PREFACE

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

This volume contains abstracts of scientific papers as presented and discussed at the 2004 meetings of the CCAMLR Scientific Committee and its working groups. It is published only in English.

There are four categories of papers:

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

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

(iii) scientific papers not intended for publication, which are listed as 'unpublished'; and

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

All abstracts are listed in groups by respective CCAMLR bodies at meetings of which these papers were submitted. Each abstract is preceded with a unique CCAMLR document number, e.g. SC-CAMLR-XXII/BG/11 (background document number 11 submitted at the Twenty-second Meeting of the Scientific Committee); or WG-EMM-03/8 (document number 8 submitted at the 2003 meeting of the Working Group on Ecosystem Monitoring and Management).

Unpublished papers must not be cited without written permission of the author(s).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

CCAMLR *SCIENTIFIC ABSTRACTS* 2004

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Scientific Committee

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Marine debris collected at Cape Shirreff, Livingston Island, during the 2002/03 and 2003/04 Antarctic seasons. C. Aguilar V. and *D. Torres N. (*Departamento Científico, Instituto Antártico Chileno, Plaza Muñoz Gamero 1055, Punta Arenas, Chile, dtorres@inach.cl), 8 pp. (Spanish, unpublished).

Surveys of beached marine debris at Cape Shirreff, Livingston Island, continued during the 2002/03 and 2003/04 Antarctic seasons. A total of 337 items weighing 5.02 kg (88% were made of plastic materials) was collected during 2002/03, and 626 items weighing 39.05 kg (97% were made of plastic materials) were collected during 2003/04. The total for both seasons was 963 items, weighing 44.07 kg, of which 93% were made of plastic.

A marked and progressive reduction in the number of articles collected was observed compared to the 1 609 items collected in the 1996/97 Antarctic season. As for the weight of the items collected, it too has diminished, becoming lighter than in past seasons. For instance, items observed were mostly plastic packaging bands, polystyrene bits, plastic bottles and containers. The weight of the items found in the last two seasons has been very similar with a ratio of 1 kg per 22 items collected (1:22).

Presumably, the reduction in the number of items recently collected can be attributed to the measures taken by CCAMLR in order to minimise this problem and improve the attitude of people working on board vessels, mainly in the Convention Area.

Nevertheless, the presence of debris that contravenes the measures established by this Convention, such as uncut packaging bands, remains a problem. In the 2003/04 season there was a two-fold increase in their numbers in comparison with the previous season. Likewise, even though in low percentages, debris such as sanitary items and incinerated plastic continues to be found. Of equal significance was the collection of numerous pieces of egg cartons that can lead to the spread of avian diseases, since the hygienic procedures followed during packaging are unknown.

Finally, an interesting line of investigations is suggested in order to study the potential of bacterial diseases being transported in the pores of floating plastic in the sea.

SC-CAMLR-XXIII/BG/11
Review of CCAMLR activities on monitoring marine debris in the Convention Area. CCAMLR Secretariat, 22 pp. (English, unpublished).

The current status of national surveys on monitoring of marine debris and its impact on marine mammals and seabirds in the Convention Area has been reviewed. The CCAMLR marine debris database contains data from 11 sites, all within Area 48. Uruguay submitted data on beached marine debris at King George Island for the fourth consecutive year. There are now four sites that have data for more than three consecutive years: Cape Shirreff (Livingston Island, South Shetland Islands), Bird Island (South Georgia), Signy Island (South Orkney Islands) and King George Island (South Shetland Islands).

Marine debris, principally packaging items, fishing gear, and wood items, reached a peak in the period 1994–1996 at Bird Island and Signy Island, but have declined thereafter. The level of marine debris found in grey-headed albatross and wandering albatross colonies at Bird Island in 2004 has substantially declined from previous seasons. Fishing gear, such as lines and hooks, continues to form the major part of the debris associated with seabird

colonies. Marine mammal (Antarctic fur seal) entanglements were reported for the first time from Cape Shirreff. The number of Antarctic fur seal entanglements at Bird Island reached a peak in 1993 and has shown a general decline since, with the lowest levels on record being reported for the 2003 and 2004 seasons. Packaging bands, synthetic string and longline fragments continue to be the main entangling materials. For the first time, an Adélie penguin was reported entangled at King George Island during the 2002 season, with nylon wrapped around its wing. The number of seabirds contaminated with hydrocarbons remains low.

SC-CAMLR-XXIII/BG/12

Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Signy Island, South Orkney Islands, 2003/04. M. Dunn (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 8 pp. (English, unpublished).

The results of the eighth annual survey of entanglement of Antarctic fur seals at Signy Island, South Orkney Islands, are reported for the 2003/04 summer season. There were no sightings of seals wearing neck collars of man-made debris. Data are compared with results from a parallel study undertaken at Bird Island, South Georgia, in 2003/04. In the case of Bird Island, data indicated that the number of entangled fur seals had decreased by 31% compared to the previous year, this being the lowest number recorded at Bird Island between the austral summers of 1988/89 and 2003/04. Although such a decrease is encouraging, the number of seals with neck collars at Bird Island highlights the need for CCAMLR Members to continue their campaign to ensure that vessels are aware of, and comply with, regulations prohibiting the disposal of man-made debris at sea.

SC-CAMLR-XXIII/BG/13

Beach debris survey, Main Bay, Bird Island, South Georgia, 2002/03. C.J. Green and N.L. Warren (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 16 pp. (English, unpublished).

During the 13th year of standardised beach surveys of man-made debris at Bird Island, South Georgia, a total of 183 items was collected. This represents a 5% decrease on the total recorded in 2001/02 and the lowest levels of beach debris during summer since the first year of recording in 1990/91. The distribution of debris between summer and winter was similar to the previous year with 26% of the total number of items collected during winter. The total weight of debris collected (3.6 kg) was a decrease of 1 kg since last year. There was a decrease in the proportion of nylon fishing line (braid) and plastic packaging bands (only 0.6 and 2.2% respectively of the annual total) compared to previous years. The greatest proportion of debris (95%) was miscellaneous debris. The reduction in fishing gear found on the beach throughout the recording period, particularly during the winter months when the fisheries at South Georgia are most active, is encouraging. Nevertheless, the amount of miscellaneous debris, such as ropes and styrofoam, which has increased during summer by an order of magnitude over the last decade, indicates that debris is still being lost by vessels into the marine environment. All vessels operating in this region should be encouraged to comply with the correct waste disposal procedures not only for fishing-related waste, but for all types of waste.

SC-CAMLR-XXIII/BG/14

Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Bird Island, South Georgia, during the 2003 winter and 2003/04 breeding season. S.L. Robinson (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 17 pp. (English, unpublished).

In the 14th consecutive winter of the survey at Bird Island, South Georgia, the number of entanglements increased by 56% compared to last year and the majority of injuries was classified as severe (71%). In contrast, the 16th consecutive summer of reporting saw a decrease of 45% compared to last year and was the lowest number of entanglements recorded since the first observations were made in 1989. Severe injuries accounted for only a single entanglement during summer. As in previous years, most individuals observed entangled in debris were juveniles (79% of winter and 55% of summer observations). Of the entanglements where the animal could be sexed, males made up the majority in both seasons. Although there was a welcome reduction in plastic packaging band entanglements in summer (27%), they caused the majority of winter entanglements (71%). For the second year running no entanglements in fishing nets were observed. These findings highlight the need for continued monitoring and increased effort in ensuring correct disposal of debris with the potential to entangle wildlife at sea.

SC-CAMLR-XXIII/BG/15

Beach debris survey, Signy Island, South Orkney Islands, 2003/04. M. Dunn (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 16 pp. (English, unpublished).

During the 2003/04 austral summer, the 14th annual beach debris survey was carried out at Signy Island, South Orkney Islands. Debris was cleared each month between December and March from the three study beaches. The debris was counted, measured and classified by type, material, mass and size categories. A total of 21 items weighing 11.59 kg was collected. The number of items found was lower than the total found during the previous season, as was the total mass of the waste recovered (a decrease of 61 and 57.56% respectively since 2002/03). There was a decrease in the number of plastic packaging bands (5) from the total recorded the previous season (23), this decrease reversing the rise in packaging bands experienced over the previous two seasons and marking a return to what has otherwise proved a declining trend since 1993/94. Despite this season's decrease in packaging bands, the fact that they continue to appear as beach debris indicates that the ban on their use on board fishing vessels, brought into force by CCAMLR in 1995/96, has yet to prove entirely effective and should continue. Plastic waste was predominant, as in previous seasons, making up 62% of all items recorded, followed by wood at 24%. The results of this season's litter survey clearly show that the longevity of plastics and other materials with a high resistance to degradation in the marine environment remains a problem and highlights the need for continued monitoring to ensure that vessels are aware of, and comply with, regulations prohibiting the disposal of debris at sea.

SC-CAMLR-XXIII/BG/16

Fishing equipment, marine debris and oil associated with seabirds at Bird Island, South Georgia, 2003/04. I. Forster (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 20 pp. (English, unpublished).

This report describes and quantifies occurrences of fishing gear, marine debris and oil associated with seabirds at Bird Island, South Georgia, from 1 April 2003 to 31 March 2004. It is the 11th such annual report. As in most previous years, more items of fishing gear (mostly longlining gear) were found in association with wandering albatrosses than with any

other species, although the number has decreased substantially since last year. Grey-headed albatross collected the highest number of marine debris items, mostly small plastic fragments, of the study species. The quantity of fishing gear and entanglements associated with giant petrels (northern and southern) was well above the average, as was the number of debris items collected. An increase in the amount of debris and fishing items associated with brown skuas was recorded for the first time and was probably attributable to an increase in observer effort associated with greater field-work intensity. Hooks were typical of those used in the toothfish fishery around South Georgia and the Falklands, and evidence of the discarding of longline hooks in offal and by-catch is of concern.

SC-CAMLR-XXIII/BG/20

Structure and distribution of the slope fish community in the vicinity of the sub-Antarctic Prince Edward Archipelago. E.A. Pakhomov, T. Bushula, S. Kaehler, B.P. Watkins and R.W. Leslie (Department of Earth and Ocean Sciences, University of British Columbia, 6339 Stores Road, Vancouver, BC V6T 1Z4, Canada, epakhomov@eos.ubc.ca, and Zoology Department, Faculty of Science and Technology, University of Fort Hare, Private Bag X1314, Alice 5700, South Africa), 67 pp. (English, unpublished).

Demersal fish community structure, distribution and trophic relationships on the slope (depth range 200–1 500 m) of the sub-Antarctic Prince Edward Islands and surrounding sea rises have been investigated during the pilot survey conducted in April 2001 on board the fishing vessel MV *Ibis*. A total of 56 fish taxa were collected during the survey, of which 43 were identified to species level, eight to the genus level and five to the family level. Among identified taxa, 36 constituted new records for the area investigated. Total CPUE (catch per unit effort) during the survey ranged from 1.1 to 268.1 ind.h^{-1}. Both average fish diversity and total CPUE positively correlated with the trawling depth. Overall, mean sampling depth and near-bottom temperature explained 56% of both total fish CPUE and diversity variation. The hierarchal analysis identified three distinct fish assemblages with very pronounced dominant species, which occupied different vertical zones with likely specific environmental characteristics. Major shifts in communities have occurred at the 500–600 and 800–900 m depth strata, which were probably augmented by the physical and biological vertical zonation. Analyses of diets of selected fish species showed that they are feeding generalists consuming predominantly pelagic, including epipelagic and meso-/benthopelagic prey. Diet data on six species and stable isotopes of 22 fish species revealed that, with a few exceptions, most species occupy the fourth trophic level and are tertiary consumers. Wide variability in carbon isotopic signatures is discussed in respect of alternative (possible importance of high-Antarctic and chemoautotrophic versus photoautotrophic sub-Antarctic primary production) organic matter sources at the base of deep-sea food webs.

SC-CAMLR-XXIII/BG/22

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

SC-CAMLR-XXIII/BG/23

Incidental mortality of seabirds during unregulated longline fishing in the Convention Area. Ad Hoc Working Group on Incidental Mortality Arising from Fishing (WG-IMAF), 9 pp. (English, unpublished).

SC-CAMLR-XXIII/BG/29

The biology, ecology and vulnerability of seamount communities. A.D. Rogers (British Antarctic Survey). Published in 2004 by the International Union for Conservation of Nature and Natural Resources (English).

While much remains unknown about seamount communities, scientific evidence suggests that high-seas bottom trawling may have significant and irreversible impacts on the diversity and ecology of seamounts and other similar hard-bottom communities. The booklet explains the reasons and gives more information on seamount ecology.

SC-CAMLR-XXIII/BG/30

The applicability of international conservation instruments to the establishment of marine protected areas in Antarctica. S. Grant (Scott Polar Research Institute, University of Cambridge, Lensfield Road, Cambridge CB2 1ER, United Kingdom, smg40@cam.ac.uk), 33 pp. (English, unpublished).

Many international conservation treaties, non-binding agreements and other instruments that have relevance to marine protected area (MPA) development provide for action to be taken globally, and thus include Antarctica within the scope of a worldwide system of marine protected areas. However, depending on their specific provisions, full application in Antarctic waters may be difficult, inappropriate or even impossible because of the area's unique political situation and existing regimes.

The provisions of many international conservation agreements are designed to be implemented through the national jurisdiction of adhering States within their territorial waters or exclusive economic zones, based on the principles of maritime jurisdiction embodied in the United Nations Convention on the Law of the Sea (UNCLOS). However, there are differing 'positions of principle' between claimant and non-claimant States with regard to the existence of territorial sovereignty and corresponding maritime zones in the area south of 60°S. In addition, the instruments of the Antarctic Treaty System already provide for resource management and environmental protection, thus raising questions about the necessity and feasibility of applying other agreements with overlapping provisions.

It is concluded that although direct application of other international conservation agreements is in most cases unlikely to be feasible, efforts should be made to apply within the Antarctic Treaty System, certain principles and requirements agreed under instruments with global purview. These include the formulation of guidelines and criteria for MPA establishment, the consideration of marine protection as a separate, but linked, issue to protection of other environments, and the development of more specific guidelines on the timeframe in which these should take place. In addition, the consideration of Antarctic waters, in parallel with global work to develop high-seas protected areas, should be undertaken to achieve the goal of a global, representative system of MPAs, of which Antarctic MPAs should be an important component.

Working Group on Ecosystem Monitoring and Management

WG-EMM-04/4

The diet of Antarctic fur seals, *Arctocephalus gazella*, at King George Island, during the summer–autumn period. G.A. Daneri, A.R. Carlini, C.M. Hernandez and A. Harrington (Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia', División Mastozoología, Avenida Angel Gallardo 470 (C 1405 DJR) Buenos Aires, Argentina, gdaneri@macn.gov.ar/gadaneri@mail.retina.ar), 17 pp. *Polar Biology*, submitted (English).

The diet of non breeding male Antarctic fur seals, *Arctocephalus gazella*, at Stranger Point, King George Island, was investigated by scat analysis from February to April 1996. Overall, krill and fish were the most frequent prey, occurring in an average of 97 and 69% of samples (n = 128), followed by cephalopods (12%). Myctophids constituted almost 90% of the fish predated, with *Electrona antarctica* and *Gymnoscopelus nicholsi* the most abundant and frequent prey species. All fish taxa identified were krill-feeding species suggesting that seals foraged primarily on krill and opportunistically on fish species associated with krill swarms. A seasonal change observed in the relative proportions of the different fish prey taxa would indicate that fur seals spent more time foraging over the shelf in summer and off the shelf in autumn. During the study period, commercial fishing in the area was not based upon any of the fish species identified in this study.

WG-EMM-04/5

Seabird research at Cape Shirreff, Livingston Island, Antarctica, 2003–2004. M. Antolos, A.K. Miller and W.Z. Trivelpiece (Antarctic Ecosystem Research Division, Southwest Fisheries Science Center, La Jolla, CA 92037, USA), 8 pp. (*AMLR 2003/2004 Field Season Report*, in press (English).

The seventh consecutive season of data collection at Cape Shirreff has enabled us to examine trends in penguin populations, as well as interannual variation in reproductive parameters, penguin diet and foraging behaviour. The chinstrap breeding population at Cape Shirreff has continued to decline over the past five years, and is at its lowest size in the past seven years of study. While the gentoo breeding population increased slightly from last year, it is at its second lowest size in the past seven years. Chinstrap fledging success was higher during the 2003/04 breeding season than in the previous season, but lower than the average for the past seven years. Gentoo fledging success in 2003/04 was greater than in 2002/03, and was either similar to, or greater than, the seven-year mean, depending on the methodology used. Fledging weights of both species increased from last year, but were below the eight-year mean for this parameter. Total chick meal mass was larger in both species compared to the past seven years of study. Chinstrap penguin diet contained more fish than in other years on average, while gentoo diets contained less fish. The majority of krill in chinstrap diets was in the 36–45 mm range; the majority of krill in gentoo diets was in the 41–55 mm range. This is the first season where the two penguin species have selected different sized krill during the chick-rearing period. Foraging trip durations during the chick phase were longer than during the 2002/03 breeding season. The interpretation of the foraging trip behaviour may be clarified when we finish our analyses of the PTT derived, at-sea foraging locations used by chinstrap and gentoo penguins during this period.

WG-EMM-04/9

Register of non-CEMP time-series data. CCAMLR Secretariat, 3 pp. (English, unpublished).

WG-EMM-04/10

Results of scientific observations on board the RKT-S (cannery fishing super trawler) *Konstruktor Koshkin* in Statistical Area 48 in March–June 2003 compared to previous seasons. V.A. Bibik and S.A. Klementiev (YugNIRO, 2 Sverdlov Street, Kerch 98300, Crimea, Ukraine, island@crimea.com), 20 pp. (English, unpublished).

This report presents data on Antarctic krill (*Euphausia superba*) catches with regard to vessel operations, biological condition of krill and results of identification of the main size groups with the aim of determining which year class krill belong to. The paper provides an analysis of weather and ice conditions, an assessment of krill density in aggregations and of the state of the fisheries in Subareas 48.2 and 48.3 in 2003 in comparison to previous years.

WG-EMM-04/11

Summary table of current and proposed Antarctic marine protected areas. S. Grant (Scott Polar Research Institute, University of Cambridge, Lensfield Road, Cambridge CB2 1ER, United Kingdom, smg40@cam.ac.uk), 10 pp. (English, unpublished).

WG-EMM-04/12

The biology, ecology and vulnerability of seamount communities. A.D. Rogers (British Antarctic Survey). Published in 2004 by the International Union for Conservation of Nature and Natural Resources (English).

While much remains unknown about seamount communities, scientific evidence suggests that high-seas bottom trawling may have significant and irreversible impacts on the diversity and ecology of seamounts and other similar hard-bottom communities. The booklet explains the reasons and gives more information on seamount ecology.

WG-EMM-04/13

History of development and completion of tasks put forward by WG-EMM (2001–2003). CCAMLR Secretariat, 6 pp. (English, unpublished).

WG-EMM-04/14

CEMP indices 2004: analysis of anomalies and trends. CCAMLR Secretariat, 150 pp. (English, unpublished).

WG-EMM-04/15

Krill fishery information. CCAMLR Secretariat, 61 pp. (English, unpublished).

WG-EMM-04/16

The living planet index. CCAMLR Secretariat, 4 pp. (English, unpublished).

WG-EMM-04/18

Development of the acoustic survey database. CCAMLR Secretariat, 6 pp. (English, unpublished).

WG-EMM-04/20

Acquiring a 'base datum of normality' for a marine ecosystem: the Ross Sea, Antarctica. D. Ainley (H.T. Harvey and Associates, 3150 Almaden Expressway, Suite 145, San Jose, CA 95118, USA dainley@penguinscience.com), 19 pp. (English, unpublished).

The Ross Sea Shelf Ecosystem (RSShelfE) offers the last chance to understand ecological processes in a system where both top-down and bottom-up forcing are still intact. Elsewhere in Earth's oceans the systems used for understanding ecological processes and fishery effects all have lacked significant natural top-down forcing for such a long time that it is a concept rarely considered by researchers who currently investigate open-ocean systems. Herein, the

importance of top-down forcing in pelagic and neritic marine ecosystems is reviewed with concrete evidence given for its existence in the current functioning of the RSShelfE. In spite of this unique evidence for the Antarctic region, much remains to be learned about cross-component interactions in the Ross Sea system. Should the RSShelfE be unnaturally altered, an easy accomplishment given increasing fishery pressure, the last opportunity to understand the processes that take place in a healthy, complete marine ecosystem will have been lost.

WG-EMM-04/22

Foraging patterns in the Antarctic shag (*Phalacrocorax bransfieldensis*) at Harmony Point, Antarctica. R. Casaux and A. Baroni (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina, pipocasaux@infovia.com.ar, current address: Laboratorio de Ecología Acuática, Universidad Nacional de la Patagonia, Sarmiento 849, 9200 Esquel, Chubut, Argentina), 22 pp. (English, unpublished).

During the 1995/96 and 1996/97 summer seasons the foraging pattern of the Antarctic shag (*Phalacrocorax bransfieldensis*) was studied by direct observation of individuals breeding at Harmony Point, Nelson Island, South Shetland Islands. During pre-laying and incubation, individuals of both sexes usually foraged once a day; females early in the morning and males when their partners returned to the nests. During the chick-rearing period the parents increased the number of daily foraging trips, usually taking turns to have time at sea. Compared to the incubating period, when rearing chicks, individuals of both sexes reduced the length of their foraging trips which, in years of scarce food availability, may not result in reducing the daily total time spent foraging due to the marked increment in the number of trips required to cover the demands at the nest. Individuals rearing chicks responded to increasing energy requirements at the nest (i.e. as chicks grew older or as the number of chicks at the nests increased) by increasing the number of daily foraging trips and the time spent foraging. The information obtained suggests that Antarctic shags display behavioural mechanisms which tend to buffer variations in food abundance or energy requirements at the nest. The possibility of using the foraging parameters considered in this study for monitoring programs is discussed.

WG-EMM-04/23

Demography of Antarctic krill in the Lazarev Sea (Subarea 48.6) and the Elephant Island area (Subarea 48.1) in 2004. V. Siegel, V. Loeb, B. Bergström, S. Schöling, M. Haraldsson, J. Kitchener and M. Vortkamp (Institut für Seefischerei, Palmaille 9, 22767 Hamburg, Germany, volker.siegel@ish.bfa-fisch.de), 22 pp. (English, unpublished).

Standardised krill net sampling surveys were conducted in the Lazarev Sea (Subarea 48.6) in April 2004 and in the Elephant Island area (Subarea 48.1) in January and February/March 2004. Krill densities in the Elephant Island area were below the long-term average which mark a substantial decline after the good krill years in 2001 and 2002. Krill density was lower in the Lazarev Sea, even after taking substantial day/night differences in the catches into account. Recruitment indices of one-year-old (R1) and two-year-old krill (R2) were calculated for both areas, showing low values for R1 and high, but different, values for R2. Spatial distribution of krill density and size/age classes is discussed for the Lazarev Sea. Information is given on the development of maturity stages and 'rejuvenation processes' after the spawning season. Distribution and density of krill calyptopis and furcilia larvae are provided for the Lazarev Sea.

