).

Working Group on Fish Stock Assessment

WG-FSA-93/5
Analyses performed at the 1992 Meeting of the Working Group on Fish Stock Assessment. D.J. Agnew (CCAMLR Data Manager, 25 Old Wharf, Hobart, Tasmania 7000, Australia), 37 pp. (English, unpublished).

WG-FSA-93/6 Rev. 1
Cross-sectional structure and validation of the timing of annulus formation in otoliths of the Antarctic fish *Notothenia coriiceps* Richardson (Nototheniidae). J.R. Ashford and M.G. White (British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom). *Cybium*, 17 (2): 153-163, 1993 (English).

To validate the timing of annuli in otoliths of immature *Notothenia coriiceps* Richardson, a time-series of samples was taken over a complete year. Light and scanning electron microscopy (SEM) techniques were used to examine the structure of sectioned otoliths. Six growth regions were identified in the otolith sections and micro-increments were also evident. The timing of growth and annual nature of annuli revealed by SEM were demonstrated. Annuli revealed by SEM and light microscopy techniques were shown to correspond, supporting the hypothesis that annuli visible by using light microscopy represent one year. Using SEM the potential errors due to light illumination artefacts and the pseudo-hyaline features could be avoided.

WG-FSA-93/7
A method for preparing large numbers of otolith sections for viewing by scanning electron microscope. J.R. Ashford, K. Robinson and M.G. White (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 11 pp. (English, unpublished).

In an investigation of the age structure of the population of *Notothenia coriiceps* Richardson at the South Orkney Islands, Antarctica, the microstructure of otoliths was examined. Progress is reported on a method used for processing large numbers of otoliths using a scanning electron microscope (SEM). Compared with previous SEM techniques, which normally prepare otoliths individually for viewing, this allowed larger sample sizes to be examined. Compared with similar light microscope techniques, this method gave

enhanced resolution particularly for discerning edge structures, and thus may facilitate present methods of ageing fish populations, especially for fishery work in the Antarctic where otoliths are often small and difficult to interpret using conventional techniques.

WG-FSA-93/8 Rev. 1
By-catch of juvenile Antarctic fish from krill (*Euphausia superba* Dana) fisheries in the South Georgia area, in 1992. E.A. Pakhomov and S.A. Pankratov (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine). *CCAMLR Science*, (in press): 18 pp. (English).

Discussed in this paper is an investigation on juvenile Antarctic fish caught during krill fishing by the trawler *Grigory Kovtun* in the region of the South Georgia Islands during the period May to June 1992. Two species were predominant in the by-catches: *Champsocephalus gunnari* and *Nototh*eniops *larseni*. The frequency of occurrence of juvenile fish was 18.2% when considering all krill tows and 45.5% when only tows made in shelf waters were considered. Juvenile fish abundance, normalised to one tonne of krill, ranged from 700 to 18 900 individuals. In the case of *C. gunnari*, average values were 966 ± 225 ind./1 tonne krill and 2434 ± 579 ind./1 tonne krill for all trawls and for shelf trawls, respectively. Similarly, for *N. larseni* the corresponding averages were 557 ± 103 and 1 388 ± 248. The mean standard length of *C. gunnari* was 73 to 80 mm in May to June and 97 mm in late July. The mean growth rate of this species over this period is estimated at 0.35 mm per day. In May to June *N. larseni* juveniles were represented by fingerlings (mean length of 42 to 47 mm) and yearlings (72 to 73 mm). In late July the mean length of fingerlings increased to 50 mm. The mean daily length increase in *N. larseni* is estimated at 0.09 mm. Juveniles of *Euphausia superba* dominated by mass the diet of both *C. gunnari* fingerlings and *N. larseni* yearlings. The food bolus in *N. larseni* fingerlings consisted mainly of Chaetognatha, Copepoda and furcilia of *Thysanoessa* spp. According to the results obtained from krill fisheries of the Ukrainian fleet in the South Georgia area (35 500 tonnes within the period from May to August) the total elimination of *C. gunnari* and *N. larseni* is estimated to be 34.3 ± 8.0 and 19.8 ± 3.7 million individuals, respectively.

WG-FSA-93/9
Aspects of the distribution and interannual variations in larval fish assemblages at South Georgia, Antarctica. M.G. White (British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom), 7 pp. (English, unpublished).

The Antarctic fish fauna is relatively impoverished with fewer than 300 species recorded from the whole Southern Ocean. Demersal forms predominate but many of these have extended early life histories as pelagic larval and juvenile phases. Only 30 larval stages of the 103 fish species occurring at South Georgia have been identified but these represent all of the dominant and economically important forms. The larval stages occur in succession throughout the year suggesting niche separation to avoid competition. The ichthyoplankton distribution exhibits a marked division between oceanic and neritic coincident with the continental shelf-break. The neritic larval assemblages are more diverse and abundant with greater proximity to the coast. Studies on ichthyoplankton temporal distribution in the fjord, East Cumberland Bay, and the adjacent shelf areas at South Georgia show both large seasonal variations and marked interannual variations in species composition and abundance. The mechanisms controlling the larval fish assemblages are not known but the observed interannual variations must reflect interactions within the neritic ecosystem and so have important implications for subsequent recruitment at South Georgia. By-catch of young fish during the krill fishery further interfere with the recruitment success and may delay the recovery of fish populations from over-exploitation by commercial-scale fin-fisheries over the past 30 years.