WG-EMM-04/24

A possible framework in which to consider plausible models of the Antarctic marine ecosystem for evaluating krill management procedures. A.J. Constable (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Australia, andrew.constable@aad.gov.au), 56 pp. *CCAMLR Science*, submitted (English).

CCAMLR requires an assessment method for recommending a subdivision of the krill catch limit in Area 48 that will be highly likely to achieve the objectives of the Convention despite the uncertainties in knowledge. This will be part of the management procedure governing the krill fishery. The agreed work plan for developing a management procedure includes the evaluation of candidate management procedures in a simulation framework, using plausible models of the Antarctic marine ecosystem. This paper develops a framework for erecting such models. It is divided into three main parts, addressing different aspects of model development. Part 1 outlines the issues to consider in assessing the requirements of plausible models. Part 2 discusses the general model requirements, while Part 3 presents a possible framework for developing ecosystem models to evaluate krill management procedures. The first section of this part outlines a conceptual approach to the taxonomic/biological elements of a model and the manner in which linkages between those elements might be considered. The second section details a model framework for characterising: (i) the different taxa depending on the status of knowledge and their importance for understanding the ecosystem effects of fishing, (ii) important physical processes that will influence the system, and (iii) the fisheries. In developing these parts, the paper highlights areas that may be necessary to be considered by WG-EMM in the development of plausible models.

WG-EMM-04/25

Report of the Steering Committee for the WG-EMM Workshop on Plausible Ecosystem Models for Testing Approaches to Krill Management. Coordinated on behalf of the Steering Committee by A.J. Constable (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@aad.gov.au), 16 pp. (English, unpublished).

WG-EMM-04/26

Developing conceptual models of the Antarctic marine ecosystem: squid. K. Phillips (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, katrina.phillips@aad.gov.au), 26 pp. (English, unpublished).

CCAMLR is currently considering plausible models of the Southern Ocean ecosystem within WG-EMM. While recognised to be an important component of this ecosystem, particularly with regard to food-web structure and function, squid have rarely been included in previous ecosystem models except perhaps to assess their potential impact as predators of Antarctic krill. This paper describes properties for three groups of squid that may be included in future ecosystem models of the Southern Ocean: onychoteuthids, ommastrephids and small to medium nektonic squids. Important ecological differences are considered to exist among these three groups (e.g. spatial and depth distribution, ontogenetic and vertical migrations). Furthermore, this paper reiterates findings from previous studies that squid should no longer be modelled as specialist predators on Antarctic krill.

WG-EMM-04/27

Biotopic and spatial distribution of krill (*Euphausia superba* Dana) (Crustacea, Euphausiacea) length groupings in the Atlantic sector of the Antarctic in the summers of 1984 and 1988. V.V. Lidvanov, A.V. Zimin and K.E. Shulgovsky (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, hydrobio@atlant.baltnet.ru), 13 pp. *Collected Papers AtlantNIRO*, 2004, in press (English).

Three basic length groupings of krill were identified with the clustering analysis on the basis of the data of two complex surveys carried out in the western Atlantic sector of the Antarctic in the summers of 1984 and 1988. The large-length grouping is biotopically associated with the waters of the southern branch of the Antarctic Circumpolar Current (ACC). The middle-length and small-length groupings are associated with Weddell Sea waters. An additional fourth grouping with bimodal length structure was revealed in the 1988 survey. It is assumed that the first grouping is transported into the area from the Pacific sector, while the second and the third groupings are of local origin and the fourth is formed as a result of a mixture of the groupings inhabiting different biotopes under the impact of the secondary frontal zone dynamic conditions. Hydrometeorological conditions in the summer of 1988 complied with the climatic norm and seemed to stipulate the typical pattern of krill spatial distribution. The different distribution pattern observed during the survey in 1984 was related to intensification of the ACC and reduction of the Weddell Sea waters intrusion into the eastern Scotia Sea. The comparative analysis of results from surveys in 1984, 1988 and the CCAMLR-2000 Survey showed that krill population structure in the western Atlantic sector of the Antarctic has not actually changed.

WG-EMM-04/28

Accounting for food requirements of seabirds in fisheries management – the case of the South African purse-seine fishery. R.J.M Crawford. *African Journal of Marine Science*, 26, in press (English).

In South Africa, four seabirds that feed mainly on sardine *Sardinops sagax* and anchovy *Engraulis encrasicolus* all have an unfavourable conservation status or a small population: African penguin *Spheniscus demersus*, Cape gannet *Morus capensis*, Cape cormorant *Phalacrocorax capensis* and swift tern *Sterna bergii*. Availability of prey is thought to influence the populations of these species, but their food requirements have not been accounted for in management of the purse-seine fishery on sardine and anchovy. Means of identifying and attaining target populations of predators that are dependent on forage fish prey are discussed. It is suggested that criteria used by The World Conservation Union to assess the conservation status of a species may prove useful in determining minimum viable populations, and that the use of functional relationships in coupled models of predators and their prey may enable quantification of levels of escapement of prey that are necessary to maintain or rebuild populations of predators.

WG-EMM-04/29

Counts of surface-nesting seabirds at Marion Island in 2003/04. R.J.M Crawford, N. de Bruyn, B.M. Dyer, B. Hanise, N.T.W. Klages, P.G. Ryan, L.G. Underhill and L. Upfold (Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Rogge Bay 8012, South Africa, crawford@deat.gov.za), 4 pp. (English, unpublished).

Numbers of gentoo penguins (*Pygoscelis papua*), macaroni penguins (*Eudyptes chrysolophus*), eastern rockhopper penguins (*E. chrysocome filholi*) and Crozet shags (*Phalacrocorax [atriceps] melanogenis*) continued to decrease at Marion Island in 2003/04. The decreases are thought to be due to a reduced availability of prey to birds foraging near the island. Numbers of wandering albatrosses (*Diomedea exulans*), grey-headed albatrosses

(*Thalassarche chrysostoma*), light-mantled sooty albatrosses (*Phoebetria palpebrata*), northern giant petrels (*Macronectes halli),* Antarctic terns (*Sterna vittata)* and Kerguelen terns (*S. virgata*) appear stable at the island, but often with large fluctuations in numbers breeding. Numbers of dark-mantled sooty albatrosses (*P. fusca*), southern giant petrels (*M. giganteus*) and kelp gulls (*Larus dominicanus*) have shown a long-term decrease, although the count for dark-mantled sooty albatrosses was higher in 2003/04 than for several seasons.

WG-EMM-04/30

A brief review of AtlantNIRO's investigations of living marine resources: whales, krill and fish, in the Atlantic sector of the Antarctic. F. Litvinov, D. Tormosov and Zh. Frolkina. *History of Oceanography*. Abstracts of the VII International Congress on the History of Oceanography. Museum of the World Ocean, Kaliningrad, 8–12 September 2003: 273–278 (English).

The USSR fished in the Atlantic Sector of the Antarctic for three living marine resources: whales, krill and fish. In order to provide the fisheries with a rational database, the AtlantNIRO vessels conducted fishery and scientific studies. Investigations on whales commenced in 1960. A large set of statistical and biological data on the growth rate of embryos of sperm whales, pigmy blue whales and southern baleen whales, the physiological structure of the females in the aggregations of various whale species, and migrations etc. was collected. This dataset is widely used for correct stock evaluations and population dynamics. Using the information collected by whalers, the world krill fishery was initiated by the AtlantNIRO vessel *Muxun* in 1961. From 1961 to 1970, eight scientific research and fishery voyages to the Atlantic sector were undertaken: 25 voyages from 1971 to 1980, and 22 voyages from 1981 to 1989. For the entire study period in the Atlantic sector, an enormous primary database was collected by AtlantNIRO and VNIRO. Investigations of Antarctic fish were started by RV *Academik Knipovitch* in 1967. The main purpose of the research was ecology of the commercially important species, stock and recruitment assessment and a search for new resources. Since 1960, AtlantNIRO's contributions to the study of all three resources (whales, krill and fish) have been unique and very important, and may be used to better understand and protect the oceanic ecosystem, as well as for planning and development of sustainable fisheries.

WG-EMM-04/31

Incidental seal entanglements on trawl vessels fishing for krill in CCAMLR Subarea 48.3. J. Hooper, K. Reid and D. Agnew (MRAG Ltd, 18 Queen Street, London W1J 5PN, United Kingdom, j.hooper@mrag.co.uk), 6 pp. (English, unpublished).

Observers on krill vessels fishing around South Georgia in the 2003 fishing season recorded fur seal captures by some krill fishing vessels. These captures can be attributed to the absence of effective mitigation measures (escape panels in the nets) and lack of experience of crews new to the fishery. Experienced vessels, employing effective mitigation measures, caught no seals. Although these levels of seal mortality are unlikely to impact significantly on fur seal populations, it is clearly important to have observers on krill vessels monitor the effectiveness of mitigation measures as well as to collect other biological data.

WG-EMM-04/32

The applicability of international conservation instruments to the establishment of marine protected areas in Antarctica. S. Grant (Scott Polar Research Institute, University of Cambridge, Lensfield Road, Cambridge CB2 1ER, United Kingdom, smg40@cam.ac.uk), 33 pp. (English, unpublished).

Many international conservation treaties, non-binding agreements and other instruments that have relevance to marine protected area (MPA) development provide for action to be

taken globally, and thus include Antarctica within the scope of a worldwide system of marine protected areas. However, depending on their specific provisions, full application in Antarctic waters may be difficult, inappropriate or even impossible because of the area's unique political situation and existing regimes.

The provisions of many international conservation agreements are designed to be implemented through the national jurisdiction of adhering States within their territorial waters or exclusive economic zones, based on the principles of maritime jurisdiction embodied in the United Nations Convention on the Law of the Sea (UNCLOS). However, there are differing 'positions of principle' between claimant and non-claimant States with regard to the existence of territorial sovereignty and corresponding maritime zones in the area south of 60°S. In addition, the instruments of the Antarctic Treaty System already provide for resource management and environmental protection, thus raising questions about the necessity and feasibility of applying other agreements with overlapping provisions.

It is concluded that although direct application of other international conservation agreements is in most cases unlikely to be feasible, efforts should be made to apply within the Antarctic Treaty System certain principles and requirements agreed under instruments with global purview. These include the formulation of guidelines and criteria for MPA establishment, the consideration of marine protection as a separate, but linked issue to protection of other environments, and the development of more specific guidelines on the timeframe in which these should take place. In addition, the consideration of Antarctic waters, in parallel with global work to develop high-seas protected areas, should be undertaken to achieve the goal of a global, representative system of MPAs, of which Antarctic MPAs should be an important component.

WG-EMM-04/33

Food consumption estimates of southern elephant seal females during their post-breeding aquatic phase at the South Shetland Islands. A.R. Carlini, G.A. Daneri, M.E.I. Márquez, H. Bornemann, H. Panarello, R. Casaux, S. Ramdohr and J. Plötz (Departamento de Ciencias Biológicas, Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina, acarlini@dna.gov.ar), 17 pp. (English, unpublished).

Labelled water methodology was used to quantify energy expenditure during lactation and energy gain during the post-breeding aquatic phase in southern elephant seal females at Stranger Point, King George Island (25 de Mayo). During lactation, females spent a mean of 6 021 ± 1 365 MJ, which resulted in a loss of 35% of the initial mass, comprising 63% of initial body fat and 20% of initial body protein. During the 58 ± 5.4 d post-breeding foraging period, females gained 135 ± 39 kg, which allowed them to recover an average of 55% mass, including 46% fat, 71% protein and 47% energy, lost during lactation. Neither the mass nor the energy lost during lactation were related to those gained while at sea. However, protein loss expressed in absolute terms, or as a proportion of that present at the beginning of lactation, explained about 50% of the variation in the protein gained during the post-breeding phase. This might indicate the presence of a mechanism favouring an increase in lean tissue during post-breeding.

Daily energy requirements for an average-sized female during the post-breeding aquatic phase were estimated at 96 MJ. Estimation of prey consumption varies according to assumptions about diet composition. On the basis of 450 females, the total biomass of fish and squid consumed by the breeding group, assuming a diet composed of 75% cephalopods and 25% fish, was estimated at 521 and 174 tonnes respectively for the period examined.

WG-EMM-04/34

Physical forcing in the southwest Atlantic: ecosystem control. P.N. Trathan, E.J. Murphy, J. Forcada, J.P. Croxall, K. Reid and S.E. Thorpe (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, p.trathan@bas.ac.uk), 35 pp. *Management of Marine Ecosystems: Monitoring Change in Upper Trophic Levels*. Boyd, I.L. and S. Wanless (Eds) (submitted to the Zoological Society of London Symposium (English).

In the southwest Atlantic sector of the Southern Ocean, temporal variability in the physical environment has been recorded since the early part of the last century. For example, ocean temperatures are known to vary both between seasons and between years. Time series analysis of sea-surface temperature at South Georgia shows the presence of high levels of autocorrelation, with periodicity evident in temperature anomalies at lag periods of approximately three to four years. Crosscorrelation analyses with temperature anomaly data for the El Niño 4 region in the Pacific show that variability at South Georgia also reflects temperature fluctuations in the Pacific, with the Pacific leading South Georgia by approximately three years.

Biological variability is also apparent at South Georgia, being evident in data from a suite of top predators as well as in data from fish and Antarctic krill. Increased krill biomass appears to coincide with cold anomaly periods. In contrast, periods of reduced predator breeding performance are strongly correlated with warm anomaly periods, but lagged by a number of months. For some predators the most critical periods appear to be prior to the breeding season during the summer and early autumn of the preceding year. Thus, gentoo penguins (*Pygoscelis papua*) show a strong negative relationship between the number of chicks fledged and sea-surface temperatures in the preceding February some 12 months earlier. Antarctic fur seals (*Arctocephalus gazella*) show a similar negative relationship between the number of pups surviving at birth and the temperature 14 months earlier in the preceding November. Such relationships with the physical environment most likely reflect prey (krill) availability. However, the full explanation of the observed relationships requires a more detailed understanding of the temporal and spatial interactions between predator demography and foraging dynamics, prey biomass and recruitment, and environmental variability.

WG-EMM-04/35

Near-shore acoustic surveys for Antarctic krill at South Georgia, January 2004. A.S. Brierley, P.N. Trathan, J. Poncet and A. Morton (Gatty Marine Laboratory, University of St Andrews, Fife KY16 8LB, United Kingdom, asb4@st-and.ac.uk), 9 pp. (English, unpublished).

Dual-frequency (120 and 38 kHz) acoustic surveys were conducted around the Willis Islands and off the Barff Peninsula, South Georgia, from a 59 foot yacht in January 2004. The purpose of the surveys was to determine krill density near shore, in regions that have not traditionally been surveyed by large research vessels, and to survey responsively in areas where adult macaroni penguins provisioning chicks ashore were foraging. Despite its relatively small size, the yacht (*Golden Fleece*) proved to be well suited as an acoustic survey platform. The echo-sounder transducers were deployed on a removable scaffold-tubing frame midships. With sails up the yacht had good roll stability and useable data were collected in sea-state 6 with winds up to 30 knots and swells of approximately 2.5 m at survey speeds of up to 7 knots. Echo-intensity data were scaled to krill density using a target strength determined from the length distribution of krill sampled from fur seal scats at Bird Island (mean krill length 53.13 mm, TS = –38.43 dB kg^{-1}). Mean krill densities were 7.1 g m^{-2} off the Barff Peninsula and 5.7 g m^{-2} around the Willis Islands. Krill densities in both regions were low compared to time series of observations from the past 20 years. A low density was

perhaps not unexpected in line with recent cyclical patterns in density but may have been exacerbated by the presence of a large iceberg (40 by 30 miles) aground on the shelf edge to the northeast of South Georgia that may have been blocking the influx of krill. In conclusion, acoustic surveys from small vessels enable data to be collected from regions where large vessels cannot operate safely, and offer flexibility to sample reactively on time scales that cannot always be accommodated under the scheduling constraints of multidisciplinary cruises. A combination of data from small vessels operating near shore with data collected over more extensive, offshore areas by large ocean-going research vessels will provide a more comprehensive understanding of the prey field available to krill predators.

WG-EMM-04/36

DYNAMOE and Albatross papers 2003–2004. British Antarctic Survey (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 5 pp. (English, unpublished).

This is a list of publications produced by two BAS core-funded science programs: *Dynamics and Management of Ocean Ecosystems* (principal investigator: E. Murphy; project leaders: P. Trathan and J. Watkins); and *Albatross* (principal investigator: J. Croxall).

WG-EMM-04/37

Proposal for an acoustic krill biomass survey in CCAMLR Division 58.4.2. S. Nicol, S. Kawaguchi, T. Jarvis and T. Pauly (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, steve.nicol@aad.gov.au), 12 pp. (English, unpublished).

WG-EMM-04/38

Interannual variation in the summer diet of Adélie penguins (*Pygoscelis adeliae*) at Edmonson Point. S. Olmastroni, F. Pezzo, I. Bisogno and S. Focardi (Dipartimento di Scienze Ambientali 'G. Sarfatti', Università degli Studi di Siena, Via P.A. Mattioli 4, 53100 Siena, Italy, olmastroni@unisi.it), 18 pp. (English, unpublished).

Diet sampling of Adélie penguins (*Pygoscelis adeliae*) was carried out at two colonies in the Ross Sea, Antarctica, to study the feeding ecology of this species for the CCAMLR Ecosystem Monitoring Program (CEMP). The study took place at the Edmonson Point CEMP site over five years, 1995–1997, 1999 and 2001, and was extended to Inexpressible Island in 2001. Mean diet composition varied from year to year and between the two locations in 2001. Meal size for chicks was found to be higher during the crèche than the guard period and males were found to return with a larger mean meal weight containing more krill than females. The overall composition of diet varied between locations: mean weights of food and krill content were generally higher at Edmonson Point. In the guard period, mean weight of food was lower at Inexpressible Island. Mean content of *Euphausia superba* was significantly higher at Inexpressible Island while more *E. crystallorophias* was found in stomach contents from Edmonson Point.

WG-EMM-04/39

CPUE values derived from Soviet fishery statistics as indicators of Antarctic krill density fluctuations from 1977 to 1991. F.F. Litvinov, A.Z. Sundakov and G.N. Andrianov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, flit@atlant.baltnet.ru), 9 pp. (English, unpublished).

The average CPUE values, annual and calculated, for the periods 1977–1986 and 1986–1991 are considered. It is assumed that these values adequately describe trends in krill density fluctuations. The rather high stability of the values investigated is shown. It is proposed that krill density of 170–200 g/m^2 may be considered as an average characteristic

value for Area 48. It was shown that interannual CPUE variability is lower for Area 48 as a whole, compared to all subareas combined, most probably due to krill transport between subareas.

WG-EMM-04/40

Broadbandwidth sound scattering and absorption from krill (*Meganyctiphanes norvegica*), mysids (*Praunus flexuousus* and *Neomysis integer*) and shrimp (*Crangon crangon*). S.G. Conti, D.A. Demer and A.S. Brierley (Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, stephane.conti@noaa.gov), 21 pp. *Journal of the Acoustical Society of America*, submitted (English).

Sound scattering and absorption measurements were made of northern krill (*Meganyctiphanes norvegica*) over the acoustical bandwidth of 30 to 210 kHz and compared to similar scattering measurements made of Antarctic krill (*Euphausia superba*). The measurements of total target strength (TTS) match the SDWBA model recently developed for Antarctic krill, indicating its validity for other euphausiid species with similar size and shape. However, the total target strengths (TTS) of crustaceans with markedly different shapes (i.e. Mysidacea, a mix of *Praunus flexuosus* and *Neomysis integer*; and Decapoda, *Crangon crangon*), are not well predicted by SDWBA derived with the generic krill shape and scaled to animal length (L). This implies that crustacean target strength (TS) cannot be estimated accurately by a linear function of $\log_{10}(L)$, irrespective of shape, and brings into question the validity of the current TS relationship used for Antarctic krill because that relationship was derived from data measured from multiple crustaceans including mysids and decapods. TTS and TS are dependent on both L and shape, and krill, mysids, and decapods have significantly different shapes and girth-to-length relationships. On the other hand, modelled TTS and TS spectra for gravid and non-gravid krill appear to have differing amplitudes, but similar shapes. Additionally, the measurements of absorption spectra from decapods indicate that the absorption cross-section increases with the volume of the animal. Collectively, these results provide tools for improving the detection of krill and more accurate estimates of TS, both vital to acoustical surveys. Furthermore, because TTS measurements from both northern and Antarctic krill support the SDWBA model, there are now more opportunities to apply acoustical measurements of one species to the acoustical characterisation of the other. Thus, additional measurements of TTS over a range of frequencies, sizes and maturity stages will further improve our ability to identify species acoustically, aid ecosystem studies and assessment and management of both commercially and ecologically important euphausiid species.

WG-EMM-04/41

Sounds like more krill. D.A. Demer and S.G. Conti (Advanced Survey Technologies Program, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, david.demer@noaa.gov), 17 pp. ICES *Journal of Marine Science*, submitted (English).

Antarctic krill (*Euphausia superba*) comprise the foundation of the food web in the Southern Ocean and are the target of a large fishery. Recently, the total abundance of krill in the Scotia Sea was estimated from an international echosounder and net survey (CCAMLR-2000 Survey) to be 44.3 million tonnes (CV 11.4%). The new biomass estimate prompted the Antarctic Treaty's Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) to revise the precautionary catch level for krill in the area from 1.5 to 4 million tonnes. These survey results are based on the total echo energy attributed to krill, scaled by the Greene et al. model of krill acoustical reflectivity or target strength (TS). Presented here is a reanalysis of the CCAMLR-2000 data incorporating recent improvements in the characterisation of krill TS. Results indicate that the estimated krill biomass in the Scotia Sea

may be as high as 192.4 million tonnes (CV = 11.7%), or as low as 109.4 million tonnes (CV = 10.4%), depending solely on the expected distribution of krill orientations. As the lower krill biomass estimate is nearly 2.5 times the previous estimate, the standard krill TS model should be updated and a revision of the precautionary catch level for krill in the Scotia Sea may be warranted.

WG-EMM-04/42

Report of scientific observations of commercial krill harvest on board the Japanese stern trawler *Chiyo Maru No. 5* from 2 August to 21 September 2003. T. Hayashi, M. Naganobu* and K. Taki (*National Research Institute of Far Sea Fisheries, 5-7-1 Shimizu-Orido, Shizuoka, 424-8633 Japan, naganobu@affrc.go.jp), 10 pp. (English, unpublished).

Japan deployed one scientific observer on a Japanese krill trawler, the *Chiyo Maru No. 5*, from 2 August to 21 September 2003. The observation was essentially undertaken in accordance with the CCAMLR *Scientific Observers Manual*. Summaries of fishing efforts, processing, fish by-catch, biological measurements of krill, product types, vessel and marine mammal observations are described in the report. During observation the trawler made trips to the west and north areas of South Georgia Island.

WG-EMM-04/43

Short note: report of bacterial infections in Antarctic krill *(Euphausia superba)* in the South Georgia region. T. Hayashi and M. Naganobu* (*National Research Institute of Far Sea Fisheries, 5-7-1 Shimizu-Orido, Shizuoka, 424-8633 Japan, naganobu@affrc.go.jp), 5 pp. (English, unpublished).

This paper reports on Antarctic krill (*Euphausia superba*) with bacterial infections observed during observations on board the FV *Chiyo Maru No. 5*, from 8 August to 17 September 2003 in the South Georgia region.

WG-EMM-04/44

Characteristics of seasonal variations in diurnal vertical migrations and aggregation of Antarctic krill (*Euphausia superba*) in the Scotia Sea, using Japanese fishery data. K. Taki, T. Hayashi and M. Naganobu (National Research Institute of Far Seas Fisheries, 5-7-1 Shimizu-Orido, Shizuoka, 424-8633 Japan, takisan@affrc.go.jp), 19 pp. *CCAMLR Science*, submitted (English).

The authors examined seasonal variations in CPUE (catch per volume of trawled water) and diurnal vertical migrations of Antarctic krill (*Euphausia superba*) associated with the brightness categories of the day based on the angles between the centre of the sun and the celestial horizon on the Scotia Sea; South Shetland Islands (SS), South Orkney Islands (SO) and South Georgia (SG) areas, using Japanese fisheries data.

Average trawling depth usually showed a marked diurnal change during summer and winter in SS and SO, being deepest during the day and shallowest at night from summer to winter, but did not show such diurnal vertical migration during winter in SG, being deepest during morning twilight and shallowest at evening twilight. The range of trawling depth was narrower in certain layers (usually upper layers except in winter in SG) during dusk and dawn, but was wider during morning and afternoon in every season in every area. Diurnal changes in CPUE occurred, being greatest during the day and smallest at night during autumn and winter in each area, but being smaller during the day during summer in SS and SO.

Daily average trawling depth tended to be shallower during summer and early autumn, and deepened gradually from autumn and reached its maximum depth in winter in the Scotia Sea. However, it became shallower in early spring, when krill began to feed on phytoplankton. The vertical range of trawling depth was narrower during spring and early autumn, but greater during the middle of autumn and winter in each brightness category.

WG-EMM-04/45

Comparison of the 1981 FIBEX survey and the CCAMLR-2000 Survey on oceanographic variability in the Scotia Sea, Antarctica. M. Naganobu and Y. Yoda (National Research Institute of Far Sea Fisheries, 5-7-1 Shimizu-Orido, Shizuoka, 424-8633 Japan, naganobu@affrc.go.jp), 11 pp. *CCAMLR Science*, submitted (English).

The authors compared physical parameters (temperature, salinity, density and geostrophic current) in order to investigate differences in oceanographic structures in the same area and season (summer) between the 1981 FIBEX survey and the CCAMLR-2000 Survey in the Scotia Sea, Antarctica. As a result, the distribution range of the cold Antarctic surface water (less than 0°C) in the 1981 FIBEX survey is clearly larger than was found during the CCAMLR-2000 Survey. In other words, the differences between the two surveys suggested that the Antarctic surface water, as observed in the CCAMLR-2000 Survey had, on the whole, retreated to the south compared with the 1981 FIBEX survey.

WG-EMM-04/46

Spectra analysis of Drake Passage Oscillation Index (DPOI) from 1952 to 2003, Antarctica. M. Naganobu and K. Kutsuwada (National Research Institute of Far Sea Fisheries, 5-7-1 Shimizu-Orido, Shizuoka, 424-8633 Japan, naganobu@affrc.go.jp), 4 pp. (English, unpublished).

An assessment of the environmental processes influencing variability in the recruitment and density of Antarctic krill (*Euphausia superba* Dana) is important as variability in krill stocks affects the Antarctic marine ecosystem as a whole. Naganobu et al. (1999) assessed variability in krill recruitment and density with hypothesised environmental factors, strength of westerly winds (westerlies) determined from sea-level pressure differences across the Drake Passage, between Rio Gallegos, Argentina, and Base Esperanza, at the tip of the Antarctic Peninsula, sea-ice cover and chlorophyll-*a* in the Antarctic Peninsula area during 1982–1998. Significant correlations between krill recruitment and those factors were found. Fluctuations in the westerlies across the Drake Passage were referred to as the Drake Passage Oscillation Index (DPOI). In addition, the time series of the DPOI using historical data from May 1952 to May 2003 was extended and the spectra analysis of the DPOI was tested. The spectrum peaks are 20, 35 and 55 months including short cycles of 6 and 12 months.

WG-EMM-04/47

A survey plan of the Japanese RV *Kaiyo Maru* in 2004/05 for the Ross Sea and adjacent waters, Antarctica. M. Naganobu, K. Taki and T. Hayashi (National Research Institute of Far Seas Fisheries, 5-7-1 Shimizu-Orido, Shizuoka, 424-8633 Japan, naganobu@affrc.go.jp), 5 pp. (English, unpublished).

WG-EMM-04/48

Reconciling fisheries with conservation: three examples from the Southern Ocean. R.P. Hewitt, I. Everson and C.D. Jones (Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, roger.hewitt@noaa.gov), 21 pp. *Proceedings of Fourth World Fisheries Congress*, submitted (English).

Preservation of ecosystem structure is the guiding principle by which the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) endeavours to manage the harvests of living resources of the Southern Ocean (with the notable exception of marine mammals). The experiences of CCAMLR with regard to fisheries on Antarctic krill (*Euphausia superba*), mackerel icefish (*Champsocephalus gunnari*) and Patagonian toothfish (*Dissostichus eleginoides*) are reviewed. The unifying paradigm employed by CCAMLR is the application of a precautionary approach, which explicitly incorporates uncertainty in the analysis of risk of exceeding defined management criteria. Each fishery, however, presents a

unique set of circumstances and unresolved concerns. While the current fishery for krill is small compared to the precautionary limit established by CCAMLR, fishing effort concentrated near colonies of land-breeding krill predators may pose a threat as well as those posed by the broader-scale influence of climatic cycles and trends on krill production. Management of the fishery on mackerel icefish relies on frequent surveys and short-term population projections because of high variability in natural mortality and is further complicated by the dual role of icefish as both consumers of krill and alternative prey to krill predators. While CCAMLR's management of the fishery on toothfish is based on longer-term projections and has demonstrated success in addressing incidental mortality of seabirds, large-scale misreporting of catches threatens to compromise the viability of the fishery. These concerns are discussed in the context of CCAMLR's long-term goal of feedback management schemes, whereby conservation measures are adjusted in response to ecosystem monitoring.

WG-EMM-04/49

Krill caught by predators and nets revisited: interpreting prey selection in proper temporal–spatial scales. M.E. Goebel, V. Loeb, D.P. Costa, S.N. Sexton, A.R. Banks, J.D. Lipsky and A.C. Allen (Southwest Fisheries Science Center, Antarctic Ecosystem Research Division, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, mike.goebel@noaa.gov), 27 pp. (English, unpublished).

Krill demography and recruitment are tracked through time using scientific net sampling and predator diet sampling. Comparisons of these two methods show broadly coherent results but also frequently show differences that have fuelled speculation of prey selectivity by predators. Krill, however, are not homogenously distributed and matching temporal–spatial scales of sample collections can be problematic. In this paper, ARGOS satellite location data from foraging female fur seals are used to first identify foraging habitat and its proximity to breeding colonies where diet studies are conducted. Krill length-frequency data collected over the entire western area of the US AMLR survey grid are compared with that collected only in fur seal foraging habitats. Both are compared to krill in fur seal diet. When spatial–temporal scales for the two datasets are approximated as close as possible, no difference in krill length-frequency distributions was found. It is suggested that fur seals are not selecting large krill while foraging but are instead selecting foraging locations that have larger krill in densities that maximise energy gain.

WG-EMM-04/50

Developing conceptual models of elements of the Antarctic marine ecosystem: Antarctic krill (*Euphausia superba*). S. Nicol and S. Kawaguchi (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, steve.nicol@aad.gov.au), 20 pp. (English, unpublished).

A simple generalised conceptual life-history model for Antarctic krill is developed based on observations and data from the literature. The model attempts to take into account the observed relationships between Antarctic krill and its biotic and abiotic environment. Krill life history is thus viewed as an evolved product of interactions between the species and its environment. In particular, the model focuses on the different forces that act on the larval and adult stages.

WG-EMM-04/51

A conceptual model of the krill fishery. S. Kawaguchi, S. Nicol, K. Taki and M. Naganobu (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, so.kawaguchi@aad.gov.au), 14 pp. (English, unpublished).

The behaviour patterns of Japanese krill fishing vessels in Area 48 were analysed using questionnaires on the reasons why the vessels changed their fishing grounds, which have been sent to Japanese fishing vessels since the 1989/90 fishing season. Among many reasons for changing fishing grounds, krill density and size, ice condition, transhipment and salp by-catch accounted for 95.6% of the changes. Although low krill density was the primary reason for changing fishing grounds, other seasonal factors, such as greenness or ice condition, could become important. A general picture of the seasonal succession of the Japanese krill fishing operations revealed that they tend to utilise fishing grounds close to the southern limit within the ice-free range. This pattern may well vary between nations, and it is essential to perform similar analyses for the other nations' vessels. A conceptual model for Japanese krill fishing operations is proposed.

WG-EMM-04/52

Analysis of trends in the Japanese krill fishery, and its implication. S. Kawaguchi, S. Candy, S. Nicol, K. Taki and M. Naganobu (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, so.kawaguchi@aad.gov.au), 21 pp. *CCAMLR Science*, submitted (English).

Haul-by-haul logbook data from the Japanese krill fishery from the 1980/81 to the 2003/04 fishing seasons were analysed. By using statistical modelling (linear mixed model) a series of predicted intra- and interannual trends of standardised fishery indices are presented. The results strongly suggest that the krill fisheries in the South Orkney and South Georgia areas are both operating around a critical point which is just enough to maintain the best factory performance. The status of fishing in Subarea 48.1 was not clear through this analysis. Linear correlation was observed between catch per searching time and catch per day within the lower range, suggesting these may have some value as abundance index. To refine these indices, it is necessary to collect more detailed information from fishing vessels. It is also important to undertake the same kind of analysis for fleets from other fishing nations.

WG-EMM-04/53

Developing conceptual models of elements of the Antarctic marine ecosystem: Adélie penguins. L.M. Emmerson, J. Clarke, M. Tierney and L. Irvine (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, louise.emmerson@aad.gov.au), 19 pp. (English, unpublished).

This paper presents a simple generalised conceptual life-history model of Adélie penguins based primarily on data collected from Béchervaise Island, East Antarctica. The model uses life-history categories based on an individual penguin's reproductive potential in any given year, their past reproductive experience and their spatial location. While there may be generalities which are relevant to other Adélie populations and also other penguin species, details in relation to parameter estimation and functional relationships are likely to differ.

WG-EMM-04/54

Modelling availability bias using existing time-series count data: Adélie penguins as a case study. L. Emmerson, B. Raymond and C. Southwell (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, louise.emmerson@aad.gov.au), 12 pp. (English, unpublished).

It is widely acknowledged that counts of Adélie and other penguin species at breeding sites in Antarctica during the breeding season are influenced by the date at which they are

undertaken. A count of some attribute of the population on any date may therefore need to be adjusted by some date-specific factor (termed the availability fraction) if the count is to form the basis of an estimate of the breeding population. Existing time-series count data of adult Adélie penguins from a range of sites and years around Antarctica were modelled using quantile regression to estimate the range of the availability fraction at times other than the date of last egg lay. Differences in the availability curve were found between the East Antarctic and Ross Sea regions. Spatial and temporal variability in the availability fraction is much higher prior to late November and after early January than through December. Implications for the planning of future regional-scale surveys of land-based predators are discussed.

WG-EMM-04/55

Assessing the accuracy of penguin breeding abundance estimates at regional scales in Antarctica from existing count data: a review using Adélie penguins as a case study. C. Southwell (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, colin.southwell@aad.gov.au), 29 pp. *CCAMLR Science*, submitted (English).

There is a large body of existing count data in the literature for penguins at their breeding sites in Antarctica and the sub-Antarctic islands. These data have been summarised into several compilation documents and their accuracy assessed therein on a site-by-site basis. There has been no previous attempt to determine how the accuracy of regional-scale abundance estimates derived from these data might be assessed. A formal abundance estimator appropriate to regional-scale abundance estimation from existing data is developed and the assumptions underlying that estimator outlined. Existing data for Adélie penguins are then examined to determine how well the estimator assumptions are fulfilled, and hence how accurate regional estimates of breeding populations, as derived from existing data, might be.

WG-EMM-04/56

Developing and applying a general abundance estimator for land-based predator surveys: Adélie penguins as a case study. C. Southwell (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, colin.southwell@aad.gov.au), 15 pp. *CCAMLR Science*, submitted (English).

The development of a general estimator of abundance would facilitate a standardised approach to regional and circum-Antarctic surveys of land-based predators. Such a generalised estimator is outlined, and its applicability illustrated by adapting it to the specific problem of estimating the abundance of Adélie penguins at regional scales in Antarctica, given a range of logistical scenarios and related survey designs.

WG-EMM-04/57

Changes in the foraging range of Adélie penguins as the breeding season progresses. J. Clarke and L. Emmerson (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, judy.clarke@aad.gov.au), 24 pp. *Journal of Animal Ecology*, submitted (English).

This paper describes temporal changes in foraging range throughout the breeding season of Adélie penguins nesting at Béchervaise Island on the Mawson coast of Eastern Antarctica. A decade's worth of satellite-tracking data was loaded into geographical information systems (GIS) software to produce maps of where the penguins travel to feed during each of the incubation, guard, crèche and pre-moult stages of the breeding cycle.

Penguins ranged furthest north during incubation and made their shortest trips during the guard stage of chick rearing. An annually recurrent polynya was consistently used as access to the sea during incubation.

Kernel analyses showed that penguins foraged most intensively at the continental shelf break and over submarine canyons, particularly whilst feeding chicks. Birds foraging prior to their annual moult travelled hundreds of kilometres to both the west and east of their breeding sites.

Foraging ranges at the different stages of the breeding season are consistent with the changing requirements of adults and chicks. However, increases in range as the chick-rearing period progresses are also consistent with prey depletion and intraspecific competition.

Projection of the foraging ranges demonstrated for the Mawson coast onto other Adélie penguin colonies in the Prydz Bay region indicates varying degrees of overlap depending on the stage of the breeding season and the distance between populations. Overlap in foraging ranges between neighbouring colonies is least likely when chicks are small due to shorter foraging trips at this time.

WG-EMM-04/58

Conceptual model of Antarctic epi- and mesopelagic fish. R. Williams (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, dick.williams@aad.gov.au), 10 pp. (English, unpublished).

CCAMLR is currently considering plausible models of the Southern Ocean ecosystem within WG-EMM. Epi- and mesopelagic fish are key components in the oceanic (deep-water) marine ecosystem throughout the CCAMLR Convention Area. While not in most cases the object of commercial fisheries, these generally small (<20 cm long) species are widespread and abundant and are a key link in the food chain between crustacean and larger fish, seals and birds. Data on the species' distribution, biology, ecological interactions and susceptibility to environmental change are summarised for use in ecological modelling work.

WG-EMM-04/59

Conceptual model of icefish (*Champsocephalus gunnari*). R. Williams (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, dick.williams@aad.gov.au), 10 pp. (English, unpublished).

CCAMLR is currently considering plausible models of the Southern Ocean ecosystem within WG-EMM. The icefish (*Champsocephalus gunnari*) is one of the key components in the sub-Antarctic marine ecosystem in the Scotia Sea and northern Kerguelen Plateau areas, as well as supporting commercial fisheries. Data on the species' distribution, biology, ecological interactions and susceptibility to environmental change are summarised for use in ecological modelling work.

WG-EMM-04/60

Approaches to evaluating and testing of CEMP methods for parameters A1, A5 and A7. G. Watters and K. Reid (NOAA Fisheries, Pacific Fisheries Environmental Laboratory, 1352 Lighthouse Avenue, Pacific Grove, CA 93950, USA, george.watters@noaa.gov), 18 pp. *CCAMLR Science*, submitted (English).

The methods and presentation of CEMP parameters A1, A5 and A7 were evaluated using simulated time-series data. The effects of sampling timing and intensity during five-day periods for measures of arrival and fledging mass suggested that situations where sampling is distributed unevenly around the peak arrival/fledging date may introduce substantial bias in CEMP parameters A1and A7. The description of foraging trip duration using the mean arising from a bimodal distribution of trip durations may provide a useful index of foraging performance, however, the use of the 90th percentile of the cumulative foraging effort may provide a more sensitive measure of changes arising from changes in foraging strategies of penguins.

WG-EMM-04/61

Approaches to the simplification of the summary and presentation of CEMP data. K. Reid and G. Watters (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, k.reid@bas.ac.uk), 14 pp. *CCAMLR Science*, submitted (English).

The current approach to providing advice on the status of the krill-centric ecosystem relies on the evaluation of statistical anomalies in the CEMP database. A new approach based on the ordination of variables according to functional groupings is suggested. This approach uses the methodology developed within WG-EMM to produce composite standardised indices (CSIs) from matrices containing missing data to summarise the variability in CEMP parameters.

WG-EMM-04/62

An initial analysis of the characteristics of Antarctic krill taken by the commercial fishery and Antarctic fur seals during the winters of 2002 and 2003 at South Georgia. K. Reid, D.J. Agnew, N.L. Warren and E. Owen (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, k.reid@bas.ac.uk), 18 pp. (English, unpublished).

This paper presents an initial analysis of the fishing locations, fishing depth and length-frequency distribution of krill at South Georgia during the winters of 2002 and 2003 and compares these with the length-frequency distribution and frequency of occurrence of krill in the diet of Antarctic fur seals. There were significant differences in the mean size of krill taken by vessels or measured by observers that should be addressed prior to more detailed analysis, nevertheless there was considerable overlap in the size composition of krill in the fishery and the diet of Antarctic fur seals. During the period of the winter when there was a reduction in the frequency of occurrence of krill in the diet of seals, the fishery appeared to operate at greater depth suggesting a possible depth change of krill during winter. It may be appropriate to review the number of krill measured by observers in order to ensure that sufficient time can be allocated to other activities, especially the assessment of by-catch.

WG-EMM-04/63

Monitoring krill population variability using seabirds and seals at South Georgia – new samplers provide new insights. K. Reid, E.J. Murphy, J.P. Croxall and P.N. Trathan (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, k.reid@bas.ac.uk), 23 pp. *Proceedings of the Zoological Society of London Symposium, March 2004*, submitted (English).

Variability in the Southern Ocean is often characterised by fluctuations in the distribution and abundance of a single dominant zooplankton species, Antarctic krill (*Euphausia superba*). At South Georgia interannual variability in the krill-based marine ecosystem has historically been most frequently detected in the response of upper-trophic level predators. Analysis of the changes in the population size structure of krill in the diet of Antarctic fur seals (*Arctocephalus gazella*), particularly associated with periods of low krill biomass, has shown that the population dynamics of krill is a major factor in driving the interannual variability in its abundance. The ability to sample krill in the diet of predators at temporal scales not available using conventional (i.e. ship-based) sampling methods has provided the basis for a re-evaluation of the role of recruitment variability and high rates of growth and mortality in generating the high amplitude of variability in krill abundance at South Georgia. Furthermore, the production of a consistent index of krill population size composition from the diet of predators at Bird Island over the past decade has provided evidence for a relationship between sea-surface temperature and the level of krill recruitment. Krill-dependent predators not only show distinct behavioural responses to changes in krill

abundance but also provide critical dietary data with which to elucidate the mechanisms underlying those changes. Using predators as samplers of commercial prey species can provide information on the key life-history parameters of prey species that are fundamental to reducing uncertainty in fisheries management models.

WG-EMM-04/64

Shipboard line transect surveys of crabeater seal abundance in the pack-ice off East Antarctica: evaluation of assumptions. C. Southwell, W. de la Mare, D. Borchers and L. Burt (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, colin.southwell@aad.gov.au), 20 pp. *Marine Mammal Science*, in press (English).

The extent to which the assumptions underlying line transect sampling are satisfied in shipboard surveys of crabeater seals hauled-out on the Antarctic pack-ice is examined. Crabeater seals showed little movement in response to the approaching ship. Movement away from the ship by seals close to the ship's track was partially responsible for a relative lack of sightings close to the transect-line, but otherwise had little effect on the sighting histogram. Minor deviations from the transect direction to avoid running over seals violated the assumption of uniform distribution of groups, and contributed to a relative lack of sightings, close to (<40 m) the transect line. We estimate that 5–10% of seal groups close to the transect-line were not sighted by bridge observers prior to passing abeam of the ship, but most of these missed groups were likely to have been sighted some distance behind-abeam. Shipboard transects provided a biased sample of four environmental features known to be related to crabeater seal abundance because of logistical difficulties in the ship traversing along straight transects through thick ice. Calculation of transect length L from successive GPS locations was mildly sensitive to the frequency of the locations. We provide analytical recommendations to reduce or eliminate the effect of assumption violation when present and hence minimise bias in abundance estimation.

WG-EMM-04/65

Developing conceptual models of elements of the Antarctic marine ecosystem: marine mammals. N. Gales and C. Southwell (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, nick.gales@aad.gov.au), 17 pp. (English, unpublished).

CCAMLR is currently considering plausible models of the Southern Ocean ecosystem within WG-EMM. This paper describes properties for two groups of marine mammals that may be included in future ecosystem models of the Southern Ocean: cetaceans and pack-ice breeding seals. Important ecological differences exist among and between these groups, which should be considered in the development of such models.

WG-EMM-04/66 Rev. 1

The structure and spatial distribution of Antarctic krill aggregations from acoustic surveys in the South Georgia area. S.M. Kasatkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, ks@atlant.baltnet.ru), 14 pp. *CCAMLR Science*, submitted (English).

Results of acoustic surveys carried out during the winter months of 2000 and 2002 show significant distinctions between the spatial distribution patterns of krill in the northwestern and northeastern parts of South Georgia. The boundary between the two areas is located at about 37°30'W. It is shown that in winter months, the northwestern sector, where foraging grounds of dependent predators are located, is unattractive to the fishery. Areas in which krill density was observed to exceed the threshold value of 100 g/m^2 and therefore identified as potential fishing grounds, were located in the northeastern part of South Georgia.

A comparison of krill aggregation structures in the northwestern and northeastern parts of South Georgia gives grounds to assume that a dispersed distribution (layers and irregular forms) suits the foraging tactics of dependent predators much better than krill distribution in the form of dense swarms or patches which, on the other hand, are attractive to the fishing fleet. The results indicate that not only krill biomass density, but also its availability as determined by characteristics of krill distribution, may be very important both to fishery and to dependent species. Therefore, investigations of the foraging tactics of dependent predators and a comparison of the availability of different patterns of krill aggregation to the fishery and to dependent predators are important for an understanding of how the interaction between upper-trophic level predators and krill biomass might be used to manage levels of krill fishing effort.