WG-FSA-93/10
A suggested bottom trawling survey on the Ob and Lena Banks. Ukraine, 5 pp. (English, unpublished).

WG-FSA-93/11
Some problems of water flow through the trawl codend. W. Moderhak (Sea Fisheries Institute, Kollataja Str. 1, 81-332, Gdynia, Poland), 6 pp. (English, unpublished). Submitted to ICES, Fish Capture Committee, Document C.M. 1993/B:11.

The paper presents calculations of water flow velocity through the codend under the assumption that the flow is uniform and equal on its entire surface. The calculations were made for different ratios of codend length to its diameter, mesh bar length to mesh bar perimeter, and for various mesh opening coefficients. The results obtained were analysed with regard to the impact of flow velocity on hydrodynamic forces opening the codend. These forces, different for different codend constructions, have great impact on selection properties. The greater velocity of water outflow results in the wider opening of the codend meshes and a greater probability of undersized - juvenile fish escaping. An idea of a new setup of meshes in the codend, changing the effect of operation of longitudinal forces (hydromechanical drag forces) was presented. Closing forces become mesh opening forces, which should ensure greater mesh opening coefficient and better selectivity of the codend of the trawl.

WG-FSA-93/12 Rev. 1
Submission of plans for conducting finfish surveys in the Convention Area. CCAMLR Secretariat, 4 pp. (English, unpublished).

WG-FSA-93/13
Size variations associated with abundance changes in juvenile *Notothenia rossii*, observed at Potter Cove, South Shetland Islands, since the end of the fishery in the area. E. Marschoff and E. Barrera-Oro (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina), 12 pp. (English, unpublished).

Samples of fish collected from 1983 to 1992 at Potter Cove, King George Island, South Shetland Islands, are used to study the decline in abundance previously reported for fjord *Notothenia rossii*, in association with changes in the size and age structure of the juvenile population. Mean length increased in correlation with poor recruitment to inshore waters and sharply decreased as stronger year classes entered the cove. In comparison, *Notothenia neglecta*, a non-commercially fished species with similar ecological habits in the fjords, showed little variation around the expected overall mean size, without any significant trend. Thus, the changes in the juvenile *N. rossii* population are not thought to be caused by local factors, but to be related to the operations of the commercial fishery during the late seventies in the area, mainly around Elephant Island. Data from 1991 and 1992 might be indicating the beginning of a recovery of the *N. rossii* population in Potter Cove.

WG-FSA-93/14
The early life history and the onset of scale formation in the Patagonian toothfish, *Dissostichus eleginoides* Smitt, 1898. K.-H. Kock (Institut für Seefischerei, Palmaille 9, D-22767 Hamburg, Germany), 16 pp. (English, unpublished).

Patagonian toothfish, *Dissostichus eleginoides*, spawn from July to September. Hatching is likely to occur in October/November. Scales do not start to form before the fish are 64 to 74 mm long. It is far from being resolved when the first 'winter ring' is formed. Available information suggests that the annulus may not be completed before spring. Length composition of fish <40 cm exhibited distinct modes. These modes have been tentatively attributed to age classes. This suggests that *D. eleginoides* grow 7 to 11 cm annually.

WG-FSA-93/15
The *Dissostichus eleginoides* fishery in Division 58.5.1 (Kerguelen Islands). G. Duhamel (Muséum national d'histoire naturelle, laboratoire d'ichtyologie générale et appliquée, 43 rue Cuvier, 75231 Paris, Cedex 05, France), 15 pp. (English, unpublished).

The Kerguelen trawl and longline fisheries for *Dissostichus eleginoides* are analysed in the light of knowledge of the life cycle of the species. Catches reach a similar cumulative value to those in the

South Georgia subarea (Subarea 48.3). All data have been analysed separately by fishing grounds and fishing methods and the tendencies from the length frequency distribution and an index of abundance compared.

WG-FSA-93/16
The Patagonian toothfish (*Dissostichus eleginoides*) fishery on the Kerguelen Island Shelf. V.G. Prutko (YugNIRO, 2 Sverdlov Street, Kerch 334500, Crimea, Ukraine), 12 pp. (Russian, unpublished).

Results of the Ukrainian commercial fishery in the 1992/93 season for Patagonian toothfish in the Kerguelen Islands area are presented and compared with the corresponding data from of the preceding 1991/92 fishing season. Catches per fishing effort (for an hour of trawling) in the 1992/93 season increased by 2.6 to 3.8 tonnes, while during the 1991/92 season they did not exceed 1 to 2 tonnes. Size composition analysis of fish groupings removed from different depths in 1992/93 showed the absence of statistically significant changes in demographic structure of the Patagonian toothfish population as compared with the preceding fishing season. In our opinion, the data presented indicate that the catch taken in the preceding years did not exert any considerable influence on the Patagonian toothfish stock status and does not exceed TAC.

WG-FSA-93/17
On the status of mesopelagic fish (Myctophidae) in the southern ocean ecosystem. A.N. Kozlov (VNIRO, 17a V. Krasnoselskaya Street, Moscow 107140, Russia). *CCAMLR Science*, (in press): 12 pp. (English).

Analysis and synthesis of Russian and foreign research into the trophic relationships of myctophids demonstrate that this group of mesopelagic fish plays a significant role in the community of Southern Ocean marine organisms. Myctophids have the trophic status of zooplankton-eaters. The large amount of meso- and macroplankton consumed by myctophids determines their high abundance and biomass. Thus, according to a preliminary estimate, the yearly consumption of zooplankton by *Electrona carlsbergi*, the most abundant species of myctophid, ranges from 196 to 364 million tonnes. Myctophids occupy the third level in the Southern Ocean trophic system and are consumers of the second order. Myctophids play a major role as producers, guaranteeing the production of organisms higher up the food chain (certain species of squid, notothenioids, seabirds and mammals). The large deepwater squid *Mesonychotheuthis hamiltoni* consumes approximately 48 to 57 million tonnes of myctophids each year. A summary table of the trophic relationships of myctophids is presented, based on general patterns of energy transfer from one trophic level to the next.

WG-FSA-93/18
The migration patterns of *Electrona carlsbergi* (Tåning, 1932). A.N. Kozlov (VNIRO, 17a V. Krasnoselskaya Street, Moscow 107140, Russia). *CCAMLR Science*, (in press): 28 pp. (English).

On the basis of analyses and review of published data on the biology and distribution of *Electrona carlsbergi*, as well as of the hydrological patterns of the Southern Ocean - especially concerning the structure and spatial variation of the Antarctic Circumpolar Current (ACC) - this paper describes possible ways and means (mechanisms) by which this species carries out meridional migration across various frontal zones. The yearly transport of *E. carlsbergi* into the waters of the Southern Polar Frontal Zone (SPFZ) occurs regularly although its intensity changes with time. The densest concentrations are observed here in the spring-summer period (November to February) when zooplankton, the main food component for *E. carlsbergi*, is undergoing rapid development. In various areas of the SPFZ and in all sectors of Antarctica *E. carlsbergi* is represented by immature specimens 7 to 8 cm in length and 2 years of age, indicating dominance by a single cohort. Moreover, a very similar size composition in the SPFZ is evident from both a seasonal and interannual point of view. The proportion of immature specimens in the sub-Antarctic zone, classified as a breeding area, decreases from 20 to 40%, while the

number of mature specimens 8.5 to 11 cm in length and 3 to 5 years old increases. Based on the dynamic processes of the Southern Ocean and taking account of the locations of spawning areas and distribution of *E. carlsbergi* in the early stages of its life cycle, a theory has been put forward concerning the presence in the notal region and various sectors of Antarctica of several reproductive zones coinciding with areas of large-scale disruptions to the zonality of transport of waters by the ACC under the influence of topogenic factors. This paper examines the fate of large aggregations (in terms of biomass) of *E. carlsbergi* transported beyond the notal region and the possibility of a part of the population returning to the reproductive zone. There is a strong likelihood that *E. carlsbergi* migrates from the SPFZ into the sub-Antarctic zone in areas where eddy formations occur periodically in the ACC system. These eddies play an important role in the meridional transport of waters between frontal zones. The paper also discusses questions of the within-species structure of *E. carlsbergi* and an ecological assessment of the impact of fishing on the ecosystem of the open waters of Antarctica.

WG-FSA-93/19
Estimates of seabed areas within selected depth ranges. E.N. Sabourenkov, A. Blake and D.J. Agnew (CCAMLR Secretariat, 25 Old Wharf, Hobart, Tasmania 7000, Australia), 7 pp. (English, unpublished).

WG-FSA-93/20
Estimating confidence intervals for fish stock abundance estimates from trawl surveys. W.K. de la Mare (Australian Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia). *CCAMLR Science*, (in press): 8 pp. (English).

A method is developed for calculating asymptotic confidence intervals for trawl surveys using the swept area method, using likelihood ratios from Aitchison's delta distribution. Simulation tests of the method show that unbiased estimates of the density and biomass can be obtained and that the estimated confidence intervals have close to the nominal coverage probability. Performance deteriorates in cases where few of the hauls contain fish, and the coefficient of variation is high. The lower confidence bound appears to be more reliable than the upper.

WG-FSA-93/21
Status of the *Dissostichus eleginoides* stock in Subarea 48.3 and adjacent zones. C.A. Moreno and P.S. Rubilar (Instituto de Ecología y Evolución, Universidad Austral de Chile, Casilla 567, Valdivia, Chile), 24 pp. (Spanish, unpublished).

This paper presents a summary of data reported by the Chilean longlining fleet fishing in international waters in 1992. Catch and length distribution data are also analysed. A study of the biomass of *Dissostichus eleginoides* in Subarea 48.3 was undertaken using part of the above information; this showed a reduction in the biomass from 33 717 tonnes in 1991/92 to 27 167 tonnes in 1992/93. The information is considered in relation to various management regime options which are intended to conserve the *D. eleginoides* stock.