WG-EMM-04/67

A review of models of Southern Ocean ecosystems: krill, ecosystems and the impacts of harvesting. S.L. Hill, E.J. Murphy, K. Reid, P.N. Trathan and A.J. Constable (British Antarctic Survey, Natural Environment Research Council, Madingley Road, High Cross, Cambridge CB3 0ET, United Kingdom, sih@bas.ac.uk), 55 pp. (English, unpublished).

An ecosystem approach for the management of human activities in the Southern Ocean is enshrined in the principles of CCAMLR. The implementation of such an approach requires an understanding of the wider dynamics of the ecosystem, which is best achieved through the development of ecosystem models. However, not all models will be suitable for developing an ecosystem approach to management. To facilitate the development of ecosystem models appropriate for CCAMLR, the existing models of Southern Ocean ecosystems that include krill and the higher trophic levels are reviewed. Modelling approaches from elsewhere in the world are also briefly considered. The main categories considered are models of krill populations and life cycles, predator–prey models and models of ecosystems. A range of approaches has been developed in each of these categories and the major results of each approach are reviewed. Finally, the issues highlighted by the studies that are still relevant today are discussed, and note is made of where major requirements for model development were identified.

WG-EMM-04/68

Predation on cephalopods by *Pygoscelis papua* and *Arctocephalus gazella* at the South Orkney Islands. M.M. Libertelli, G.A. Daneri, U. Piatkowski, N.R. Coria and A.R. Carlini (Instituto Antártico Argentino, Cerrito 1248, 1010 Buenos Aires, Argentina, aguara35@ yahoo.com.ar), 16 pp. *Polish Polar Biology*, submitted (English).

The cephalopod diet of the gentoo penguin (*Pygoscelis papua*) and the Antarctic fur seal (*Arctocephalus gazella*) was comparatively analysed at Laurie Island, South Orkney Islands. A total of 125 stomach samples was collected from gentoo penguins by the water off-loading method during the autumns of 1993, 1995 and 1996, and 39 fur seal scats were collected from mid-March to April 1988.

Cephalopods preyed on by gentoo penguins were represented by 1 974 beaks (1 628 lower, 346 upper) which occurred in 50.4% of the samples. Lower beaks identified belonged exclusively to the squid *Psychroteuthis glacialis*. The mean lower rostral length (LRL) of these beaks was 1.1 mm (range 0.4–1.8 mm).

From the Antarctic fur seal scats, 103 beaks (41 lower, 62 upper) were removed from 60.6% of scats which contained prey remains. The cephalopod species identified were *Slosarczykovia circumantarctica* and *P. glacialis* which constituted 78.8 and 21.1% respectively in terms of numbers. The mean lower rostral length for *S. circumantarctica* was 2.7 mm (range 2.0–3.5 mm), while that of *P. glacialis* was 1.6 mm (range 1.0–2.5 mm).

The foraging behaviour of the two top predators was analysed and discussed according to the composition and size of their cephalopod prey.

WG-EMM-04/69

Ecological implications of body composition and thermal capabilities in young Antarctic fur seals (*Arctocephalus gazella*). M.R. Rutishauser, D.P. Costa, M.E. Goebel and T.M. Williams (Long Marine Laboratory, 100 Shaffer Road, Santa Cruz, CA 95060, USA, rutishauser@biology.uscc.edu), 41 pp. *Physiological and Biochemical Zoology*, accepted (English).

In comparison to other homeotherms, young recently weaned marine mammals in high latitudes face exceptional energetic demands when foraging and thermoregulating. Lipids are an important source of energy and a major component of insulation that allow them to meet these demands. To examine the role of lipid stores in a high-latitude pinniped, the body composition and thermoregulatory capabilities of Antarctic fur seal (*Arctocephalus gazella*) pups and yearlings were measured via flow-through respirometry and hydrogen isotope dilution. From these data we constructed a model to examine the importance of post-weaning fasting capability in free-ranging, young fur seals. Resting metabolic rates were different for pups and yearlings measured in 0.6°C water, 10.3°C water and ambient air; however, mass and lipid percentage as covariates accounted for the different metabolic responses in pups and yearlings for all treatments. The estimated lower critical temperature for combined pups and yearlings was 14.4°C, 10–15°C above water temperatures normally experienced by Antarctic fur seals. Modelling predicted that a weaned fur seal pup would survive at-sea from 9.8 to 36.2 days before succumbing to starvation. The most likely maximum travel distance within this time constraint suggests food resources close to the natal rookery are important to first-year survival for this species.

WG-EMM-04/70

Review of the CEMP standard methods and their delivery to the CEMP database. C. Southwell, J. Clarke, K. Reid, G. Watters and D. Ramm (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, colin.southwell@aad.gov.au), 33 pp. (English, unpublished).

This paper reports on the discussions that occurred among individuals tasked by WG-EMM to continue the review of the CEMP standard methods and their delivery to the CEMP database. The discussions were diverse in covering a wide range of parameters, methods and issues, but in the limited time available it was not possible to discuss all aspects of CEMP. The issues considered are presented under broad themes with some historical background to the development of those themes provided as context. Issues relating to each theme that were discussed by the group are summarised, and recommendations for any work or action are provided.

WG-EMM-04/71

Preliminary results of a survey on krill, environment and predators in CCAMLR Subarea 88.1 carried out in December 2003 and January 2004 (Project 8.4). M. Azzali, A. Russo, A. Sala, A. de Felice and B. Catalano (Istituto di Ricerca Marittima (ISMAR-CNR) sez. Ancona, Largo Fiera della Pesca, 60100 Ancona, Italy, azzali@irpem.an.cnr.it), 24 pp. (English, unpublished).

In December 2003–January 2004 four synoptic surveys were conducted in CCAMLR Subarea 88.1 (Ross Sea): acoustic survey on two krill species (*Euphausia superba* and *E. crystallorophias*), net sampling of krill and other pelagic species, visual sampling of krill

predators and CTD and XBT sampling of water masses. This paper describes the aim and conduct of the project and the instruments and methods used, and presents some preliminary results.

WG-EMM-04/72

Krill and zooplankton populations monitored during AMLR 2004 surveys (Subarea 48.1) with respect to the long-term Elephant Island area datasets. V.J. Loeb (Moss Landing Marine Laboratories, 8272 Moss Landing Road, Moss Landing, CA 95039, USA, loeb@mlml.calstate.edu), 14 pp. (English, unpublished).

Net sampling during annual field season activities of the US Antarctic Marine Living Resources (AMLR) Program yielded about average concentrations of post-larval krill during January and February–March surveys. Overall length-frequency distributions and maturity stage composition reflected good recruitment of the 1990/2000, 2000/01 and 2001/02 year classes and little contribution from the 2002/03 season. Although little reproductive activity and unusually large proportions of immature individuals occurred in the Elephant Island area during January, larval concentrations and maturity stage composition indicated a very early onset of seasonal spawning activity. Krill demographics during February–March indicated an influx of large spawning individuals; these, along with greatly increased concentrations of larval stages, suggested potentially good recruitment success from the 2003/04 year class.

The 2004 survey period was marked by a rapid and large-scale change in overall zooplankton abundance, composition and species abundance relations. This was similar to marked 'transition periods' observed in 1994 and 1997 and, like those, was believed to result from hydrographic rather than biological processes. Qualitative differences between this and previous transition periods highlighted significant changes in zooplankton abundance and abundance relations, frequency of krill recruitment success and sea-ice development that coincided with an oceanic–atmospheric 'regime shift' affecting the Pacific Ocean basin.

Working Group on
Fish Stock Assessment
Subgroup on Assessment Methods

WG-FSA-SAM-04/4

Further development of the fishery plans. CCAMLR Secretariat, 467 pp. (English, unpublished).

The Secretariat has been developing Fishery Plans under the Regulatory Framework established by the Scientific Committee and Commission. In recent years, plans have been drafted for the krill fishery in Area 48 (see WG-EMM-01/7, 02/6 and 03/28) and other fisheries (see WAMI-01/5, WG-FSA-02/9 and 03/6). Each Fishery Plan draws together the history of management measures and fishery requirements agreed by the Commission, as well as key operational information for each fishery.

In 2004, the Secretariat undertook a major reorganisation and reconstruction of the database which holds the time series of information used in the Fishery Plans. This information includes:

- management measures and fishery requirements reported in the *Schedule of Conservation Measures in Force*;
- other management information reported in the reports of the Scientific Committee and Commission;
- operational and catch information derived from data submitted to CCAMLR.

In addition, the layout of the Fishery Plan was revised and the information is now presented under three sections:

1. management measures and fishery requirements;
2. operational aspect (i.e. 'what really happened');
3. catches (STATLANT, fine-scale and in-season datasets).

This paper outlines these further developments.

WG-FSA-SAM-04/5

Update on the external review of the Generalised Yield Model (GYM) software and manual. CCAMLR Secretariat, 10 pp. (English, unpublished).

In 2003, WG-FSA requested that the Secretariat supervise an external review of the GYM software and manual (SC-CAMLR-XXII, Annex 5, paragraph 9.18). The key steps in this proposed review included:

- Members providing guidance on the scope of the review;
- Members proposing appropriate independent experts to conduct the review;
- reviewer to complete the review by the end of June 2004 and report to WG-FSA-SAM at its meeting in July 2004;
- WG-FSA-SAM to consider the review and advise WG-FSA.

A call for expressions of interest for the review was made in March 2004 (SC CIRC 04/06); the deadline for responses was 23 April. Members did not provide formal feedback or expressions of interest, and the window of opportunity for conducting a review before the 2004 meeting of WG-FSA-SAM passed.

As a way forward, it is proposed that WG-FSA-SAM determine exactly what the group would like to see in terms of an external review of the GYM. The Secretariat could then send a new call for tenders in August 2004. Members could then evaluate tenders at the meeting of WG-FSA in October 2004, and SC-CAMLR-XXIII could consider the outcome of this process and secure appropriate funding for a review in 2005.

WG-FSA-SAM-04/7

Feasibility of trawl surveys to estimate abundance of juvenile toothfish in Subarea 88.1. R.L. O'Driscoll, B.A. Wood and S.M. Hanchet (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, r.odriscoll@niwa.co.nz), 19 pp. (English, unpublished).

This report presents results from a desktop study to determine the feasibility of conducting trawl surveys for juvenile toothfish in Subarea 88.1 (Ross Sea). Potential problems including a largely unknown juvenile distribution, variable ice cover, large survey area, and rough bottom topography, were considered using data from published and unpublished literature, the exploratory longline fishery and previous research cruises.

The major limitation on a trawl survey in the Ross Sea is ice cover. On average over the last three years, 63% of the seabed area from 0–600 m depth was not fishable in January–February because of ice. Ice cover varied greatly between years, with the untrawlable area ranging from 31% in 2002 to 89% in 2002. Less than 10% of the potential trawl survey area was fishable in all three years.

WG-FSA-SAM-04/8

Approaches to monitoring and assessing toothfish in new and exploratory fisheries, with particular reference to Subarea 88.1. S.M. Hanchet and R.L. O'Driscoll (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, s.hanchet@niwa.co.nz), 21 pp. (English, unpublished).

This report presents results from a desktop study to consider approaches to monitoring and assessing toothfish in new and exploratory fisheries. Standardised CPUE analysis, quantitative research longline surveys, experimental manipulation of fishing effort, tagging programs, bottom trawl surveys of juvenile grounds and acoustic surveys are reviewed. Because of potential biases the authors believe that it would be imprudent to rely solely on any one of these methods at the present time. It is recommended that tag–recapture experiments, or trawl surveys, be used in conjunction with experimental manipulation of effort to monitor toothfish, and perhaps as importantly, the wider ecosystem effects of the toothfish fisheries. It is further recommended that simulation studies be carried out to determine the best way to use the effort manipulation approach in all new and exploratory fisheries, and in particular the current active fisheries (e.g. Subareas 88.1 and 88.2 and Division 58.4.2). Such studies should examine the spatial and temporal scales required for this approach and possible methods (and sample sizes) required to implement the pulsed fishing experiments.

WG-FSA-SAM-04/9

Application of the bootstrap method in assessments of target strength regression parameters on the basis of *in situ* measurements. P.S. Gasyukov and S.M. Kasatkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, ks@atlant.baltnet.ru), 10 pp. (English, unpublished).

Target strength (TS) as a function of fish length (L) must be known to estimate fish density in acoustic surveys. This TS-length function may be estimated by comparing *in situ* acoustic measurements with the fish size composition from trawl catches and should be accompanied with accuracy indices characterising the uncertainty of its parameters. This paper shows that the bootstrap-method is a highly efficient method of estimating the parameters of TS-length functions and emphasises that calculation results depend on the adopted mapping rule of fishing data into acoustic data. The bootstrap method has been applied to data from icefish measurements. The TS-length functions based on full probability density functions (PDFs) of fish length and target strength at 38 kHz and truncated PDFs are presented. It is revealed that it is probably necessary to use different regression equations for different length ranges.

WG-FSA-SAM-04/10

Revision of the icefish (*Champsocephalus gunnari*) stock estimate in the South Georgia area based on the 2002 Russian acoustic trawl survey. S.M. Kasatkina and P.S. Gasyukov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, ks@atlant.baltnet.ru), 12 pp. (English, unpublished).

A revision of the icefish (*Champsocephalus gunnari*) stock estimate in the South Georgia area was triggered by the development of the following aspects of acoustic trawl surveys: an improvement in the method of processing target strength estimates using *in situ* measurements; the combination of trawl and acoustic survey results for icefish biomass estimates.

The authors discuss these aspects and present a new estimate of icefish target strength obtained using *in situ* measurements, data analysis by the bootstrap method and biomass estimates. Major sources of uncertainty in icefish stock estimates and some ways of improving icefish stock estimates are also shown.

WG-FSA-SAM-04/11

Bottom trawl catchability in relation to icefish (*Champsocephalus gunnari*). S.M. Kasatkina and V.F. Ivanova (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, ks@atlant.baltnet.ru), 13 pp. (English, unpublished).

The paper presents an analysis of catchabilities of the Russian HAK-4M trawl, as used in bottom trawl surveys of icefish. An analysis of total and differential catchability (that is trawl catchability in relation to fish of different lengths) was carried out using statistical probability models for fishing trawls. The influence of trawling speed, trawl configuration and distribution patterns of fish aggregations on trawl catchability is revealed. It is demonstrated that the bottom trawl could not be currently used as a measuring system. A discussion of ways of improving trawl survey methods relating to the use of the bottom trawl as a measuring system is provided.

WG-FSA-SAM-04/12

Variants of the ASPM assessment of the toothfish (*Dissostichus eleginoides*) resource in the Prince Edward Islands vicinity which attempt to reconcile CPUE and catch-at-length data. A. Brandão and D.S. Butterworth (Marine Resource Assessment and Management Group, Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa, bela@maths.uct.ac.za), 21 pp. (English, unpublished).

Two variants of the ASPM assessment of the Prince Edward Islands toothfish resource are examined. One allows for the possibility of changes in somatic growth rate in response to increased food availability as resource abundance drops. The other permits annual fluctuations about a deterministic stock-recruitment relationship. A fit of the first variant yields the biologically implausible result of a decrease in somatic growth rate as abundance drops. For the recruitment variability model, results remain highly sensitive to the relative weights given to CPUE and catch-at-length data in the model fitting processes. Therefore, unfortunately, neither of the variants examined appears able to resolve the discrepancy between the implications of the CPUE and the catch-at-length data regarding the current status of the resource.

WG-FSA-SAM-04/13

Development of a population model for the assessment of Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea. A. Dunn, D.J. Gilbert, S.M. Hanchet and B. Bull (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 14-901, Kilbirnie, Wellington, New Zealand, a.dunn@niwa.co.nz), 24 pp. (English, unpublished).

Catch-per-unit-effort for New Zealand vessels, catch-at-age proportions in the catch from New Zealand vessels, and tag–release and tag–recapture data from New Zealand vessels operating in the Ross Sea are included with a preliminary model using the generalised stock modelling software CASAL.

The CASAL software allows for alternative scenarios on stock structure, while including a variety of options for incorporating processes for maturity, catch, migration, fishery selectivities, and tag–release and tag–recapture data either by length or by age. It also allows for stratification by an arbitrary number of areas and time-steps. As well as generating point estimates of the parameters of interest (maximum posterior density or maximum likelihood), CASAL can calculate likelihood or posterior profiles, and can generate Bayesian posterior distributions using Monte Carlo Markov Chain methods. In addition, the CASAL model can be employed as an operating model simulator, allowing investigation of model performance and assessing the impact of model misspecification.

An initial model was run using three time steps (summer fishery, winter spawning and a time for nominal age incrementation). A single fishing selectivity in a single area was assumed with tag–release and tag–recapture data included as observations for the model. In this paper, these results are compared to estimates from tag–recapture Petersen abundance estimates.

The initial model run suggested better spatially structured fisheries data would substantially improve fits, and, in addition, model performance would be improved by the inclusion of a greater volume of tag–recapture data. While model results are reported for the purposes of the discussion, these are preliminary, based on incomplete data, and possibly inadequate model assumptions. Hence, any quantitative results presented in this report should not be used to formulate conclusions on the stock status of Ross Sea Antarctic toothfish.

WG-FSA-SAM-04/14

Estimating the level of illegal fishing using simulated scaling methods on detected activity. I. Ball (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, ian.ball@aad.gov.au), 16 pp. (English, unpublished).

At its 2003 meeting, WG-FSA recommended that investigations be undertaken to determine whether the method for estimating catches from illegal, unregulated or unreported (IUU) fishing developed by Agnew and Kirkwood (2002) for Subarea 48.3 could be applied to other CCAMLR areas (SC-CAMLR-XXII, Annex 5, paragraph 3.18).

The results of these simulations suggest that more information on IUU fleet dynamics, particularly evasion tactics, will be necessary to devise an observation strategy for estimating the number of IUU fishing days, particularly for areas where patrolling may be relatively infrequent or prone to evasion. Also, the assessment method may need to be refined to take these issues into account.

An important consideration for the future will be the inevitable tension for fishery patrol vessels between detecting IUU activity, thereby estimating the number of IUU fishing days, and deterring such activity. For assessment purposes, this highlights a general problem that the method of observation has a strong effect on the behaviour of the system (of the illegal fishing cruises). It may be necessary to develop other forms of observations to facilitate this task.

WG-FSA-SAM-04/15

Technical specifications of Fish Heaven: version 2.1.5. I. Ball (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kinston 7050, Tasmania, Australia, ian.ball@aad.gov.au), 27 pp. (English, unpublished).

WG-FSA-SAM-04/16

Survey estimates of recruitment of toothfish in Subarea 48.3. D.J. Agnew, J. Moir-Clark, R.C. Wakeford, M. Collins and M. Belchier (MRAG Ltd, 18 Queen Street, London W1J 5PN, United Kingdom, d.agnew@imperial.ac.uk), 20 pp. (English, unpublished).

This paper reanalyses 16 groundfish surveys at South Georgia to determine whether recruitment data used by WG-FSA in 1999 and later were correct. Several unexplainable errors were found. A new, corrected, series of recruitment estimates was derived using new procedures and six strata (three depth strata each at Shag Rocks and South Georgia). It is easy to spot, visually, the modal progression of peaks in the length densities corresponding to cohorts assessed by sequential surveys. Length-based analysis of these confirms the growth rate expected from the CCAMLR growth equation for South Georgia. Although it is easy to spot cohorts, the size of individual cohorts cannot be consistently determined from the survey data. The expected reduction in cohort density with time at a log-scale rate of –0.16 (natural mortality) was evident in only very few cohort plots, even those which were particularly obvious as visual modal progressions, and even when the data were trimmed to remove suspect surveys. It is concluded that survey-based estimates of recruitment biomass are not reliable input data for assessment models using the GYM approach at South Georgia.

WG-FSA-SAM-04/17

Alternative assessment methods for toothfish at South Georgia. D. Agnew, A. Payne and G. Kirkwood (MRAG Ltd, 18 Queen Street, London W1J 5PN, United Kingdom, d.agnew@imperial.ac.uk), 14 pp. (English, unpublished).

Two alternatives to the survey recruitment/GYM for estimating toothfish abundance are examined. An age-structured production model (ASPM) is constructed and tuned to the CPUE series. The fit of the model to the CPUE series is not good, and there are several unexplained problems. The first is that the CPUE in the early 1990s did not decline as would be expected as the resource was initially fished quite heavily. The second is that when a decline was seen, it was much more abrupt than would be predicted by the model. Thirdly, all models predict a continuing decline, not the increase in CPUE that actually has been seen since 1996. Fitting the model to partial CPUE series, or assuming an unknown additional level of IUU fishing, improves the fit of the model but does not fully explain the initial lack of early decline, the abrupt decline between 1995 and 1996 and the subsequent increase in CPUE. Toothfish have been tagged at South Georgia since 2000, and it is possible now to examine the usefulness of tagging data to estimate population size. Two equations are used: the Jolly–Seber unbiased method and a simple M- and tagging-mortality adjusted Petersen estimator. This latter analysis suggests biomass in 2002 was between 78 000 and 114 000 tonnes.

WG-FSA-SAM-04/18

Estimating toothfish biomass in Subarea 48.3 using local depletions. D. Agnew and J. Pearce (MRAG Ltd, 18 Queen Street, London W1J 5PN, United Kingdom, d.agnew@imperial.ac.uk), 12 pp. (English, unpublished).

Local depletions of toothfish are investigated under concentrated fishing effort as a means of estimating toothfish density at South Georgia. Over the four years 2000–2003, 25 areas of 12' by 12' where there had been forty or more hauls in any particular year were found. There were 62 individual vessel fishing events in these areas over this period, 40 of which appeared

to be depletions. Applying a Leslie method derived toothfish densities in these areas which were linearly correlated with the initial CPUE experienced by the fishing vessels. Using this correlation, combined with the average CPUE over the four years and multiplying by the total fishable area in Subarea 48.3, gave an estimate of total toothfish biomass of 55 666 tonnes. Clearly this method requires development, but it does hold out some possibility of potential as an alternative assessment method for toothfish.

WG-FSA-SAM-04/19

Considerations on the design and evaluation of surveys for estimating recruitment of Patagonian toothfish (*Dissostichus eleginoides*) with preliminary outcomes for the Heard Island Plateau region (Division 58.5.2). C.R. Davies, S. Candy and A.J. Constable (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, campbell.davies@aad.gov.au), 14 pp. (English, unpublished).

Assessments of long-term sustainable yield using the Generalised Yield Model and the setting of catch limits for Patagonian toothfish (*Dissostichus eleginoides*) for the Heard Island Plateau region (Division 58.5.2) are based on data obtained from annual random stratified trawl surveys (RSTS) and from targeted commercial fishing operations via an observer program. The current RSTS design for Division 58.5.2 is reviewed and estimates of optimal distribution of trawl stations among strata provided for estimates of abundance of individual pre-recruitment age classes and total abundance for a range of levels of confidence. The results indicate that while the current and previous survey stratifications appear appropriate, the current levels of survey effort are not sufficient to provide reasonable levels of confidence in the estimates of abundance for all but the youngest year class. It is recommended that the implications of these results need to be examined as part of a full evaluation of the current management procedure for *D. eleginoides* in Division 58.5.2 in order to determine the potential implications for meeting long-term yield and conservation objectives. An approach to progressing such evaluations in the context of the elements of the current monitoring and assessment methods is outlined.

WG-FSA-SAM-04/20

Does the current South Georgia groundfish survey accurately estimate the standing stock of mackerel icefish? M. Collins, J. Xavier, K. Reid, M. Belchier, C. Goss and D. Agnew (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, macol@bas.ac.uk), 24 pp. (English, unpublished).

In Subarea 48.3 mackerel icefish (*Champsocephalus gunnari*) are currently assessed by a bottom trawl survey, but evidence from predators and acoustics indicates that a considerable portion of the icefish biomass is in midwater and therefore missed by the bottom trawl survey. In January 2004, a short acoustic survey on FPRV *Dorada* showed that mackerel icefish, of all age classes, spend time in midwater and reinforced the evidence that a bottom trawl survey significantly underestimates biomass. An acoustic survey has the potential to give a better estimate of icefish biomass, however acoustic methods need to be developed to distinguish between krill and icefish and to improve target strength estimates of icefish.

Working Group on
Fish Stock Assessment

WG-FSA-04/5 Rev. 1
Fishery-related information for WG-FSA-04. CCAMLR Secretariat, 25 pp. (English, unpublished).

WG-FSA-04/6 Rev. 1
A summary of observations on board longline vessels operating within the CCAMLR Convention Area. CCAMLR Secretariat, 25 pp. (English, unpublished).

WG-FSA-04/7 Rev. 1
Summary of observations on board trawlers operating in the Convention Area during the 2003/04 season. CCAMLR Secretariat, 12 pp. (English, unpublished).

WG-FSA-04/8 Rev. 1
A summary of scientific observations related to Conservation Measures 25-01 (1996), 25-02 (2003) and 25-03 (2003). CCAMLR Secretariat, 15 pp. (English, unpublished).

WG-FSA-04/10
Antarctic icefishes (Channichthyidae) – a unique family of fishes – a review. K.-H. Kock (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany, karl-hermann.kock@ish.bfa-fisch.de), 102 pp. (English, unpublished).

Icefish are a family of species unique among vertebrates in that they possess no haemoglobin. With the exception of one species, icefish live only in the cold, stable and oxygen-rich environment of the Southern Ocean. It is still questionable how old icefish are in evolutionary terms: they may not be older than 6 million years, i.e. they evolved well after the Southern Ocean started to cool down, or they are 15–20 million years old and started to evolve some time after the formation of the Antarctic Circumpolar Current. Certain icefish species, such as *Chionobathyscus dewitti*, have been found at depths of more than 2 000 m. Icefish have been shown to present organ-level adaptations on different levels to compensate for the 'disadvantages' of lacking respiratory pigments. Biological features, such as reproduction and growth, are not unique and are comparable to other notothenioids living in the same environment. Icefish produce large yolky eggs which have a diameter of more than 4 mm in most species. Most icefish species do not attain maturity before they are 5–8 years old. The spawning period of most icefish species is autumn–winter. The incubation period spans from two months in the north of the Southern Ocean to more than six months close to the continent. Growth in icefish to the extent it is known is fairly rapid. They grow 6–10 cm in length per annum before they reach spawning maturity. Icefish feed primarily on krill and fish. Some icefish species are abundant enough to be exploited by commercial fisheries, primarily in the 1970s and 1980s with *Champsocephalus gunnari* as the main target species. Most stocks of this species had been overexploited by the beginning of the 1990s.

WG-FSA-04/11
Seabird mortality in the Patagonian toothfish longline fishery around Crozet and Kerguelen Islands, 2001–2003. K. Delord, N. Gasco, H. Weimerskirch and T. Micol (Centre d'Etudes Biologiques de Chizé/Centre National de la Recherche Scientifique, 79 360 Villiers en Bois, France, delord@cebc.cnrs.fr), 41 pp. *CCAMLR Science*, submitted (French and English).

The legal Patagonian toothfish longline fishery operating in the French EEZ of Crozet (Subarea 58.6) and Kerguelen (Division 58.5.1) killed 26 668 seabirds, accidentally drowned,

during 24 months of fishing between September 2001 and August 2003. Overall, white-chinned petrels (*Procellaria aequinoctialis*) were by far the most frequently killed species, and large numbers of grey petrels (*P. cinerea*) were incidentally taken. Giant petrels, black-browed and grey-headed albatrosses were also caught over this period. The multivariate analysis contributed to highlight that a combination of variables (environmental and relating to fishing techniques) have an effect on the observed incidental capture of seabirds.

WG-FSA-04/12

Diet of grey-headed albatrosses at the Diego Ramírez Islands, Chile: ecological implications. J. Arata, G. Robertson, J. Valencia, J.C. Xavier and C.A. Moreno. *Antarctic Science*, 16 (3): 263–275 (2004). (English).

The diet of grey-headed albatrosses at Diego Ramírez, Chile, was analysed and compared to that of the sympatric black-browed albatross. Diet composition was inferred from an analysis of prey hard parts present in 103 chick regurgitates obtained during breeding seasons 2000, 2001 and 2002. The squid *Martialia hyadesi* predominated in the diet samples in 2001 and 2002 (89% and 81% of reconstituted mass), but was absent from the 2000 samples. Reconstituted mean mass per sample in 2000 was significantly lower than in 2001 and 2002. Chick growth rate during 2000 was also the lowest recorded. This suggests that *M. hyadesi* plays an important role in the breeding performance of grey-headed albatrosses at Diego Ramírez. Low presence of *M. hyadesi* in grey-headed albatrosses' diet at South Georgia in 2000, a year with significant low breeding success, suggests ocean-wide processes affecting the availability of this prey to both populations simultaneously. Overlap in diet composition, and inferred feeding areas, between the sympatric albatross species at Diego Ramírez was minimal. Grey-headed albatrosses fed mainly on species associated with the Antarctic Polar Front, whereas black-browed albatrosses consumed benthopelagic species frequently caught in fishing operations in southern Chile.

WG-FSA-04/13

Seabird by-catch update on industrial Patagonian toothfish fishery in southern Chile. J. Arata, C.A. Moreno and R. Hucke-Gaete (Instituto de Ecología y Evolución, Universidad Austral de Chile, Casilla 567, Valdivia, Chile, javierarata@entelchile.net), 8 pp. (English, unpublished).

Implementation of the FAO National Plans of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries (NPOA-Seabirds) requires firstly an assessment of all longline fisheries in which incidental mortality of seabirds is presumed to occur. Chile took this responsibility in 2001 and started the NPOA-Seabird process by estimating the seabird by-catch in the Patagonian toothfish fishery in southern Chile, a fishery and zone with a high probability of having significant levels of incidental mortality. Final results of this study are presented in this paper. Seabird by-catch rates in 2002 had a markedly temporal pattern, with very high values from September to December (0.37 to 1.28 birds/thousand hooks). The main species caught was the black-browed albatross (96% of total birds). Considering the monthly fishing effort and by-catch rate, during 2002 an estimated total of 2 162 birds were incidentally killed. This result determined the initiation of the NPOA to reduce seabird incidental mortality in all longline fisheries in Chile, which is being developed during 2004 with the close collaboration of all industrial fishery companies. Despite these by-catch levels, the black-browed albatross population at Gonzalo Island, Diego Ramírez Islands, seems to be increasing.

WG-FSA-04/14

Chilean NPOA-Seabirds: first steps. C.A. Moreno and J. Arata (Instituto de Ecología y Evolución, Universidad Austral de Chile, Casilla 567, Valdivia, Chile, javierarata@ entelchile.net), 3 pp. (English, unpublished).

WG-FSA-04/17

Mitigation measures of fur seal entanglement by Japanese krill vessels. Delegation of Japan, 5 pp. (English, unpublished).

Mitigation measures for incidental fur seal entanglements employed by Japanese krill trawl vessels are illustrated.

WG-FSA-04/19

Preliminary analyses of data collected during experimental fishing for Patagonian toothfish in international waters of the southwest Indian Ocean (Area 51). L.J. López Abellán (Instituto Español de Oceanografía, Centro Oceanográfico de Canarias, Ctra. de San Andrés No. 45, Santa Cruz de Tenerife, Spain, luis.lopez@ca.ieo.es), 8 pp. *CCAMLR Science*, submitted (English).

Experimental fishing for Patagonian toothfish took place during the period from 28 June to 27 July 2003. This experiment was carried out by a Spanish longliner, following commercial procedures, in a restricted area south of Madagascar and north of the Prince Edward and Marion Islands and the Crozet Islands, and outside EEZs and CCAMLR waters. A total of 57 sets was taken at between 360 and 1 950 m depth. Patagonian toothfish were present in all sets with catches weighing between 53 and 1 158 kg. The northward distribution of Patagonian toothfish is closely related to the extension of the sub-Antarctic Front to the north. The prospected area would seem to be located at the edge of the main ground, in which a residual recruitment effect persists. The total CPUE was 42.21 kg/thousand hooks. Depth is the most important factor in Patagonian toothfish distribution within the study area.

WG-FSA-04/20

A characterisation of the toothfish fishery in Subareas 88.1 and 88.2 from 1997/98 to 2003/04. S.M. Hanchet, M.L. Stevenson, N.L. Phillips and P.L. Horn (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, s.hanchet@niwa.co.nz), 23 pp. (English, unpublished).

An exploratory fishery for Antarctic toothfish (*Dissostichus mawsoni*) has been in operation for seven seasons in Subarea 88.1 and for three seasons in Subarea 88.2. A large amount of data on toothfish and the associated by-catch from the fishing operations has been collected. This report is somewhat different to earlier reviews of the exploratory fishery. In the first instance, it reports catches by the new SSRUs used to manage Subarea 88.1; secondly, the report includes catch data from all countries fishing in the area, whereas previous reports included data from only New Zealand vessels; and thirdly, the reported catch is confined to C2 data.

The catch of *D. mawsoni* was 2 414 tonnes, and contributed 87% of the total catch in 2004. *D. mawsoni* was the dominant species caught in all 12 SSRUs fished. In 2004, about 12 tonnes of Patagonian toothfish (*D. eleginoides*) was taken, almost entirely from SSRU 881B. The main by-catch species was *Macrourus whitsoni*, which contributed about 11% of the 2004 catch. By-catch of skates (mainly *Amblyraja georgiana*) was only 19 tonnes (less than 1% of the total catch[1]). Other by-catch species (including morid cods, icefish and moray cods) each contributed less than 1% of the overall catch.

Because of changes in ice condition and fleet composition, no two seasons have been the same. In 2001, 2003 and 2004, ice conditions restricted fishing and resulted in new areas being explored. The change in fishing patterns between seasons is reflected in the mean

length and age composition of the catch. In the past few seasons, there has been a trend towards fishing in deeper water and this is reflected in an increase in the length and age of the toothfish catch and in the by-catch, particularly the increase in catch of morid cods and icefish.

An approach to allocating the rattail catch to the SSRUs in Subarea 88.1 was examined. The indicative catch limits appear to be little better than the catch limits set for the 2004 season. Further examination of the problem is warranted.

[1] Note that this does not include skates released at the surface.

WG-FSA-04/21

Genetic structuring of Patagonian toothfish populations in the southwest Atlantic Ocean: the effect of the Antarctic Polar Front and deep-water troughs as barriers to genetic exchange. P.W. Shaw, A.I. Arkhipkin and H. Al-Khairulla (School of Biological Sciences, Royal Holloway University of London, Egham TW20 0EX, United Kingdom, p.shaw@rhul.ac.uk), 12 pp. *Molecular Ecology* (2004), in press (English).

The environmental and/or life history factors affecting genetic exchange in marine species with potential for high dispersal are of great interest, not only from an evolutionary standpoint but also with regard to effective management. Previous genetic studies have demonstrated substantial differentiation among populations of the Patagonian toothfish around the Southern Ocean, indicating breakdown of gene flow across large distances between inhabited shelf areas. The present study examined genetic structuring through analysis of microsatellite loci and restriction fragment length poymorphism (RFLP) of the mitochondrial ND2 gene and control region of the toothfish population in the SW Atlantic, allowing examination of the relative effects of the Antarctic Polar Front (APF), deep-water troughs and distance between sites. Mitochondrial DNA (mtDNA) data indicated a sharp genetic division between the Patagonian Shelf/North Scotia Ridge and the Shag Rocks/South Georgia samples, whereas microsatellite data showed much less distinct structuring and an intermediate position of the North Scotia Ridge samples. We suggest these data indicate that the APF, as a barrier to larval dispersal, is the major inhibitor of genetic exchange between toothfish populations, with deep-water troughs and distance between sites contributing to genetic differentiation by inhibiting migration of relatively sedentary adults. We also suggest that differences between mtDNA and nuclear DNA population patterns may reflect either genome population size effects or (putative) male-biased dispersal.

WG-FSA-04/22

United States research under way on seabirds vulnerable to fisheries interactions. Delegation of the USA (Compiled by K.S. Rivera, National Marine Fisheries Service, Alaska Region, PO Box 21668, Juneau, AK 99802, USA, kim.rivera@noaa.gov), 15 pp. (English, unpublished).

WG-FSA-04/23

Electronic monitoring of seabird interactions with trawl third-wire cables on trawl vessels – a pilot study. H. McElderry, J. Schrader, D. McCullough, J. Illingworth, S. Fitzgerald and S. Davis. *NOAA Technical Memorandum – NMFS-AFSC-147*: 39 p. (2004) (English).

Archipelago Marine Research Ltd was selected by the Alaska Fisheries Science Center to test electronic monitoring (EM) equipment for possible use to examine seabird interactions with trawl third-wire cables on trawl vessels. This pilot study involved field testing of EM systems on shoreside delivery and head and gut bottom trawl vessels conducting operations in the Bering Sea, US Exclusive Economic Zone. EM systems, consisting of two closed circuit television cameras, GPS, hydraulic and winch sensors, and on-board data storage, were

deployed on five fishing vessels for 14 fishing trips during a one-month period in the fall of 2002. Detailed analysis of about 200 hours of fishing imagery occurred, representing 20 shoreside delivery vessel fishing events and 32 head and gut fleet fishing events. Results from the study demonstrated that EM could effectively monitor seabird interactions with trawl third-wire cables. The EM system provided imagery of sufficient quality to detect the presence, abundance, and general behaviour of seabirds during most daylight fishing events. As well, EM-based imagery was also able to detect third-wire entanglements of seabirds although it was not possible to determine the cause of these entanglements. EM imagery was not very useful for seabird enumeration and species identification. In regard to monitoring seabird interactions with trawl third-wires, EM would be suitable for monitoring the use and effectiveness of mitigation measures.

WG-FSA-04/24

Using digital video monitoring systems in fisheries: applications for monitoring compliance of seabird avoidance devices and seabird mortality in Pacific halibut longline fisheries. R.T. Ames, G.H. Williams and S.M. Fitzgerald (International Pacific Halibut Commission Seattle, Washington, USA), 96 pp. *NOAA Technical Memorandum – NMFS*, accepted (English).

The National Marine Fisheries Service (NMFS) contracted the International Pacific Halibut Commission (IPHC) for a project examining the feasibility of electronic monitoring systems (EMS) in the Pacific halibut longline fleet operating off the state of Alaska. The project was conducted on two of the IPHC stock assessment survey vessels fishing in Alaska during 2002. The objectives of the project were to: 1) examine the ability of an EMS to provide images that would allow an analyst to monitor seabird-avoidance devices for regulatory compliance; 2) determine the feasibility of using video images for detecting and identifying incidentally-caught seabirds; and 3) discuss options for the future use of electronic monitoring as a fishery management tool.

To determine if EMS could be used to assist in compliance determination, an EMS was installed on two halibut longline vessels chartered by the IPHC. Cameras were placed on the stern and recorded images of halibut gear being set and the performance of seabird avoidance devices, or streamer lines, during setting. Vessel and video observations were compared on 106 setting events. The video observations determined that the EMS was successful in detecting streamer line deployment and relative position on 100% of the daytime sets when two setting cameras were operating together. The results of the streamer line performance evaluations suggest that accurate performance recognition was positively related to the increase in image recording speed and the video analysts' ability to distinguish measured interval markings that were attached to the streamer lines.

The ability of a video analyst to recognise and identify the species of retrieved seabirds was examined by intentionally setting previously-caught frozen seabirds on the fishing gear. No birds were caught incidentally during this study. The results indicated that correct seabird identification is related both to the analyst's knowledge of distinguishing species characteristics, and to the size of the seabird.

In conclusion, this study indicates that an EMS program would produce accurate data and enable compliance evaluations for seabird avoidance devices. In addition, an EMS program would be able to detect a high proportion of incidentally caught seabirds. However, additional work is needed on seabird image identification and verification methods and testing the effects of soak time on the physical characteristics of seabirds.

WG-FSA-04/25

Standardised CPUE analysis of the Antarctic toothfish fishery in CCAMLR Subarea 88.1 from 1988/89 to 2003/04. N.L. Phillips, R.G. Blackwell and S.M. Hanchet (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901 Kilbirnie, Wellington, New Zealand, n.phillips@niwa.co.nz), 22 pp. (English, unpublished).

A toothfish fishery has operated during the Antarctic summer (December–May) from 1997 to 2004, in Subareas 88.1 and 88.2. A preliminary standardised analysis of toothfish CPUE (catch (kg) per baited hook per set) carried out in 2003 compared two alternative toothfish CPUE analyses for the 1998 to 2003 seasons for Subarea 88.1.

This report revises and updates the previous analysis with the addition of data from the 2004 season using datasets based on all vessels and the two main New Zealand vessels that have been in the fishery over the entire time period. However, the fishing grounds were changed to reflect the new SSRUs used to manage the fishery, and the larger regions used to assess the fishery (Dunn et al., 2005). It also examines alternative approaches to modelling catch and effort data by using mixed-effect models following Candy (2003).

The variables entering each of the three models were similar and all explained a reasonable amount (35–46%) of the variation. The variables included in the analysis are plausible, but the models may be influenced by extreme values of soaktime and depth that reflect the exploratory nature of the fishery. Model diagnostics show a reasonable pattern in the residuals for all models, but the quantile-quantile plots indicate a deviation from the normal distribution of the residuals at either end for the lognormal GLM models, and at the lower end for the fixed effects of the mixed model. This suggests that extreme values of catch rate were not modelled well and there may be violations of model assumptions.

The CPUE indices showed consistent trends in all three models. The indices were essentially flat apart from a slight decline in 2001 and a large decline in 2004. The reason for the large decline is unclear, but may reflect the bad ice conditions in 2004 as well as increasing competition between the large number of vessels operating in the fishery.

The relationship between these indices and relative abundance is unknown, and fishery independent data are unavailable to validate this relationship. Continued monitoring of CPUE for the main grounds and main vessels is recommended. Also further research on other possible CPUE models, and inclusion of first-order interactions in the analysis is suggested. Research into suitable methods for validating the relationship between CPUE seasonal indices and the relative abundance of toothfish is also recommended.

WG-FSA-04/26

Nesting behaviour of the icefish *Chaenocephalus aceratus* at Bouvetøya Island, Southern Ocean (CCAMLR Subarea 48.6). H.W. Detrich III, C.D. Jones, S. Kim, A.W. North, A. Thurber and M. Vacchi (Department of Biology, Northeastern University, Boston, MA 02115, USA, iceman@neu.edu, 11 pp. (English, unpublished).

This paper describes *in situ* observations on nesting by the Scotia Sea (or blackfin) icefish (*Chaenocephalus aceratus*) that constitute the first substantive evidence of egg brooding and parental care by species of the family Channichthyidae. These novel observations are enriched by descriptions of the seafloor community that is impacted by fish nesting. Given the vulnerability of spawning grounds and their associated megafauna to damage by bottom trawling and the associated impact on recruitment to adult fish populations, it is argued that appropriate management of icefish fisheries must exclude, or severely restrict, fishing techniques that damage the seabed.

WG-FSA-04/27

An exploratory analysis of skate speciation using DNA identification techniques. P.J. Smith and S.M. McVeagh (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901 Kilbirnie, Wellington, New Zealand, p.smith@niwa.co.nz), 10 pp. (English, unpublished).

Two regions of the mitochondrial DNA, part of the cytochrome *b* gene and the control region, were sequenced in specimens of Antarctic skates from the Ross Sea (Pacific Ocean sector), the Australian Antarctic Territory (Indian Ocean sector), and around Elephant Island and the South Shetland Islands (Atlantic Ocean sector). Based on the DNA results, the species of *Bathyraja* referred to as *B. eatonii* in the Ross Sea appears to be a discrete sister species to *B. eatonii* from the Atlantic sector. In contrast, the DNA results for the undescribed species *Bathyraja* n. sp. would suggest that this species is common to the Atlantic and Pacific (Ross Sea) Ocean sectors. Two specimens of *B. maccaini* from the Atlantic and Indian Ocean sectors appeared similar.

WG-FSA-04/28 Rev. 1

Geographical differences in the condition, reproductive development, sex ratio and length distribution in Antarctic toothfish (*Dissostichus mawsoni*) from the Ross Sea, Antarctica (CCAMLR Subarea 88.1). J.M. Fenaughty (Silvifish Resources Ltd, PO Box 17-058, Karori, Wellington, New Zealand, jmfenaughty@clear.net.nz), 30 pp. *CCAMLR Science*, submitted (English).

A number of morphological and reproductive measurements made on Antarctic toothfish (*Dissostichus mawsoni*) over the four summer seasons from 2000/01 to 2003/04 on board the autoliner *San Aotea II* have been analysed. Summer seasons are defined here as the period from mid-December to the beginning of April. Results of this study indicate measurable differences in a number of indices from toothfish found on the Ross shelf proper, as distinct from those sampled on the more isolated seamounts and features to the north. These differences are fish body condition factor, reproductive development, sex ratio and length modal distribution. *D. mawsoni* samples from the northern region showed that this section of the population was more advanced in reproductive development, were in poorer condition, showed a consistent and significant higher ratio of males to females, and showed a unimodal length distribution at a consistent peak over all seasons in comparison with the southern group in which the distribution was multimodal.

WG-FSA-04/29

Age and growth of Antarctic skate (*Amblyraja georgiana*) in the Ross Sea. M.P. Francis and C. Ó Maolagáin (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, m.francis@niwa.co.nz), 15 pp. *CCAMLR Science*, submitted (English).