WG-FSA-93/22
Proposal for an experimental crab fishery in Subarea 48.3. G. Watters (Southwest Fisheries Center, 8604 La Jolla Shores Drive, La Jolla, Ca. 92038, USA), 11 pp. (English, unpublished).

An experimental management strategy is proposed for the *Paralomis spinosissima* fishery around South Georgia. The strategy is designed to answer specific, *a priori* questions about the population dynamics of *P. spinosissima*, and consists of three phases to be conducted over a period of two years/fishing seasons. Phase 1 occurs at the start of the first fishing season and is a 'survey' regime where fishing effort is artificially distributed over a large area. After Phase 1, normal fishing operations continue until the TAC for the first fishing season is attained. Phase 2 starts at the beginning of the second fishing season and is a series of three depletion experiments conducted in local areas. After Phase 2, normal fishing operations are conducted until CCAMLR initiates closure of the second fishing season. Phase 3 commences just prior to the close of the second fishing season. In

this phase, fishing effort is redirected to the three local areas depleted during Phase 2. The experimental management strategy is designed for application on a per vessel basis (i.e., vessels may not 'cooperate' to complete phases - each vessel must complete all three phases on its own). The strategy is more powerful when multiple vessels participate in the fishery, but valuable information can still be obtained if only one vessel participates.

WG-FSA-93/23
Using production models to assess the stock of *Paralomis spinosissima* around South Georgia Island. G. Watters (Southwest Fisheries Center, 8604 La Jolla Shores Drive, La Jolla, Ca. 92038, USA), 19 pp. (English, unpublished).

Four production models were fitted to a time series of daily catch-per-unit-effort (CPUE) data from the 1991/92 fishery for *Paralomis spinosissima* around South Georgia Island. The four models considered recruitment in different ways. Model 1 contained a linear recruitment function; Model 2 had constant recruitment; Model 3 contained a Beverton-Holt recruitment function, and Model 4 used a Ricker recruitment function. The best fitting model was Model 1. Model 1 had three parameters: an estimate of initial abundance (N_o), an estimate of the scaling coefficient relating abundance to CPUE (q), and a recruitment parameter (a). The generalised likelihood ratio was used to place 95% confidence bounds around the parameter estimates from Model 1. These confidence bounds were very precise: $Pr(240928 \leq N_o \leq 255374) \approx 0.95$; $Pr(8.56 \times 10^{-7} \leq q \leq 9.49 \times 10^{-7}) \approx 0.95$; and $Pr(0.00804 \leq a \leq 0.00890) \approx 0.95$. Assuming that fishery removals should not be greater than the number of crabs that recruit to the fishery during the course of a fishing season, Bayesian statistics were used to evaluate alternative levels of a Total Allowance Catch (TAC) for the 1993/94 crab fishery. An optimal TAC was determined to be about 300 tonnes. However, this TAC was conditional on the 1991/92 fishery data, and this data was limited to small temporal and spatial scales (about 4 months and 3 600 n miles^2). To extrapolate the estimated TAC to longer time periods information about the frequency and duration of the moulting/mating event is required. To extrapolate the estimated TAC to larger areas (i.e., to estimate a TAC for all South Georgia), it was necessary to determine whether growth or movement was predominantly responsible for recruitment. Monthly length frequency histograms were constructed and showed that growth was probably not the primary recruitment mechanism. Since movement may be important to the recruitment process, a TAC for all of South Georgia cannot be estimated by simple multiplication.

WG-FSA-93/24
Variations in the diet composition and feeding intensity of mackerel icefish (*Champsocephalus gunnari*) at South Georgia (Antarctica). K.-H. Kock, S. Wilhelms, I. Everson and J. Gröger (Institut für Seefischerei, Palmaille 9, D-22767 Hamburg, Germany), 43 pp. (English, unpublished).

The diet composition and feeding intensity of mackerel icefish (*Champsocephalus gunnari*) around Shag Rocks and South Georgia Island was analysed from c. 8 700 stomachs collected in January/February 1985, January/February 1991 and January 1992. Main prey items were krill (*Euphausia superba*), the hyperiid *Themisto gaudichaudii*, mysids (primarily *Antarctomysis maxima*) and in 1985 also *Thysanoessa* species. The proportion of krill and *Themisto* in the diet varied considerably between the three seasons, whereas the proportion of mysids in the diet remained fairly constant. Krill, which has a high energy content, appears to be the preferred diet. In years of krill shortage, such as in 1991, krill is replaced by the ubiquitous *T. gaudichaudii.* The occurrence of krill in the diet in 1991 was one of the lowest within a 28-year period of investigation. Variation in food composition between sampling sites was high. This high variation can be primarily attributed to differences in prey availability, but was much less influenced by prey size selectivity due to differences in length composition of fish between sampling sites.

Feeding intensity varied considerably between seasons. The proportion of empty stomachs was uncommonly high and stomach content weight was uncommonly low in 1991 in a period when energy-rich food is needed for the final maturation of the gonads. The proportion was highest in 1992. At the same time, an unusually high proportion of sexually mature fish showed no signs of the gonad development necessary leading up to spawning in that season. It was hypothesised that like in other non-Antarctic fish species the shortage of suitable food, such as krill, may have forced the fish to sacrifice gonad maturation in order to maintain body size.

WG-FSA-93/25
On the taxonomy of the *Lepidonotothen squamifrons* group (Pisces, Perciformes, Notothenioidei). R. Schneppenheim, K.-H. Kock, G. Duhamel and G. Janssen (Klinik für Allgemeine Pädiatrie, Christian-Albrechts-Universität Kiel, Schwanenweg 20, D-24105 Kiel 1, Germany), 22 pp. (English, unpublished).

The *Lepidonotothen squamifrons* group has been described as comprising three species: *L. squamifrons* (Günther, 1880), *L. kempi* (Norman, 1937) and *L. macrophthalma* (Norman, 1937). All three species closely resemble each other and morphological and meristic characters utilised to distinguish between species are overlapping. Enzyme electrophoresis of enzyme polymorphisms has been applied to specimens morphologically recognised as *L. squamifrons* and *L. kempi* from various localities in the Scotia Arc region and the Kerguelen Islands to assist in clarifying their taxonomic status. Results suggest that both 'species' represent only populations of one species. Evidence is presented that the third species of the group, *L. macrophthalma*, may also be identical with *L. squamifrons* and that the *L. squamifrons* 'group' comprises only one species, *L. squamifrons* (Günther, 1880). We found no statisticallysignificant difference in allele frequencies between specimens from geographically isolated shelf areas of the Scotia Arc. This does not necessarily mean that the Scotia Arc region is inhabited by a single population but suggests some gene flow between shelf areas via larval drift for which evidence exists.

WG-FSA-93/26
Timescale of ovarian maturation in *Notothenia coriiceps* (Richardson); evidence for a prolonged adolescent phase. I. Everson (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom). *Journal of Fish Biology*, 45: 18 pp., 1994 (English).

Ovarian maturation in *Notothenia coriiceps* is known to include a period during which yolk deposition begins to take place. This 'adolescent' phase was thought originally to last for about one year. The results from a two year study at Signy Island indicate that this adolescent phase lasts for about four years. There is also some evidence to indicate that not all sexually mature fish spawn each season. Two reproductive strategies are considered, one where adverse conditions are accompanied by a failure to spawn and an alternative where fecundity is controlled by the number of small oocytes which ripen.

WG-FSA-93/27
Distribution of catches of *Dissostichus eleginoides* in Subareas 48.3 and 48.4, 1992/93 season. CCAMLR Secretariat, 10 pp. (English, unpublished).

WG-FSA-93/28
UK scientific research cruise for finfish: Subarea 48.3. United Kingdom, 1 pp. (English, unpublished).

WG-FSA-93/29
Revision of the commercial catch-at-age of the Antarctic icefish *Champsocephalus gunnari* over the period 1976/77 to 1990/91. G.B. Parkes (Renewable Resources Assessment Group, Centre for Environmental Technology, Imperial College, 8 Prince's Gardens, London SW7 1NA, United Kingdom), 8 pp. (English, unpublished).

A revision of the calculation of total international catch-at-age of *Champsocephalus gunnari* over the period 1976/77 to 1990/91 is presented. This revision uses iterative application of two

age/length keys to obtain age distributions, according to a method described by Kimura and Chikuni (1987). It is proposed that the revised catch-at-age be used for future assessment of the *C. gunnari* fishery at South Georgia using VPA.

Workshop on the Management of the Antarctic Crab Fishery

WS-CRAB-93/5
Management and assessment options for the crab fishery around South Georgia. M. Basson and D.D. Hoggarth (Renewable Resources Assessment Group, Imperial College, 8, Prince's Gardens, London SW7 1NA, United Kingdom). *CCAMLR Science*, (in press): 10 pp. (English).

This paper briefly looks at management and assessment options for crab fisheries in general. Most lithodid crab fisheries are managed by a minimum of regulations known as the 'size-sex-season' approach. Some crab fisheries may be further managed by a range of catch and/or effort controls. The requirements of Article II of the CCAMLR Convention and the characteristics of this new fishery all point to a conservative approach to harvesting. There is a need for catch and effort controls in addition to 'size-sex-season' regulations. Implementation of such a management approach requires information on the biology, particularly the growth and life-history, of the species. Estimates of abundance and productivity are also required. Depletion methods, which require catch and effort data, could be used to estimate abundance.

WS-CRAB-93/6
Data required for implementation of management options. M. Basson and J.R. Beddington (Renewable Resources Assessment Group, Imperial College, 8, Prince's Gardens, London SW7 1NA, United Kingdom), 2 pp. (English, unpublished).

This document summarises the data requirements for the implementation of the management options identified by Basson and Hoggarth (WS-CRAB-93/5). In addition to information on growth and the life-history of *P. spinosissima*, catch and effort data on appropriate spatial and temporal scales are required. Information on rhizocephalan parasitism is also essential, as highlighted by Basson (WS-CRAB-93/7).