X-rays of vertebral half-centra, and X-rays and transmitted white-light examination of caudal thorns, were used to estimate the ages of *Amblyraja georgiana* from the Ross Sea. Caudal thorns viewed with transmitted white light provided the clearest growth bands, but reading precision was low, producing uncertain age estimates. Furthermore, annual deposition of thorn bands has not been validated. The maximum age was 14 years, but this should be regarded as a conservative estimate of longevity because of the possibility that thorn growth ceases in large individuals. Von Bertalanffy growth curves are provided for females, males, and both sexes combined. There was no obvious difference between the sexes, so the curve for both sexes provides the best available representation of growth in the species: $L_t = 70.8(1-e^{-0.308[t+1.10]})$, where L_t is the pelvic length (PL) in centimetres at age t. Applying this growth curve to the estimated lengths at maturity for males and females (64 cm

and 66–69 cm PL respectively) produced estimated ages at maturity of 6–7 years for males and 8–11 years for females. These estimates are near the middle to upper end of the range of ages at maturity for skates worldwide.

WG-FSA-04/30

Report on the identification of fish eggs and larvae taken in the Ross Sea, Subarea 88.1, autumn/winter 2003. M. van der Poest Clement and M. Lamare (Department of Marine Science, University of Otago, PO Box 56, Dunedin, New Zealand, vanma012@ student.otago.ac.nz), 8 pp. (English, unpublished).

Icthyoplankton sampling was carried out by the New Zealand bottom longliner *Avro Chieftain* in the Ross Sea (Subarea 88.1) in the 2002/03 fishing season. Four direct haul samples were taken with a UNESCO WP2 net to a maximum depth of 1 620 m in areas where mature *Dissostichus mawsoni* had been observed. No *D. mawsoni* eggs or larvae were observed. Larvae of *Kreffichthys anderssoni* and *Electrona antarctica,* and two unidentified egg types, were found.

WG-FSA-04/31

Stomach contents of Antarctic toothfish (*Dissostichus mawsoni*) from the western Ross Sea, Antarctica. D.W. Stevens (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 14-901 Kilbirnie, Wellington, New Zealand, d.stevens@niwa.co.nz), 16 pp. (English, unpublished).

The stomach contents of 496 Antarctic toothfish (*Dissostichus mawsoni*) captured by bottom longline in the western Ross Sea during the 2003 summer fishing season (from December 2002 to June 2003) were analysed. Fish sampled were caught in 770–1 890 m depths and ranged between 72 and 212 cm in total length. *D. mawsoni* feeds on a wide range of prey but is primarily piscivorous. The most important prey species was Whitson's grenadier (*Macrourus whitsoni*), which dominated the overall diet. In continental slope waters, *M. whitsoni*, the icefish *Chionobathyscus dewitti*, eel cods (*Muraenolepis* spp.) and cephalopods predominated in the diet, while on oceanic seamounts *M. whitsoni*, violet cod (*Antimora rostrata*) and cephalopods were important.

WG-FSA-04/32

Genetic analysis of Antarctic toothfish samples from the Southern Ocean to explore potential stock boundaries. P.J. Smith, S.M. McVeagh and P.M. Gaffney (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901 Kilbirnie, Wellington, New Zealand, p.smith@niwa.co.nz), 12 pp. *CCAMLR Science*, submitted (English).

Two molecular methods, mitochondrial DNA and introns, were used to determine genetic relationships among Antarctic toothfish (*Dissostichus mawsoni*) samples from CCAMLR Subareas 48.1 and 88.1 and Division 58.4.2. *D. mawsoni* appeared to be characterised by low diversity; no genetic variation was detected with restriction-enzyme digests of nine sub-regions of the mitochondrial genome. Polymorphisms were found in four out of seven introns digested with the restriction enzymes, but there was no population differentiation among the three sea areas. While direct sequencing of cytochrome *b* (665 base pair) showed virtually no variation, sequences for ~600 bp of the left domain of the control region showed nucleotide variation with some haplotypes restricted to sea areas. The weak genetic differentiation is supported by oceanic gyres, which may act as juvenile retention systems, and by limited movement of adult tagged fish. It is recommended that the Ross Sea *D. mawsoni* be treated as a separate stock unit.

WG-FSA-04/34

Information on the spawning of *Dissostichus mawsoni* from Subareas 88.1 and 88.2 in the 2003/04 season. G.J. Patchell (Sealord Group Ltd, PO Box 11, Nelson, New Zealand, gjp@sealord.co.nz), 7 pp. (English, unpublished).

Data on maturity, gonadosomatic index (GSI) and length weight of Antarctic toothfish (*Dissostichus mawsoni*) were collected from Subareas 88.1 and 88.2 in the 2002/03 season by the New Zealand bottom longline vessels *Janas, Avro Chieftain* and *San Aotea II* operating in the exploratory fishery. The first fully mature female fish were found in December, three months earlier than in the previous season.

The onset of spawning in *D. mawsoni* is in December and continues until at least June, in both Subareas 88.1 and 88.2, and spawning occurs on isolated geographic features north of the main Antarctic shelf areas. One of the mature fish caught in Subarea 88.2 had originally been tagged in McMurdo Sound in Subarea 88.1 in 1986.

A new seven-stage recording system is proposed for *D. mawsoni* to be agreed at WG-FSA.

WG-FSA-04/36

Development of an Antarctic toothfish (*Dissostichus mawsoni*) stock model for CCAMLR Subarea 88.1 for the years 1997/98 to 2003/04. A. Dunn, D.J. Gilbert, S.M. Hanchet and B. Bull (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 14-901, Kilbirnie, Wellington, New Zealand, a.dunn@niwa.co.nz), 39 pp. (English, unpublished).

This report outlines a preliminary Bayesian sex- and age-structured population model for the assessment of Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea. The Ross Sea fisheries resources are managed by CCAMLR and the area is divided into two main management areas: the western Ross Sea (Subarea 88.1) and the eastern Ross Sea (Subarea 88.2).

Catch, catch-per-unit-effort, proportions-at-age in the catch, and New Zealand vessels tag–release and tag–recapture data from Subarea 88.1 are included with a preliminary model using the generalised stock modelling software CASAL v2.06.

Three preliminary model scenarios were run using three time steps (summer fishery, winter spawning, and a step for nominal age incrementation), including tag–release and tag–recapture data, CPUE indices, and commercial proportions-at-age estimates as observations. However, it is noted that the results presented here are reported for the purposes of the discussion, as these are based on incomplete or preliminary data. Hence, any quantitative results presented in this report should not be used to formulate conclusions on the stock status of Ross Sea Antarctic toothfish.

The first scenario considered the Ross Sea Subarea 88.1 fishery as a single fishery, with a single selectivity curve. This run suggested that better spatially structured fisheries data would substantially improve fits, as the observed proportions-at-age in the catch were clearly fitted poorly. The second scenario parameterised the fishing selectivity by shifting the selectivity to the left or right based on the mean depth fished in each year. Here, better fits to the age data were obtained, but they were still not adequate. In this scenario, fits to the (preliminary) tag–recapture data were the most favourable. In the third scenario, Subarea 88.1 was considered to be made up of five independent fisheries, based on SSRU stratifications (i.e. 88.1A–G, 88.1H, 88.1I, 88.1J/L and 88.1K). While this scenario was expected to be similar to that for the depth-shifted scenario, fits to the observed proportions-at-age data showed strong evidence of poor fit. It appears likely that such simple spatially structured models may not be adequate to model the Antarctic toothfish population. More complex models, accounting for size- or age-structured differences in the population, movements (migrations), fishing behaviour, and the adequacy of the homogeneity assumptions of the tag rate will need to be explored.

WG-FSA-04/37

Updated ASPM assessment of the toothfish (*Dissostichus eleginoides*) resource in the Prince Edward Islands vicinity. A. Brandão and D.S. Butterworth (Marine Resource Assessment and Management Group, Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa, bela@maths.uct.ac.za), 25 pp. (English, unpublished).

The ASPM assessment of the Prince Edward Islands toothfish resource by Brandão and Butterworth (2004) that permitted annual fluctuations about a deterministic stock-recruitment relationship is updated to take account of further catch, GLM standardised CPUE and catch-at-length information that have become available for the year 2004. Twenty-year biomass projections under the assumption of various constant annual catches are also shown. These suggest that maintenance of the present catch limit of 500 tonnes is defensible.

WG-FSA-04/38

Incidental mortality of marine birds during fishing operations directed to wreckfish with semi-pelagic longlines. Y.H. Marín, A. Stagi and J. Chocca (Dirección Nacional de Recursos Acuáticos (DINARA), Constituyente 1497, 11200 Montevideo, Uruguay,), 19 pp. (Spanish, unpublished).

Between August and November 2001, two fishing vessels carried out exploratory and experimental surveys with semi-pelagic and other configurations of longlines directed to the capture of wreckfish (*Polyprion americanus*) and other fish species within the Uruguayan EEZ. Observers included the recording of seabird information amongst their normal tasks. Seabird mortality associated with longline operations was analysed, as well as species involved, factors influencing mortality, and the application of mitigation measures. Total mortality recorded was of 3 birds/thousand hooks, and the main species captured were *Procellaria aequinoctialis* (50%), *Puffinus gravis* (27%) and *Thalassarche melanophrys* (21%). Bird species composition varied during the operation period. No significant differences in mortality were found between longline types, being higher in those with floats attached to the main line. Mortality increased with bird abundance and was higher during daylight setting. Mitigation measures most difficult to apply were night-time setting and the utilisation of bird scaring streamer lines (these became entangled in the intermediate buoys and broke). Although this fishery is no longer practiced in Uruguay, the need to improve and broaden the information related to fishing gear and seabirds interaction is discussed, as well as the revision of current regulations.

WG-FSA-04/39

Marine birds recorded in the southern and southwestern regions of the Atlantic Ocean during the period 1994-2003. Y.H. Marín, L.C. Barea, J.F. Chocca and A. Stagi (Tecnología Pesquera, Dirección Nacional de Recursos Acuáticos (DINARA), Constituyente 1497, 11200 Montevideo, Uruguay, ymarin@dinara.gub.uy), 31 pp. (English, unpublished).

Records of seabirds collected by on-board observers on different research or fishing vessels between the years 1994 and 2003 are presented. A total of 883 daily censuses was included. Twenty-two species and three genera were identified in the Atlantic Ocean, within an area between 20°S and 57°W and from the Uruguayan coast up to 30°W longitude. This preliminary paper refers to qualitative data (presence–absence), and contains a description of the area, of the recording methods, the species and records constraints.

WG-FSA-04/40

Population structure of icefish (*Champsocephalus gunnari*) in the South Georgia area (Antarctica). Zh.A. Frolkina and I.A. Trunov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, atlant@baltnet.ru), 19 pp. *CCAMLR Science*, submitted (English).

The environmental conditions in which *Champsocephalus gunnari* is found in the eastern and western shelf areas of South Georgia and at Shag Rocks are different. The length–age structure of *C. gunnari* groupings found in the areas around Shag Rocks and South Georgia is characterised by a lack of fish below 11 cm in length and older than 6–7 years (10–11 years in the South Georgia area) and a considerably lower number of large fish above 40 cm in length in catches. These distinctions are the result of the area's relative geographic isolation. A cluster analysis revealed similarities between icefish up to 22 cm in length in the western and Shag Rocks groupings and differences between those and the eastern grouping in terms of both otolith morphology and morphometric characteristics. In larger fish, a similarity between the eastern and western groupings and the differences between those two and the Shag Rocks grouping becomes apparent. These differences increase with fish length. The analysis of all data available suggests that the western and Shag Rocks groupings have a common origin. *C. gunnari* aged 2–3 years (at a length of 22–23 cm) migrate from the South Georgia area and remain at Shag Rocks. Icefish reaching 40–43 cm in length either die or return to South Georgia. The results obtained give grounds to assume with a high probability that the *C. gunnari* population in the South Georgia area is the major reproductive unit of the area around the island, while the shallow Shag Rocks area is an additional part of the distributional area or the foraging zone.

WG-FSA-04/41

On the problem of icefish (*Champsocephalus gunnari*) (Channichthyidae) and krill (*Euphausia superba*) interaction in the South Georgia area. S.M. Kasatkina and Zh.A. Frolkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, atlant@ baltnet.ru), 16 pp. (English, unpublished).

The interaction of icefish and krill in the South Georgia area has been analysed on the basis of trawl, acoustic and juvenile fish surveys carried out by AtlantNIRO from 1986 to 2002 and data from the national fishery. It is demonstrated that *C. gunnari*, both at the early development stages and as adults, utilise the pelagic forage resource, the bulk of which is constituted by krill. At the same time, krill content in the food of different length groups varied. The effect of krill on icefish growth and spatial distribution at various development stages is discussed. It is shown that a near-bottom pelagic distribution pattern of fish is sufficiently stipulated by the impact of krill distribution, being the preferred food item, on icefish diurnal vertical migrations. The comparison analysis of spatial distribution of near-bottom and pelagic fish aggregation density relative to krill distribution is presented.

WG-FSA-04/42

Summary of the seabird and marine mammal observations during observed toothfish (*Dissostichus* spp.) longline fishing operations in CCAMLR Subareas 88.1 and 88.2. S.J. Baird (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 14-901, Kilbirnie, Wellington, New Zealand, s.baird@niwa.co.nz), 45 pp. (English, unpublished).

Twenty-eight species of seabirds were reported from observations during longline setting operations that targeted toothfish (*Dissostichus* spp.) in 2001–03 in Subareas 88.1 and 88.2. The distribution of fishing effort was dictated by the presence of sea-ice and there are differences in the seabird composition reported each year because of variation in the spatial distribution of the seabirds. At-sea identification of some species is difficult and some of the

species that were reported from outside their known distribution range may have been misidentified. The most commonly seen seabirds were cape petrels (*Daption capense*), Antarctic petrels (*Thalassoica antarctica*), Wilson's storm petrels (*Oceanities oceanicus*) and snow petrels (*Pagodroma nivea*). The highest species diversity was in waters north of about 70°S off the continental shelf. Seabirds were not always seen in attendance at the setting operation and appeared to be generally uninterested in the line setting and were more likely to be well astern of the vessel. There were very few observations of seabirds diving on the bait during the set. Lost bait or by-catch fish species, mainly rattails (*Macrourus* spp.), were taken by some seabird species during hauling, but this feeding was away from the vessel activity. Nine marine mammal species were observed close to vessels during hauling, but there were few observations.

WG-FSA-04/43

The diet of juvenile toothfish (*Dissostichus eleginoides*) on the South Georgia and Shag Rocks shelf (CCAMLR Subarea 48.3). M.A. Collins, K.A. Ross and M. Belchier (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, macol@bas.ac.uk), 19 pp. (English, unpublished).

The diet of juvenile (<800 mm TL) Patagonian toothfish (*Dissostichus eleginoides*) was investigated using stomach contents analysis of fish caught in research trawls on the South Georgia and Shag Rocks shelves in the Atlantic sector of the Southern Ocean. Juvenile toothfish are predominantly piscivorous, principally feeding on demersal or benthopelagic fish. The diet differed between South Georgia and Shag Rocks. On the Shag Rocks shelf, which is the main area of toothfish recruitment, the dominant prey is the demersal yellowfin notothen (*Patagonotothen guntheri)*, whilst at South Georgia the main prey were other notothenid fish. The difference in prey composition reflects differences in ichthyofauna between the two areas. The size of prey increased with size of predator, with two cohorts of toothfish taking two distinct cohorts of *P. guntheri*.

WG-FSA-04/44

Patterns in the diet of mackerel icefish (*Champsocephalus gunnari*) on the South Georgia and Shag Rocks shelf (CCAMLR Subarea 48.3). M.A. Collins, R. Mitchell, G. Tarling and M. Belchier (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, macol@ bas.ac.uk), 13 pp. (English, unpublished).

The diet of mackerel icefish was investigated from stomach contents analysis of fish caught in research trawls at South Georgia and Shag Rocks in January 2004. The results are consistent with previous studies, with the dominant species consumed being Antarctic krill (*Euphausia superba*), the pelagic amphipod (*Themisto gaudichaudi*) and mysids. The diet differed between the age classes of icefish examined (2+, 3+ and 4++), with the younger fish consuming more *T. gaudichaudi* and small euphausids and the older fish taking more krill and fish. The change in diet reflects a shift from smaller to larger prey items with size.

WG-FSA-04/45

An interlaboratory comparison of ages estimated for *Dissostichus eleginoides* from the Argentine Sea, southwest Atlantic Ocean. M.C. Cassia, P.L. Horn and J.R. Ashford (National Institute for Fisheries Research and Development (INIDEP), PO Box 175, Mar del Plata, Argentina, mccassia@inidep.edu.ar), 9 pp. (English, unpublished).

To examine consistency among laboratories in age estimation of Patagonian toothfish and the effects on readings of different otolith processing methods, scales and otoliths were taken from 124 fishes caught in the Argentine Sea (southwest Atlantic).

Ages were estimated by readers from the National Institute for Fisheries Research and Development (INIDEP), Argentina, the National Institute of Water and Atmospheric Research (NIWA), Nelson, New Zealand and the Centre for Quantitative Fisheries Ecology (CQFE), Old Dominion University, Norfolk, Virginia, USA.

As a consequence of the exchange of otoliths carried out with NIWA, and the results presented, it is apparent that the NIWA preparation method produced a clearer section. More hyaline bands were visible in the NIWA preparations, particularly near the otolith margin where the zones can be very narrow. Consequently, INIDEP has adopted the NIWA method to process otoliths of Patagonian toothfish from the Argentine Sea.

So even though Patagonian toothfish otoliths could not be classified as easy to read, the clarity of their zones is quite similar in the south Atlantic, the waters south of New Zealand, and CCAMLR Subarea 48.3.

The comparisons of age data produced by three readers indicate a reasonable consistency for otoliths. The indices of average percentage of error for comparisons between R1 and R2 are satisfactory. Reader R3 generally produced older age readings because the reader has a different interpretation of the first few increments.

Comparisons of age estimations derived from scales and otoliths are less consistent. There were significant differences in age determinations from scales between R1 and R3, and between scales and otoliths by R1 and R3. Clearly, there are differences between these readers in the interpretation of these structures, and also difficulties reconciling the counts derived from otoliths and scales from individual fish. Further work is necessary on this issue to develop consistent interpretations for age readings.

WG-FSA-04/46

The distribution of seabirds on the Alaskan longline fishing grounds: 2002 data report. E. Melvin, K. Dietrich, K. Van Wormer and T. Geernaert (University of Washington, Box 355020, Seattle, WA 98195, USA, emelvin@u.washington.edu). Washington Sea Grant Program, *WSG-TA 04-02*, 21 pp. (English).

Beginning in 2004, improved seabird avoidance measures are required in the Alaska (USA) demersal longline fisheries for groundfish and Pacific halibut based on the results of extensive collaborative research. Due to the lack of data on the distribution of seabirds, especially albatrosses and petrels, seabird mitigation requirements apply to all fishing areas. Many small (<17 m) fishing vessels are less able to use standard seabird deterrents such as streamer lines and fish the protected water of Southeast Alaska and Prince William Sound where procellariids are thought to be uncommon. We established a program where seabird abundance data is collected in the course of annual longline fish assessment surveys to determine the relative distribution of seabirds on the Alaska fishing grounds. Starting in 2002, IPHC, NOAA Fisheries Auke Bay Laboratory, and Alaska Department of Fish and Game collected seabird abundance data using an easy-to-use protocol. Nearly 79 000 seabirds were recorded during 1 405 longline sets. Seabird densities were highest in the Central Gulf of Alaska and the Aleutian Islands. No albatrosses or fulmars and few seabirds were counted in inside waters during the survey strongly suggesting that seabird–longline interactions are unlikely in these areas. This program continues and is being expanded to Alaska trawl surveys. Multi-year datasets will allow assessment of where seabird mitigation is necessary on the Alaska fishing grounds and elucidate the foraging habitat of these seabirds. This collaboration emphatically demonstrates the value and economy of using existing fishery surveys to gather information on the at- sea distribution of seabirds and the extent of overlap of seabirds with fishing activities.

WG-FSA-04/47

Annotated bibliography: seabird interactions with trawl fishing operations and cooperative research. K. Dietrich and E. Melvin (University of Washington, Box 355020, Seattle, WA 98195, USA, emelvin@u.washington.edu). Washington Sea Grant Program, *WSG-TA 04-02*, 5 pp. (English).

We briefly summarise the available literature (17 documents) on the nature of seabird interactions with trawl gear, efforts to date on the development of technologies to prevent these interactions, and management imperatives affecting the Alaska trawl fleet. We also summarise available literature on cooperative research with the fishing industry (two documents). The purpose of this review was to bring this emerging issue in seabird conservation to the attention of the fishing industry and fishery managers, and to inform the process of developing appropriate mitigation technologies for the Alaska fleet.

WG-FSA-04/48

Trends in breeding numbers and survival of black-browed (*Thalassarche melanophrys*) and grey-headed albatrosses (*T. chrysostoma*) breeding on Macquarie Island. A. Terauds, R. Gales and R. Alderman (University of Tasmania, Churchill Avenue, Sandy Bay 7005, Tasmania, Australia, current address: Nature Conservation Branch, Department of Primary Industries, Water and Environment, GPO Box 44, Hobart 7001, Tasmania, Australia, aleks.terauds@dpiwe.tas.gov.au), 32 pp. *Wildlife Research*, CSIRO Publishing, Australia, submitted (English).

Black-browed (*Thalassarche melanophrys*) and grey-headed (*T. chrysostoma*) albatrosses are globally threatened seabirds that breed on remote sub-Antarctic islands. Population trends of black-browed and grey-headed albatrosses breeding on Macquarie Island were described using historical data in conjunction with data from a more intensive 10-year monitoring program. Survival estimates were also calculated for both species over similar time frames. Breeding numbers and survival rates of black-browed and grey-headed albatrosses appear to have remained relatively stable since the mid-1970s. There was no conclusive evidence of survival varying over time and it is unlikely that these populations have been impacted significantly by extra mortality due to fisheries activities. This is in contrast to most other sub-Antarctic populations of these species and may be attributed to their foraging ranges not overlapping significantly with areas of high fisheries activities. However, both species forage in areas of new and expanding legal and illegal fishery operations. Due to their extremely small size, these populations remain chronically vulnerable to any elevated levels of mortality.

WG-FSA-04/49

Foraging areas of black-browed and grey-headed albatrosses breeding on Macquarie Island in relation to marine protected areas. A. Terauds, R. Gales, G.B. Baker and R. Alderman (University of Tasmania, Churchill Avenue, Sandy Bay 7005, Tasmania, Australia, current address: Nature Conservation Branch, Department of Primary Industries, Water and Environment, PO Box 44, Hobart 7000, Tasmania, Australia, aleks.terauds@dpiwe.tas.gov.au), 28 pp. (English, unpublished).

While Marine Protected Areas (MPAs) are often established to protect threatened top-order predators, there is a paucity of data that can be used to evaluate their efficacy in achieving this purpose.

The effectiveness of a network of MPAs around Macquarie Island in the Southern Ocean was assessed by examining the foraging areas of black-browed and grey-headed albatrosses that were breeding on the island.

During late incubation and brood periods, over 90% of time spent foraging by black-browed albatrosses (*Thalassarche melanophrys*) was contained within MPAs,

principally the Exclusive Economic Zone (EEZ) around Macquarie Island. In contrast, grey-headed albatrosses (*T. chrysostoma*) spent only 34% of their time foraging in MPAs.

Black-browed and grey-headed albatrosses spent 30 and 15% of their respective foraging time in the marine park around Macquarie Island.

Both black-browed and grey-headed albatrosses foraged in Antarctic waters under the jurisdiction of CCAMLR, accounting for 5 and 12% of the total foraging time respectively.

There was significant spatial overlap in the areas utilised by black-browed albatrosses and a licensed trawl vessel operating within 200 n miles of Macquarie Island.

The spatial extent of MPAs around Macquarie Island appears to adequately cover much of the foraging distribution of breeding black-browed albatrosses from Macquarie Island; however, most of this was in the EEZ not covered by the Macquarie Island marine park.

Grey-headed albatrosses spend significantly more time in waters outside the spatial extent of these areas and are at higher risk from fisheries activities and other threats.

Further information on albatross movements is required to assess the efficacy of MPAs in protecting foraging habitats outside the breeding season.

WG-FSA-04/50

Population and survival trends of wandering albatrosses (*Diomedea exulans*) breeding on Macquarie Island. A. Terauds, R. Gales, R. Alderman and G.B. Baker (University of Tasmania, Churchill Avenue, Sandy Bay 7005, Tasmania, Australia, current address: Nature Conservation Branch, Department of Primary Industries, Water and Environment, PO Box 44, Hobart 7000, Tasmania, Australia, aleks.terauds@dpiwe.tas.gov.au), 30 pp. (English, unpublished).

Wandering albatrosses (*Diomedea exulans*) are globally threatened due to population declines and the Macquarie Island breeding population is particularly vulnerable as it comprises fewer than 20 breeding pairs. Most breeding birds in this small population are banded and monitoring over the last 40 years has increasingly focused on their conservation status. Demographic trends of the Macquarie Island wandering albatrosses between 1955 and 2003 are described in this paper, combining historical data with information from an intensive demographic study conducted between 1994 and 2003. Annual breeding effort and survival varied markedly with breeding numbers declining from a peak in 1964 to near extinction levels in the mid-1980s. Underlying this decline was a significant decrease in juvenile survival and, to a lesser extent, adult survival. These survival changes were coincident with changes in fishing effort in the eastern Indian Ocean. Breeding numbers slowly increased on Macquarie Island through the 1980s, reaching 19 breeding pairs in the mid-1990s and the population remains at this level today. Trends in population numbers and survival are similar to that observed in other populations in the Indian Ocean including Marion, Crozet and Amsterdam Islands. The age distribution of the current breeding population also provides supporting evidence that there were periods of low juvenile survival. Although the current population has remained stable at approximately 19 breeding pairs for the last seven years, the small size makes it extremely vulnerable to any activities that elevate mortality rates.

WG-FSA-04/51

Update on the Agreement on the Conservation of Albatrosses and Petrels (ACAP). B. Baker and T. Hewitt (Interim Secretariat, ACAP, hosted by the Government of Australia), 3 pp. (English, unpublished).

The Agreement on the Conservation of Albatrosses and Petrels (ACAP) entered into force on 1 February 2004. Six countries (Australia, Ecuador, New Zealand, Spain, South Africa and the UK) have ratified the Agreement, and another five have signed it (Argentina, Brazil, Chile, France and Peru). ACAP is expected to provide a major boost for the conservation of

threatened seabirds. The first Meeting of the Parties is to be held in Hobart, Australia, on 10–12 November 2004. The agenda for this meeting is prescribed under Article VIII of the Agreement, and will principally address administrative matters. Issues to be discussed include adoption of rules of procedure; determining financial arrangements, a scale of contributions and a budget; establishment of a Secretariat for the Agreement; establishment of an Advisory Committee to provide expert advice to the Parties; and adoption of criteria to define emergency situations that require immediate action.

WG-FSA-04/54

Seabird mortality in the artisanal austral hake and Patagonian toothfish longline fisheries in southern Chile. C.A. Moreno, P. Rubilar, J. Arata, R. Hucke-Gaete and G. Robertson (Instituto de Ecología y Evolución, Universidad Austral de Chile, Casilla 567, Valdivia, Chile, javierarata@entelchile.net), 24 pp. (English, unpublished).

Industrial longline fisheries are considered worldwide as the main threat to albatross and petrel populations, particularly at open oceans. However, inside countries' EEZs, artisanal fleets account for a significant fishing effort and, eventually, could represent a greater threat to albatrosses and petrels than industrial fishing. This paper describes the fishing technique, and provides the first assessment of incidental mortality, for the artisanal fleets fishing for austral hake and Patagonian toothfish in southern Chile, which account for 0.9 and 20 million hooks/year respectively. Both fleets use vertical longlines that sink fast: 0.33 and 0.69–0.22 $m \cdot sec^{-1}$ in the hake and toothfish longline fisheries respectively. Accordingly, seabird by-catch was 0.030 birds/thousand hooks in the austral hake fishery, mainly of birds caught during the slow process of hauling. The overall by-catch rate in the Patagonian toothfish fishery was 0.047 birds/thousand hooks. Considering the big fishing effort deployed by the artisanal toothfish fleet, some recommendations are made in order to improve fishing compliance with today's high conservation standards.

WG-FSA-04/55

Estimation of the incidental capture of seabird species in commercial fisheries in New Zealand waters, 2000/01. S.J. Baird, 63 pp. *Draft New Zealand Fisheries Assessment Report*, September 2004, New Zealand Ministry of Fisheries (English).

WG-FSA-04/56

Estimation of the incidental capture of seabird species in commercial fisheries in New Zealand waters, 2001/02. S.J. Baird, 51 pp. *Draft New Zealand Fisheries Assessment Report*, May 2004, New Zealand Ministry of Fisheries (English).

WG-FSA-04/57

Estimation of the incidental capture of seabird species in commercial fisheries in New Zealand waters, 2002/03. S.J. Baird, 48 pp. *Draft New Zealand Fisheries Assessment Report*, September 2004, New Zealand Ministry of Fisheries (English).

WG-FSA-04/58

Population dynamics of black-browed and grey-headed albatrosses *Diomedea melanophrys* and *D. chrysostoma* at Campbell Island, New Zealand, 1942–1996. S.M. Waugh, H. Weimerskirch, P.J. Moore and P.M. Sagar. *Ibis*, 141: 216–225 (1999). (English).

The numbers of black-browed albatrosses *Diomedea melanophrys* and grey-headed albatrosses *D. chrysostoma* at Campbell Island, New Zealand, have declined dramatically since the 1940s. Black-browed albatross numbers went into a steep decline in the 1970s and, since at least 1984, have been increasing slightly at average rates of 1.1% and 2.1% per

annum at two colonies. The long-term downward trend in numbers of the grey-headed albatross has continued into the 1990s, averaging annually between 3.0% and 4.8% per annum at different colonies. A demographic study carried out between 1984 and 1996 indicates that black-browed and grey-headed albatrosses have similar high annual adult survival rates (0.945 and 0.953 respectively). Black-browed albatrosses breed for the first time at a younger average age than do grey-headed albatrosses (10 years and 13.5 years, respectively), have a higher average breeding success (0.663 compared with 0.397 for the latter species) and are annual breeders where as grey-headed albatrosses show a typical biennial pattern of breeding. Both show low survival from fledging to first breeding; averaging 0.186 and 0.162 for black-browed and grey-headed albatrosses respectively. Both species are accidentally killed in the Japanese longline fishery for tuna *Thunnus* sp. In the Australasian region. The steep decline of black-browed albatross numbers in the 1970s was concomitant with the development of this fishery in the foraging region of the Campbell Island birds. Currently, the slight increase in numbers is due to high adult survival rates and breeding success, and is coincident with a great reduction in longline fishing. With stable and high adult survival rates, it is expected that future population trends will be mainly influenced by the recruitment rates. The continuous decline of grey-headed albatrosses since the 1940s, before longline fishing developed in this region, indicates that natural environmental processes contributed to the downward trend in breeding numbers. Modelling indicates that grey-headed albatross numbers will continue to decrease with the present demographic parameters. A comparison between the species breeding at different sites shows that differing environmental conditions influence demographic characteristics.

WG-FSA-04/59

Exploitation of the marine environment by two sypatric albatrosses in the Pacific Southern Ocean. S.M. Waugh, H. Weimerskirch, Y. Cherel, U. Shankar, P.A. Prince and P.M. Sagar. *Mar. Ecol. Prog. Ser*., 177: 243–254 (1999). (English).

The marine habitat exploited by black-browed *Diomedea melanophyrs* and grey-headed albatrosses *D. chrysostoma* breeding at Campbell Island, New Zealand, was studied using satellite telemetry. Data were analysed in relation to the bathymetry and sea-surface temperature of the foraging zones. Black-browed albatrosses spent 55% of their time on the Campbell Plateau but also carried out long foraging trips to the Polar Front and Antarctic Zone at a distance of over 2 000 km. They relied heavily on juvenile *Micromesistius australis*, a schooling fish, during foraging trips to the shelf but over oceanic waters the squid *Martialia hyadesi* was the main prey item. Grey-headed albatrosses spend 71% of their time foraging over the deep waters of the Polar Frontal Zone where *M. hyadesi* comprised over 90% of the mass of prey taken. No satellite-tracked birds fed over the shelf, but data from the duration of foraging trips and dietary analysis suggests that shelf-feeding is important for this species. Significant inter-species differences in the time spent in neritic and oceanic zones show that black-browed albatrosses were reliant primarily on shelf resources while grey-headed albatrosses are primarily oceanic feeders. In addition, the two species overlapped little in the zones used over oceanic waters, with black-browed albatrosses feeding in more southerly waters than grey-headed albatrosses. However, both species fed on *M. hyadesi* when foraging in association with the Polar Front.

WG-FSA-04/60

BioRoss – New Zealand funded marine biodiversity research in the Ross Sea region. J. Burgess (Ministry of Fisheries, PO Box 1020, Wellington, New Zealand, current address: Kanumera Consulting Ltd, 102 Rangiora Road, RD1, Waikanae, New Zealand, kanumera@clear.net.nz), 7 pp. (English, unpublished).

This paper summarises progress made in the BioRoss marine biodiversity research program administered by the New Zealand Ministry of Fisheries since 2000. The objective of the BioRoss program is to develop a more complete understanding of the biodiversity present in selected marine communities in the Ross Sea, allowing better management, and to facilitate better state of the environment reporting. This objective is being achieved by commissioning directed research on the diversity of selected marine communities within the Southern Ocean and Ross Sea.

WG-FSA-04/61

Observations of demersal fish, benthic communities and seafloor composition of the Southern Ocean Atlantic sector from the ICEFISH 2004 cruise. C.D. Jones, S.J. Lockhart and D.F. Doolittle (Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, cdjones@ucsd.edu), 22 pp. (English, unpublished).

A multi-disciplinary research cruise in the Atlantic sector of the Southern Ocean was conducted during the 2004 austral winter as part of the International Collaborative Expedition to collect and study Fish Indigenous to Sub-Antarctic Habitats (ICEFISH). Sampling during the ICEFISH cruise included demersal finfish, benthic invertebrates and information on seafloor composition. The objectives of the cruise included Antarctic fish and invertebrate biochemical, molecular and physiological, ecological and population genetics research. Trawling was conducted within the CCAMLR Convention Area at Shag Rocks, South Georgia, the South Sandwich Islands and Bouvetøya from 5 to 30 June 2004. A description of demersal finfish and benthic invertebrate collections, distribution, and composition from each island group is presented, including some preliminary information on the seabed composition of shelf areas. The total number of finfish specimens recorded within the Antarctic convergence during the ICEFISH cruise trawl deployments was 9 105 specimens of 29 species.

A wide contrast in finfish and invertebrate species composition between island groups was observed, with the greatest differences between the South Sandwich Islands and Bouvetøya, where the isolation of the latter island likely played a role in the different community structure. Due to mixed gear selectivity and possible avoidance, it was not feasible to make quantitative estimates of finfish abundance. However, using data from the Blake trawl, estimates of benthic invertebrate densities by station were computed and maps generated that provide information on benthic communities.

WG-FSA-04/63

An alternative method for estimating the level of illegal fishing using simulated scaling methods on detected effort. I. Ball (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, Ian.ball@aad.gov.au), 18 pp. *CCAMLR Science*, submitted (English).

A new method for estimating illegal fishing effort is put forward. The results from this new method are similar to the Agnew and Kirkwood method and this suggests that the current method is adequate under circumstances of low evasion and for when good knowledge exists that zero observations reflects zero illegal fishing. The new method performs better in the case of zero detections and can potentially better handle the evasion of detection by illegal activity.

Both the new and the current method suffer from the type of observation method used, which directly affects the system. This is the prevention/detection problem, in which the greater the number of detections for a given level of illegal fishing, the more often the illegal fishers will curtail their fishing trips. This leads to a negative correlation between the amount of fishing and the estimated amount of fishing, for a given number of illegal vessels.

As the number of illegal vessels increases, both the estimate and the average amount of illegal fishing increases. This gives us some confidence that the method can produce results that have a degree of legitimacy. However, the range of actual fishing (in the simulation datasets) for a given estimated level of fishing is very large. This range of uncertainty increases as the evasion rate increases.

This research suggests that it would be possible to calculate a precautionary assessment of illegal fishing such that the actual number of illegal fishing days is less than, or equal to, the precautionary estimate with some given level of confidence (for example 80%).

WG-FSA-04/64

Scientific observations in CCAMLR fisheries – past, present and future. CCAMLR Secretariat, 22 pp. *CCAMLR Science*, submitted (English).

CCAMLR has the primary competency for managing fishing south of the Antarctic Polar Front. Despite a relatively long history of scientific research and fisheries, CCAMLR's fisheries management strategy has often had to address incomplete and uncertain information on affected resources. Fishery-independent studies are difficult and expensive to conduct. In addition, the size of the Convention Area, its remoteness and prevailing inclement weather have complicated matters. Therefore, in addition to the standard catch and effort data supplied by vessels, the collection of data by scientifically qualified observers on board fishing vessels has assumed prominence in the collection of essential data for fisheries management purposes. The Scheme of International Scientific Observation, adopted by CCAMLR in 1992, is designed to gather and validate fishery-related information essential for assessing target species status as well as the impact of fishing on dependent and related species, including seabirds and marine mammals. The scheme is limited to scientific observation only and is carefully separated from enforcement aspects covered by the CCAMLR System of Inspection. Under the scheme, observers are deployed under bilateral agreements between CCAMLR Members and they operate on vessels under flags other than their own country. This paper outlines the scheme's history in terms of its logistics, participation and coverage, changes in research priorities, volume of data collected and data usage. The scheme's benefits and shortcomings are explored and an attempt is made to evaluate the total annual cost of scientific observer programs.

WG-FSA-04/65

Testing the performance of a recompiled version of CMIX to decompose length-density distributions of Patagonian toothfish (*Dissostichus eleginoides*). T.D. Lamb, W.K. de la Mare, A.J. Constable and C.R. Davies (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, tim.lamb@antdiv.gov.au), 10 pp. (English, unpublished).

A version of the mixture fitting program CMIX was recompiled to enable it to be run within the DOS emulator of recent versions of the Microsoft Windows operating system. The performance of the recompiled version was compared with that of the original version.

The recompiled version of CMIX produced very similar, though not identical, results to the original version. We attribute this to differences in the minimisation routines of the recompiled version. We conclude that the small differences evident from these tests are unlikely to significantly influence the estimated long-term yield of *Dissostichus eleginoides*.

WG-FSA-04/66

The Australian exploratory toothfish fishery in CCAMLR Division 58.4.2 and Subdivision 58.4.3b in the 2003/04 season. D. Erceg and E. van Wijk (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, diane.erceg@aad.gov.au), 7 pp. (English, unpublished).

WG-FSA-04/67

Progress towards validation of ageing of *Dissostichus eleginoides* using otoliths. K. Krusic-Golub and R. Williams (Central Ageing Facility, Marine and Freshwater Resources Institute, PO Box 114, Queenscliff 3225, Victoria, Australia, kyne.krusicgolub@dpi.vic.gov.au), 14 pp. (English, unpublished).

During tagging programs for *Dissostichus eleginoides* at Heard and Macquarie Islands, fish have been treated with strontium to mark their otoliths for validation of subsequent age estimation. Otoliths from 69 fish that were at liberty for at least 350 days were eventually examined. Results indicate that current methods for ageing *D. eleginoides* are appropriate: the number of observed annuli on the otoliths after the strontium marking was consistent with the time at liberty of the fish after marking.

Current and future work on age validation is designed to address outstanding problems with age determination in this species: investigating the accuracy of ageing small fish (<5 years old); analysing otoliths from a range of fish that have been at liberty for >1 000 days; and developing techniques to analyse the daily marks at the centre of the otolith in order to pinpoint the position of the first annulus.

WG-FSA-04/68

By-catch in Australian fisheries in Divisions 58.4.2, 58.4.3 and 58.5.2 during the 2002/03 and 2003/04 fishing seasons. E. van Wijk and R. Williams (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, esmee.vanwijk@aad.gov.au), 12 pp. (English, unpublished).

This paper presents by-catch information for the Australian fisheries in Divisions 58.4.2, 58.4.3 and 58.5.2, with estimates of total removals by fishing ground for the 2002/03 and 2003/04 seasons. By-catch in the trawl fisheries was low, approximately 1 to 2% of the total catch (target plus by-catch). By-catch in the longline fisheries was higher, ranging from 8 to 14% of the total catch. Much higher by-catch rates occurred in longlining grounds where the fishing effort, and therefore target catch, was low. The main by-catch species were skates and grenadiers in the *Dissostichus eleginoides* fishery and skates and *Channichthys rhinoceratus* in the *Champsocephalus gunnari* fishery. The total skate catch in Division 58.5.2 (including those cut from longlines) was 43 tonnes in 2002/03 and 55 tonnes in 2003/04. Results from the skate tagging program in Division 58.5.2 indicate that skates move very little between release and recapture, even after extended periods at liberty. The distances travelled ranged between 0.2 to 7 n miles with periods at liberty ranging from 208 to 822 days. Growth rates estimated from recaptured skates were 20 mm per year in total length, 21 mm per year in disk width and 0.14 kg per year in weight. Recapture rates were 2.5% for *Bathyraja eatonii* and 0.8% for *B. murrayi* for skates tagged in the trawl fishery and 0.05% for skates tagged in the longline fishery.

WG-FSA-04/69

An alternative method of calculating the accuracy of parameters using CMIX procedures applied to toothfish recruitment estimation. P.S. Gasyukov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, pg@atlant.baltnet.ru), 14 pp. *CCAMLR Science*, submitted (English).

The paper demonstrates how the bootstrap method can be applied to estimate the accuracy of mixture distribution parameters. The method enables the statistical characteristics of component densities to be estimated as well as those of other parameters, such as the mean length of components, their standard deviations or equation parameters used to determine these standard deviations. It is possible to estimate correlations between parameters and bias.

The method has been applied to data from the UK survey in 2002 which WG-FSA-03 used for toothfish recruitment calculations in the South Georgia area. The accuracy of the mean length component is high (CV~0.04), but total densities have CVs of ~0.3–0.5. The CV of parameters of a linear equation is greater than 1.0. There was a notably high correlation between some parameters. Standard errors of densities exceed the values calculated using the agreed CCAMLR procedure.

The method can be used to determine the number of trawl stations in a survey which will yield recruitment estimates of a given accuracy.

WG-FSA-04/70

A comparison of two different methods to age mackerel icefish (*Champsocephalus gunnari*) at South Georgia. P. Gasyukov, K.-H. Kock and Zh.A. Frolkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, pg@atlant.baltnet.ru), 11 pp. (English, unpublished).

Age determinations estimated by means of otoliths and age classes derived from CMIX analysis have been compared in *Champsocephalus gunnari* using material collected around South Georgia during four Russian surveys in 1988, 1990, 2000 and 2002. Considerable differences in age estimates between the two methods were revealed. A number of suggestions including an Age Determination Worksop to be held in Kaliningrad, Russia, in 2005 and the exploration of methods in addition to CMIX are made to reconcile some of these differences in the future.

WG-FSA-04/71

Report on the status of wandering, black-browed and grey-headed albatrosses at South Georgia. S. Poncet, G. Robertson, R. Phillips, K. Lawton, B. Phalan, J. Croxall and P. Trathan (South Georgia Surveys, PO Stanley, Falkland Islands/Malvinas), 8 pp. (English, unpublished).

Surveys of all known breeding sites of wandering, black-browed and grey-headed albatrosses were carried out at South Georgia in the 2003/04 breeding season. Wandering albatrosses were censused by ground counts, and black-browed and grey-headed albatrosses mainly by yacht-based digital photography and subsequent counting on computer screen using Adobe Photoshop software. In total, an estimated 1 553 pairs of wandering albatrosses, 75 500 pairs of black-browed albatrosses and 47 800 pairs of grey-headed albatrosses were breeding at South Georgia in the 2003/04 season. Compared to results from a predominantly yacht-based survey of black-browed and grey-headed albatrosses over the whole of South Georgia conducted in the mid-1980s, numbers of these two species appear to have decreased by 26 and 14% respectively. However, comparison of annual totals for Bird Island, which was censused on both occasions mainly by ground counts, indicate more rapid declines: 4.0% pa from 1989/90–2003/04 for black-browed albatrosses, and 2.9% pa from 1990/91–2003/04 for grey-headed albatrosses. Due to the lower accuracy of the methods used in the 1980s, it is likely that the Bird Island figures are more indicative of the population trends at

South Georgia. The decline in wandering albatrosses is even more pronounced: 30% (1.8% pa) since the previous survey in 1984. The magnitude of these population decreases is alarming, given the long time span involved and consistent downward pattern. Of particular concern is the acceleration since 1997 in the rate of decline of wandering albatrosses at Bird Island, which now stands at 4.5% per year. Unless these long-term declines can be halted or reversed, there must be some doubt over the long-term viability of the breeding populations of these species of albatrosses at South Georgia.

WG-FSA-04/72

Report on the effectiveness of integrated weight (fast sinking) longlines in reducing the mortality of white-chinned petrels and sooty shearwaters in autoline longline fisheries. G. Robertson, N. Smith, B. Wienecke and S. Candy (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, graham.robertson@aad.gov.au, 9 pp. (English, unpublished).