WS-CRAB-93/7
A preliminary investigation of the possible effects of rhizocephalan parasitism on the management of the crab fishery around South Georgia. M. Basson (Renewable Resources Assessment Group, Imperial College, 8, Prince's Gardens, London SW7 1NA, United Kingdom). *CCAMLR Science*, (in press): 21 pp. (English).

Preliminary results from the first fishing trip for crabs in Subarea 48.3 indicated relatively high levels of infection of a rhizocephalan barnacle. This parasite has been found to infect other lithodid crab species. The parasite inhibits the growth and reproductive capability of its host: in particular, males are castrated and therefore no longer form part of the spawning stock. Current size regulations for the fishery in Subarea 48.3 implies that very few infected animals will be harvested. This implies that the prevalence of the parasite cannot necessarily be expected to decline under harvesting. A simple mathematical model aimed at capturing the essential features of the population dynamics of the host-parasite system is constructed. The model is used to explore the possible effects of different harvesting strategies on the prevalence of the parasite and the crab spawning stock. The results highlight the fact that parasitism may be an important factor in the management and underlines the necessity for collecting more data with regard to parasitism.

WS-CRAB-93/8
Uncertainty, resource exploitation, and conservation: lessons from history. D. Ludwig, R. Hilborn and C. Walters (Departments of Mathematics and Zoology, University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z2. *Science*, 260: 17, 35-36, 1993 (English).

Abstract not available.

WS-CRAB-93/9

Modelling crustacean fisheries: effects of parasites on management strategies. A.M. Kuris and K.D. Lafferty (Department of Biological Sciences, University of California, Santa Barbara, Ca. 93106, USA). *Can. J. Fish. Aquat. Sci.*, 49: 327-336, 1992 (English).

The reproductive performance of commercially important crustaceans may be considerably affected by symbiotic nemertean egg predators and parasitic castrators. Because these parasites commonly affect only females or feminise males, they may be protected by management practices that protect females. To manage a parasitised stock, we suggest that strategies should vary depending on the recruitment dynamics of both host and parasite. For a certain spatial scale, recruitment to a population may be 'open' or 'closed' depending on the behaviour of planktonic larvae, the duration of these planktonic stages, and the flush rate of the environment of the adult host. Both hosts and parasites may have open or closed larval recruitment. We developed mathematical models to investigate the impact of protection of females on a hypothetical fishery for different combinations of host and parasite recruitment dynamics. The models suggest that the common practice of releasing females is not advantageous when a fishery is affected by a parasite. Retaining females in the catch is preferable in most cases. Treating or culling infected females may be advisable when host recruitment is closed.

WS-CRAB-93/10

Change-in-ratio and index-removal methods for population assessment and their application to snow crab (*Chionoecetes opilio*). X. Xu, E.G. Dawe and J.M. Hoenig (Science Branch, Department of Fisheries and Oceans, PO Box 5667, St. John's, Newfoundland, Canada A1C 5X1), 24 pp. (English, unpublished).

Change-in-ratio and index-removal estimators are presented in a general form suitable for fisheries studies. We also show how to combine the two approaches in a single estimator. It is necessary to sample the population before and after the fishery, and to determine the total harvest and its composition, in order to use these methods. We use the methods to estimate the population of legal-size snow crabs (*Chionoecetes opilio*) in St. Mary's Bay, Newfoundland, before and after the fishery, and to estimate the catchability coefficient and exploitation rate. It is also possible to estimate the abundance of pre-recruits but this requires the assumption of equal catchability of all animals, a condition that may not be met. These methods have been largely neglected by fishery scientists; however, they seem to be ideally suited for studies of many populations of large crustaceans.

WS-CRAB-93/11

Relative selectivity of four sampling methods using traps and trawls for male snow crabs (*Chiocoecetes opilio*). J.M. Hoenig and E.G. Dawe (Science Branch, Department of Fisheries and Oceans, PO Box 5667, St. John's, Newfoundland, Canada A1C 5X1), 18 pp. (English, unpublished).

Catch rate and catch composition of male snow crabs were compared for four sampling methods. These methods were: (i) large-meshed commercial traps; (ii) small-meshed traps; (iii) bottom trawl deployed during the day; and (iv) bottom trawl deployed at night. Catches were characterised in terms of crab body sizes, shell conditions, and claw allometry. We concluded that: (i) mean and modal size of crabs captured in large-meshed traps was larger than those captured in small-meshed traps which, in turn, were larger than those caught in the trawl; the size of crabs caught in the trawl at night was larger than those caught during the day; (ii) large-clawed crabs predominated in the catches from traps whereas small-clawed animals predominated in the trawl catches; (iii) soft-shell crabs were more common in trawl than in trap catches whereas old-shell crabs were more common in trap than in trawl catches; (iv) mean size of the crabs caught increased with depth for all sampling methods, but especially so for traps; and (v) catch-per-unit-effort for both large- and small-clawed crabs increased with depth for all sampling methods.

WS-CRAB-93/12
Growth per moult of male snow crab *Chionoecetes opilio* from Conception and Bonavista Bays, Newfoundland. D.M. Taylor and J.M. Hoenig (Science Branch, Department of Fisheries and Oceans, PO Box 5667, St. John's, Newfoundland, Canada A1C 5X1). *Fishery Bulletin,* 88: 753-760, 1990 (English).

Over 6 000 male snow crabs were tagged during a six-year period in Conception Bay, Newfoundland, in order to estimate the increase in size at the time of moulting. Ninety-two animals were recaptured which had useable information on growth increments. Based on the amount of growth, we hypothesised that 20 of these had moulted once while the remainder moulted twice. Two lines of evidence support this interpretation. First, animals in the group presumed to have moulted twice were at liberty on average twice as long as those presumed to have moulted once. Second, a regression line fitted to data on single-moulters predicted the size after two moults in close agreement with a regression line fitted to data on double-moulters. A nonlinear regression model was developed to estimate the parameters of the relationship between post- and pre-moult sizes using the combined data set for single and double moulters. The method was also generalised to account for a quadratic relationship between post- and pre-moult size. For crabs in the size range 80 to 110 mm carapace width, the predicted size after moulting in millimetres is equal to 7.398 + 1.038 x pre-moult size. A similar study conducted in Bonavista Bay, Newfoundland, yielded growth information for 18 animals. The moult increments appear similar to those observed from Conception Bay.

WS-CRAB-93/13
Leslie analysis of commercial snow crab trap data: a comparative study of catchability coefficients. J.M. Hoenig, E.G. Dawe, D.M. Taylor, M. Eagles and J. Tremblay (Department of Fisheries and Oceans, PO Box 5667, St. John's, Newfoundland, Canada NF A1C 5X1), 8 pp. (English, unpublished). Submitted to ICES, Shellfish Committee ref. Statistics Committee, C.M. 1992/K:34.

If we could determine the relationship between catch rates in a trap survey and absolute population size, then we could estimate the standing stock of snow crabs before the fishing season from a survey conducted with traps. One way to calibrate the catch rates is to examine available historical Leslie analyses of commercial catch data obtained over several years and quantify the relationship between catch rate at the beginning of the season and the corresponding population estimate obtained by the Leslie analysis. Data from several different regions can be made comparable by expressing catches and efforts on an areal basis. Results obtained from data from Newfoundland and Nova Scotia suggest that this approach may be feasible.

WS-CRAB-93/14
Commercial vessel CCAMLR subsample logbook. USA, 3 pp. (English, unpublished).

WS-CRAB-93/15
Commercial vessel daily activity logbook. USA, 6 pp. (English, unpublished).

WS-CRAB-93/16
Commercial vessel fishing effort logbook. USA, 5 pp. (English, unpublished).

WS-CRAB-93/17
Graphical presentations of preliminary data collected aboard the FV *Pro Surveyor* in 1992. USA, 10 pp. (English, unpublished).

The figures presented in this packet were generated from preliminary data collected during the 1991/92 crab fishing season in Subarea 48.3. Figures 1 through 5 show the spatial and temporal distribution of the catch. The spatial distribution of the catch is reported for 0.5° x 1° longitude squares. The temporal distribution of the catch is reported for CCAMLR's 10-day reporting periods. Figures 6 through 10 are time series of length frequency histograms for sub-samples of the catch taken in each 0.5° x 1° square where fishing occurred. No analyses or conclusions have been drawn from these figures at this time.

WS-CRAB-93/18

Biology of blue crab, *Portunus trituberculatus* in the Yellow Sea and the East China Sea. J.U. Lee and D.-H. An (National Fisheries Research and Development Agency, 65-3 Shirang-ri, Kijang-up, Yangsan-gun, Kyongsangnam-do, 626-900, Republic of Korea), 8 pp. (English, unpublished).

Abstract not available.

WS-CRAB-93/19

Notes on the presence of *Paralomis spinosissima* and *Paralomis formosa* in the catches the 'Antartida 8611' cruise. L.J. López Abellán and E. Balguerías (Instituto Español de Oceanografía, Centro Oceanográfico de Canarias, Ctra. San Andrés s/n, Santa Cruz de Tenerife, España). *CCAMLR Science*, (in press): 11 pp. (English).

This paper provides information on Antarctic crabs obtained during the Spanish cruise 'Antartida 8611', which was carried out in 1986 and covered the shelf around all the archipelagos in the Scotia Sea. A total of 345 hauls was conducted; 29 took place around Shag Rocks, 104 around South Georgia, 8 around the South Sandwich Islands, 93 around the South Orkneys, 46 around Elephant Island and 65 around the South Shetlands. Depths surveyed ranged from 63 m down to 643 m.

The two species of crabs of genus *Paralomis* (*P. spinosissima* and *P. formosa*) were found only around Shag Rocks and South Georgia, in the whole area surveyed. *P. spinosissima* was caught from seven hauls of the 29 conducted at Shag Rocks and from 20 of the 104 hauls made at South Georgia. *P. formosa* was caught twice, once in each zone. The bathymetric distribution of *P. spinosissima* ranged from depths of 160 to 627 m and that of *P. formosa*, far less frequent in the catches, from depths of 320 to 350 metres.

The field observations show the absence of these two species in the southern archipelagos of the Scotia Arc (South Orkney, Elephant Island and South Shetland) at least in the depth range surveyed. The absence of both species from hauls conducted in underwater canyons and the qualitative composition of the fish fauna usually accompanying them in the catches suggest that *P. spinosissima* and *P. formosa* tend to concentrate in areas close to the shelf break where environmental conditions show some degree of stability.

WS-CRAB-93/20

Demography of the Korean blue crab, (*Portunus trituberculatus*) fished off the west coast of Korea and in the East China Sea. J.U. Lee and D.-H. An (National Fisheries Research and Development Agency, 65-3 Shirang-ri, Kijang-up, Yangsan-gun, Kyongsangnam-do, 626-900, Republic of Korea), 7 pp. (English, unpublished).

A quantitative analysis was carried out to estimate the maximum sustainable yield of blue crab distributed around the waters of Korea and in the East China Sea without using fishing effort data, fitting monthly catch data to a modified surplus production model. The maximum sustainable yield of this fish stock was estimated to be about 22 400 tonnes per year and F_{msy} to be 0.95.

WS-CRAB-93/21

A brief exploitation of the stone crab *Lithodes murrayi* (Henderson) off southwest Africa, 1979/80. R. Melville-Smith (South Africa). *Fish. Bull. S. Afr.*, 16: 45-55, 1982 (English).

The stone crab, *Lithodes murrayi,* was exploited briefly off southwest Africa between November 1979 and April 1980, the fishery being terminated when the catch-per-unit-effort fell to an uneconomic level. The extent of the *L. murrayi* grounds is examined on the basis of catch-per-unit-effort data. The species is largely confined to a bathymetric corridor of 500 to 700 m off southwest Africa. Prior to commercial fishing, there was a densely populated region between 24°00'S and 24°40'S, although the crabs were present in small numbers over a much larger area. Over 90% of the fishing effort was applied in this area of high concentration, accounting for almost 95% by mass of the total catch. Although the catch rate declined, the mean size of exploitable crabs

and of undersize crabs stayed virtually constant. Some morphometric relationships and a factor for converting processed crab section mass to whole crab mass have been calculated.

WS-CRAB-93/22
Quantitative stock survey and some biological and morphometric characteristics of the deep-sea red crab *Geryon quinquedens* off southwest Africa. C.J. De B. Beyers and C.G. Wilke (South Africa). *Fish. Bull. S. Afr.*, 13: 9-19, 1980 (English).

In order to assess the abundance of the red crab, *Geryon quinquedens*, two otter-trawl cruises were undertaken in July and September 1978 on the continental slope off southwest Africa. A bimodal frequency distribution of female crabs was evident with modal sizes at 7.7 cm and 8.7 cm carapace width, whereas the mode for males was at 11.2 cm. In general larger animals tended to inhabit shallower water, i.e., size is inversely related to depth. Females preferred shallower water than males. Shell states indicated that males were predominantly in the inter-moult stage while most females were either approaching or had recently completed the moult. From morphometric relationships, it was calculated that, in processing the live material to a cooked frozen product, red crab is subject to a mass loss of about 54%. Analysis of stomach contents by volume showed that only 12% of male stomachs contained 5% or more food and 2% of female stomachs exceeded the 5% level. Highest crab densities occurred at depths of 472 to 849 m whereas unusually high concentrations were encountered during two trawls at water depths of 549 and 590 m. The red crab survives at extremely low levels of dissolved oxygen and tolerates a temperature range of more than 7°C.

WS-CRAB-93/23
A system-of-equations approach to modelling age-structured fish populations: the case of Alaskan red king crab, *Paralithodes camtschaticus*. J.A. Greenberg, S.C. Matulich and R.C. Mittelhammer (Department of Agricultural Economics, Washington State University, Pullman, Wa. 99164-6210, USA). *Can. J. Fish. Aquat. Sci.*, 48: 1613-1622, 1991 (English).

This paper presents a simultaneous system-of-equations approach to modelling age-structured populations using trawl survey age-size frequency data. The analysis builds upon a Ricker spawner-recruit structure and provides a cohort-based estimation method that retains the underlying dynamic properties of a delay-difference model. The framework shares a common spawner-recruit function across age-class equations. This exploits the commonality among cohort members and serves as an instrumental variable, lessening the effect of measurement errors in estimation. The dynamic features of the underlying age-structured population are retained through age-specific net survivability and growth parameters that link age classes. The technique uses multiple observations on a cohort to further mitigate the effect of measurement error and improve overall estimation efficiency. A seemingly unrelated regression estimation method is required to address contemporaneous correlation of errors across age classes. This framework is applied to trawl survey data for adult male Alaskan king crab, *Paralithodes camtschaticus.*

WS-CRAB-93/24
Plots of South Georgia Island crab data. R.S. Otto (National Marine Fisheries Service, Box 1638, Kodiak, Ak. 99615, USA), 9 pp. (English, unpublished).

WS-CRAB-93/25
Extract from: Macpherson, E. 1988. Revision of the family Lithodidae Samouelle, 1819 (Crustacea, Decapoda, Anomura) in the Atlantic Ocean. *Monografías de Zoología Marina*, 2: 9-153 (English).