The difference in the number of white-chinned petrels (*Procellaria aequinoctialis*) and sooty shearwaters (*Puffinus griseus*) killed by unweighted longlines (UWLs; mean sink rate to 20 m depth: 0.11 m/s) and longlines containing 50 g lead/m integrated weight (IWLs; mean sink rate: 0.24 m/s) was examined in the New Zealand ling (*Genypterus blacodes*) autoline longline fishery. The experiments were conducted in the seabird breeding seasons (October/November) of 2002 and 2003 on FVs *Janas* and *Avro Chieftain*. White-chinned petrels and sooty shearwaters are more difficult to deter from baited hooks than the seabird species occurring in divisions and subareas where night-setting exemption currently applies, and are considered a worse-case scenario from a risk assessment perspective. In the experiments, the *Janas* and *Avro Chieftain* were followed by large numbers of seabirds, including 200–1 400 white-chinned petrels and up to 400 sooty shearwaters. Lines were set in daylight and at night, and a single streamer line was deployed on all sets. Differences between IWLs and UWLs in the catch rates of white-chinned petrels, sooty shearwaters and albatrosses, and ling and non-target fish species were determined for each pair of magazines or lines by counting dead birds during line hauling. In 2002, 80 white-chinned petrels were caught on UWLs compared to one white-chinned petrel on IWLs; the reduction in mortality was 98.7% ($CL_{95\%}$ = 99.8–90.6%; $P < 0.001$; n = 35 pairs of magazines). One sooty shearwater was caught on UWLs and none on IWLs. In 2003, 46 white-chinned petrels were caught on UWLs and three petrels on IWLs; the reduction in mortality was 93.5% ($CL_{95\%}$ = 98.02–78.5%, $P < 0.001$; n = 25 pairs of lines). Sooty shearwater mortality was 38 on UWLs and 15 on IWLs, a reduction of 60.5% ($CL_{95\%}$ = 78.6–27.4%, $P = 0.002$; n = 25 pairs of lines). Catch rates of white-chinned petrels on IWLs were 0.005/thousand hooks and 0.011/thousand hooks in 2002 and 2003 respectively. Catch rate of sooty shearwaters in 2003 was 0.053/thousand hooks. No albatrosses were caught on either line type in 2002; in 2003 a single Salvin's albatross was caught on a UWL. Catch rates of ling and non-target fish species were not affected by use of IWLs. The use of IWLs by autoline vessels operating in divisions and subareas where night-setting exemption currently applies would require relaxation of the minimum line sink rate (0.3 m/s; Conservation Measure 24-02) to permit the slower sink rate of IWLs (mean: 0.24 m/s; range 0.20–0.29 m/s). It is recommended that Conservation Measure 24-02 be amended so that autoline vessels operating in high-latitude divisions and subareas, where exemption from night setting applies, be permitted the option of using IWLs with 50 g lead/m and an average longline sink rate of 0.24 m/s.

WG-FSA-04/73

Proposal for the removal of night-setting requirement for autoline vessels fishing in Division 58.5.2. G. Robertson and B. Baker (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, graham.robertson@aad.gov.au), 6 pp. (English, unpublished).

This document seeks support to allow line setting operations by autoline vessels fishing in Division 58.5.2 to occur at any time of the day/night cycle. The proposal forms part of an adaptive approach to management, which considers the risk status of the fishery, knowledge of the effectiveness of mitigation measures, mitigation performance record of the vessel, seabird mortality levels and assessment of the likely effects of individual mitigation measures to total mitigation response. Since the introduction of longline fishing in Division 58.5.2 in 2002, seabird by-catch mitigation requirements have exceeded those required by CCAMLR. Evidence from Subarea 48.3 (South Georgia), where both the hooking effort and number and abundance of longline-vulnerable seabird species is far greater than in Division 58.5.2, suggests that winter fishing with appropriate mitigation presents very low risk to seabirds. This is supported by the results of the first two years of longline fishing in Division 58.5.2: a total of 2.2 million hooks have been set and no seabirds caught during line setting operations. Possible reasons why seabirds have not been caught are the very low abundance of longline-vulnerable seabird species on the fishing grounds between May and September, night setting, the requirement for a minimum line sink rate, the use of paired streamer lines and no offal discharge. In cases where seabird mortality is very low or non-existent it is appropriate to review mitigation requirements, particularly measures that might have adverse effects on fishing operations. Evidence from integrated weight longline experiments conducted in the New Zealand ling fishery in daylight and in summer suggests that the absence of seabird mortality in Division 58.5.2 is due to the low incidence of longline-vulnerable seabirds in winter, the minimum line sink rate and the use of streamer lines (the contribution to by-catch reduction of a minimum line sink rate and streamer lines, used separately, has not been determined). Removal of the night-setting requirement is unlikely to result in an increased risk to seabirds in Division 58.5.2.

WG-FSA-04/74

A simulation approach to the evaluation of recruitment surveys for *D. eleginoides* for the Heard Island Plateau region (Division 58.5.2). S.G. Candy, C.R. Davies and A.J. Constable (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, steve.candy@aad.gov.au), 24 pp. (English, unpublished).

Assessments of long-term sustainable yield using the Generalised Yield Model (GYM) and the setting of catch limits for Patagonian toothfish (*Dissostichus eleginoides*) for the Heard Island Plateau region (Division 58.5.2) are based on data obtained from annual random stratified trawl surveys (RSTS) and from targeted commercial fishing operations via an observer program. Evaluation of both the current RSTS design for Division 58.5.2 and some options for future modifications of the design is carried out in a simulation environment using the program Fish Heaven with data analysis carried out using S-plus. Fish Heaven is a simulation program that uses a spatially-explicit, age-structured fish population dynamics model. Recruitment, movement, mortality, growth, and fishing (both commercial and research) were simulated for Patagonian toothfish for the Heard Island Plateau region. Census of fish stocks by age class were compared to population estimates based on simulated RSTS hauls. For a series of 10 years of survey, age-4 recruitment was estimated using 111 RSTS stations, assuming the age of every fish caught in the surveys is known without

error and assuming knife-edge fishing selectivity at age 4, using either (a) the age 4-alone RSTS results or (b) age 4 to 8 RSTS results using back-projections from each age to age 4 for each of six cohorts.

WG-FSA-04/75

Description of an AD Model Builder implementation of the exact time of release and recapture stock assessment model of Tuck et al. (2003). S.G. Candy, A.J. Constable and D. Erceg (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, steve.candy@aad.gov.au), 9 pp. (English, unpublished).

Tuck et al. (2003) described an exact time of release and recapture stock assessment model and applied it to the stock of Patagonian toothfish (*Dissostichus eleginoides*) at Macquarie Island that have been fished by Australian trawlers from November 1994. This work was previously presented to WG-FSA in 2000 (Tuck et al., 2000; CCAMLR-XIX, paragraphs 3.126 and 3.127). The maximum likelihood estimation for this model has more recently been implemented in the AD Model Builder software by Dr Tuck. The AD Model Builder executable that implements Tuck et al. (2003) in order to estimate fish stocks where appropriate mark–recapture and catch data are available has kindly been made available to the Working Group by Dr Tuck. This paper describes the required inputs and the derived outputs for this implementation.

WG-FSA-04/76

Preliminary assessment of long-term yield of Patagonian toothfish (*Dissostichus eleginoides*) for the Heard Island Plateau region (CCAMLR Division 58.5.2) based on a random stratified trawl survey in May 2004. C.R. Davies, T. Lamb, A.J. Constable and R. Williams (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, campbell.davies@aad.gov.au), 14 pp. (English, unpublished).

A survey of Patagonian toothfish (*Dissostichus eleginoides*) was undertaken in Division 58.5.2 in the vicinity of Heard Island in May 2004 to provide the information for an assessment of short-term annual yield in the 2004/05 CCAMLR season. This paper provides a preliminary assessment of yield for the area of Division 58.5.2 to the west of 79°20'E using standard CCAMLR methods. It presents a range of sensitivity analyses for the assessment based on deliberations at WG-FSA-03 with respect to the surveys and ages included in the estimation of the recruitment series.

WG-FSA-04/77

Preliminary assessment of mackerel icefish (*Champsocephalus gunnari*) for the Heard Island Plateau region (Division 58.5.2) based on a survey in May 2004. C.R. Davies, T. Lamb, A.J. Constable and R. Williams (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, campbell.davies@aad.gov.au), 12 pp. (English, unpublished).

A survey of mackerel icefish (*Champsocephalus gunnari*) was undertaken in Division 58.5.2 in the vicinity of Heard Island in May 2004 to provide the information for an assessment of short-term annual yield in the 2004/05 CCAMLR season. This paper provides a preliminary assessment of yield using the assessment methods of CCAMLR for the Sub-Antarctic Fisheries Assessment Group Meeting 21 (SAFAG 21).

WG-FSA-04/78

Preliminary assessment of mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.3 based on a UK survey in January 2004. R.C. Wakeford, D.J. Agnew, M.B. Collins and G.B. Parkes (MRAG Ltd, 18 Queen Street, London W1J 5PN, United Kingdom, r.wakeford@mrag.co.uk), 8 pp. (English, unpublished).

A preliminary assessment of mackerel icefish (*Champsocephalus gunnari*) was undertaken for South Georgia (Subarea 48.3) using the standard CCAMLR methodology. This was based on the results of a UK bottom trawl survey during January 2004. Using CCAMLR decision rules, an estimate of the one-sided 95% confidence bound for the total biomass for 2003/04 was obtained using the bootstrap method for age 2+ fish only (age 1+ were not available from UK acoustic data in 2004). Estimates of short-term yield estimated within the GYM for 2004/05 and 2005/06 were 4 270 and 2 357 tonnes respectively.

WG-FSA-04/79

Trials to test mitigation devices to reduce seabird mortality caused by warp cable strike on factory trawlers. B.J. Sullivan, P. Brickle, T.A. Reid, D.G. Bone and D.A.J. Middleton (Seabirds at Sea Team, Falklands Conservation, PO Box 26, Stanley, Falkland Islands, and BirdLife Global Seabird Programme, Royal Society for the Protection of Birds, The Lodge, Sandy, Bedforshire, United Kingdom, ben.sullivan@rspb.org.uk), 22 pp. *Polar Biology*, submitted (English).

WG-FSA-04/80

Mitigation trials to reduce seabird mortality in pelagic trawl fisheries (Subarea 48.3). B.J. Sullivan, G.M. Liddle and G.M. Munro (Seabirds at Sea Team, Falklands Conservation, PO Box 26, Stanley, Falkland Islands, and BirdLife Global Seabird Programme, Royal Society for the Protection of Birds, The Lodge, Sandy, Bedfordshire, United Kingdom, ben.sullivan@rspb.org.uk), 8 pp. (English, unpublished).

WG-FSA-04/81

Research under way in Australia on seabirds vulnerable to fisheries interaction. R. Gales, G. Robertson, B. Baker, A. Terauds, R. Alderman and K. Lawton (Nature Conservation Branch, Department of Primary Industries, Water and Environment, GPO Box 44, Hobart 7001, Tasmania, Australia, rosemary.gales@dpiwe.tas.gov.au), 10 pp. (English, unpublished).

WG-FSA-04/82

Assessment of the status of the toothfish stock in Subarea 48.3. D.J. Agnew and G.P. Kirkwood (Renewable Resources Assessment Group, Imperial College, Royal School of Mines, Prince Consort Road, London SW7 2BP, United Kingdom, d.agnew@imperial.ac.uk), 29 pp. (English, unpublished).

Several different assessments of toothfish in Subarea 48.3 were conducted using four different methods, one fishery dependent and three fishery independent. Survey-generated recruitment is apparently not sufficient to generate realistic estimates of current biomass using the GYM. ASPM runs coded in AD Model Builder failed to fit satisfactorily to CPUE trends and catch-length composition. The most consistent results were provided by tag–recapture data adjusted for initial tag mortality, natural mortality, tag loss rates and fishery age-based selectivity. Estimations based on local depletions of toothfish generated results essentially similar to the tagging data. Based on these results, it is concluded that the most likely current exploitable biomass of toothfish in Subarea 48.3 is between 45 000 and 62 000 tonnes. The GYM was run to generate these levels of exploitable biomass at the start of 2004. This generated estimates of yield between 3 240 and 4 150 tonnes.

WG-FSA-04/83

Seal mitigation measures on trawl vessels fishing for krill in CCAMLR Subarea 48.3. J. Hooper, J.M. Clark, C. Charman and D. Agnew (MRAG Ltd, 18 Queen Street, London W1J 5PN, United Kingdom, j.hooper@mrag.co.uk), 10 pp. *CCAMLR Science*, submitted (English).

At WG-EMM in Siena, Italy, 2004, the UK reported on the by-catch of fur seals in the krill fishery around South Georgia and on mitigation methods that were being developed and deployed to avoid fur seal deaths in the fishery. WG-EMM requested the UK to provide further details of the methods employed for consideration by ad hoc WG-IMAF. Observers recorded mitigation measures for fur seal (*Arctocephalus gazella*) entanglements on krill vessels fishing around South Georgia in the 2004 fishing season. The measures implemented were based on four themes: physical barrier, barrier plus escape hatch, manufactured seal exclusion devices and gear configuration. Those vessels initially without mitigation measures were able to introduce them without further cost and minimal disruption to fishing activity.

WG-FSA-04/84 Rev. 1

Comparison of the catches and biological characteristics of *Dissostichus mawsoni* in Subarea 88.1 in the 2002/03 and 2003/04 seasons. K.V. Shust, N.V. Kokorin and A.F. Petrov (VNIRO, 17 V. Krasnoselskaya, Moscow 107140, Russia, Antarctic@vniro.ru), 10 pp. (English, unpublished).

This report presents the results of an exploratory fishery for Antarctic toothfish *(Dissostichus mawsoni*) conducted by the Russian vessels *Yantar* and *Volna* for two seasons, namely 2002/03 and 2003/04.

The analysis of the data collected relates to catch composition, effort, CPUE, and biological characteristics in different SSRUs, month and depth of longline sets. A comparison of these results showed that in the fishery as a whole, effort (number of sets and hooks) in those two seasons were similar (233 sets and 1.55 million hooks in 2002/03, and 222 sets and 1.79 million hooks in 2003/04). But the total catch of *D. mawsoni* was very different: 703 tonnes in 2002/03 and 276 tonnes in 2003/04. The CPUEs compared for different SSRUs were also much lower in the 2003/04 season.

An analysis of the length composition of fish from longline catches at different depths reveals a tendency towards an increase in the modal length on the deeper grounds. The modal length of toothfish caught in the different seasons and months did not show such a marked difference. At the same time, the modal length of fish catches in the 2003/04 season was slightly lower than in the previous season. This trend is clearly seen when comparing the length frequencies of the largest fish over different seasons. It was very interesting that in both seasons there were two modal classes: the first between 120–130 cm, and the second close to 145–150 cm. A more detailed examination of the length compositions of catches from the different SSRUs showed that the smaller-sized individuals were caught closer to the shore while the larger ones of the second modal group were captured in the northern off-shore zone of the Ross Sea.

WG-FSA-04/85

Fish stock assessment survey in Subarea 48.3, 2004. M. Belchier, M. Purves, M. Collins, S. Hawkins, T. Marlow, R. Mitchell, J. Szlakowski and J. Xavier (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, markb@bas.ac.uk), 17 pp. (English, unpublished).

This report describes the activities and preliminary results of the ninth UK fish stock assessment survey within CCAMLR Subarea 48.3 (South Georgia) which was carried our by MRAG and British Antarctic Survey scientists during January and February 2004. In addition to the random stratified bottom trawl survey, the research was extended by a week in

order that further investigations into the use of acoustic methods for the determination of icefish biomass could be undertaken. Following the recommendations of the CCAMLR Subgroup on Fisheries Acoustics (WG-FSA-SFA), emphasis was to be put on obtaining information on the target strength and length composition of the pelagic component of the icefish biomass. A continued emphasis on providing information on by-catch species gave a further key aim to the survey.

WG-FSA-04/86

The age structure and growth rate of Patagonian toothfish (*Dissostichus eleginoides*) at South Georgia. M. Belchier (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, markb@bas.ac.uk), 17 pp. (English, unpublished).

New length-at-age data for South Georgia toothfish are presented from a range of sources. Data from the commercial fishery, research trawl surveys and pelagic plankton tows are combined to generate new von Bertalanffy parameters. The new parameters ($L_{(inf)}$ 150 cm, $K = 0.073$ and $t_0 = -0.792$ are similar to values obtained in previous studies at South Georgia and other sub-Antarctic islands. Evidence for the separation of early year classes is presented along with mean sizes for each age class.

Age–length keys indicate that fish enter the fishery at 7 years and are fully recruited at between 10 and 11 years.

WG-FSA-04/87

Status of measures implemented by French fishing companies involved in the longline fishery for toothfish in the French Southern and Antarctic Territories (TAAF) to control the incidental mortality of seabirds. (France – document prepared by the Syndicat des Armements Réunionnais de Palangriers Congélateurs), 7 pp. (French).

This document supplements and updates information provided by French fishing companies at CCAMLR-XXII.

At the end of the 1990s, the French professional fishermen participating in toothfish harvesting in the TAAF switched from trawling to longline fishing in order to protect juvenile toothfish and to minimise the by-catch of fish. Longline fishing is a new technique for the French companies, and did not reach its full potential in French waters until the end of 2002.

Since the beginnings of longline fishing in the TAAF, control of incidental seabird mortality has been of concern to the fishing companies. This document describes the trends followed by French fishing companies during the 2003/04 fishing season to reduce the risk of incidental bird mortality and gives an overview of their initiatives within the context of a global approach to the problem of the incidental mortality of seabirds within the TAAF.

The 2003/04 fishing season was characterised by very significant results regarding the reduction of incidental seabird mortality, and an attempt is made here to list the factors which may explain this. The fishing companies consider that the experience and know-how of the vessels' crews and captains and their heightened awareness of methods of curbing the incidental mortality of birds played a significant role here.

The French fishing companies also consider that acquiring a better command of the deployment of bird-scaring lines has often been found to be very useful in reducing the risk of incidental mortality. They make particular mention of the vessels which often use several streamer lines. They conclude that to deploy streamer lines effectively, it is necessary to find a compromise between the number of streamer lines and their positioning – under fishing conditions, and for each individual vessel – and that it would be useful to allow the captains of vessels sufficient scope to use their discretion to judge how many streamer lines should be used and how they should be deployed.

In addition, the fishing companies report on the first trials of integrated-weight lines carried out by French vessels during the 2003/04 fishing season, and the first conclusions,

encouraging in terms of reducing incidental seabird mortality, which can be drawn from these. They observe that the rapid collection of the data necessary for the analysis of these results was made possible using TDR recorders lent by Dr Graham Robertson of the Australian Antarctic Division.

They also make particular mention of the very beneficial experience they gained with a New Zealand company which had also participated in trials of integrated-weight lines. Through this exchange, which was arranged at CCAMLR-XXII, Jacob Hals (Fiskevegn) and Malcolm McNeill (Sealord NZ) came to Réunion Island.

Finally, the French companies analysed problems associated with the use of integrated-weight lines resulting from their weight, which leads to difficulties with drag in the magazines and could give rise to vessel stability problems. They also observe that these new lines will need to be tested over longer periods under fishing conditions before being put into regular use, and because of this, but also because of current supply problems, the changeover of the vessels to this type of equipment can only be gradual.

At the end of the 1990s, the French public authorities urged professional fishers to switch from trawling to longline fishing in order to protect juvenile toothfish and to minimise the by-catch of fish.

This advice was fully endorsed by the fishing companies, who were conscious that developing a fishing technique which, unlike trawling, would guarantee the sustainable harvesting of toothfish stocks in the French Southern and Antarctic Territories (TAAF) would be both necessary and useful.

The trawlers, which were the only vessels harvesting this stock, were progressively replaced by longliners, until they were totally superseded by the end of 2002. New vessels were then brought into service to replace the vessels which had been chartered in the beginning to allow the fishing companies to familiarise themselves with a fishing technique which was entirely new to them. Longline fishing is thus a very new practice in TAAF waters, and for the French fishing companies, having only reached its full potential in the last 2two or three fishing seasons.

Since the beginnings of longline fishing in the TAAF, control of incidental mortality has been of concern to the fishing companies.

This concern is shown in their past and present efforts to:

- research and experiment with methods of avoiding bird catches that go beyond those recommended by CCAMLR, although the latter are of course also complied with by French vessels;
- contribute to initiatives which are in line with a comprehensive approach to the global issue of seabird mortality and aim at improving our understanding of changes and dynamics in bird populations in the TAAF.

With regard to the latter, the following should be noted:

- once again, the decision taken by the fishing companies to collaborate to charter a fishery surveillance vessel, which will provide an additional means of monitoring at sea aimed at complementing those already implemented by French authorities. This vessel, which has been in operation during the 2003/04 fishing season, by assuring and asserting a stronger presence on the fishing grounds, will prevent and curb illegal fishing activities and, in contributing to the reduction of the removals of toothfish by illegal fishing activities, will also reduce the bird mortality for which they are responsible;
- the decision taken by the fishing companies to become involved in financing a scientific study aimed at assessing the current size of white-chinned petrel populations, the demographic parameters of white-chinned and grey petrels in the TAAF, and trends in changes in these populations. This study should, when

completed, enable the impact of incidental mortality caused by fisheries on populations of petrels in the TAAF to be assessed; at present, it is envisaged that it will be completed in 2006.

This document details the approaches taken by French fishing companies during the 2003/04 fishing season to reduce the risk of incidental bird mortality. It supplements and updates information provided to CCAMLR-XXII by fishing companies from Réunion Island.

The 2003/04 fishing season was characterised by very significant results indeed regarding the reduction of incidental seabird mortality.

WG-FSA-04/88

Measures implemented by France in Subarea 58.6 (Crozet) and Division 58.5.1 (Kerguelen) with the aim of reducing bird mortality – 2003/04. T. Micol, E. Reuillard and S. Blais (Terres Australes et Antarctiques Françaises, BP400, 1, rue Gabriel Dejean, 97548 Saint-Pierre, La Réunion, thierry.micol@taaf.fr), 10 pp. (French, unpublished).

The toothfish fishery conducted by France in the Crozet and Kerguelen Economic Zones (CCAMLR Statistical Subarea 58.6 and Division 58.5.1 respectively) is one of the largest of its type, but also harms seabirds which are attracted by the baits and die by drowning. This is a new occurrence, as this type of fishery has only been recently introduced (trawlers were replaced by longliners in 2001), but France is actively seeking solutions to the problem. In the 2002/03 season, two main approaches were adopted: measures providing for sanctions against vessels capturing the most birds (barring them from fishing in certain areas, requiring them to leave the area, etc.) and precautionary measures governing the way the fishery proceeds (closing the Kerguelen area during the most sensitive period, using white lines, etc.). The companies were regularly asked for their advice, and their cooperation has enabled significant progress to be made, notably in taking the initiative of using multiple streamer lines. The advice of scientists has been sought and a preliminary study has looked into the major causes of bird mortality.

The introduction of a satellite surveillance system and a new fishery surveillance vessel has enabled the fight against illegal fishing to be intensified, illegal activities being the major cause of bird mortality in the fishery. This has resulted in the arrest of an illegal fisherman in June and the disappearance of all illegal activity since.

The initiation of successful cooperation with New Zealand and Australian experts should contribute to the continuation of such improvements. Experiments carried out by France, in particular the use of white lines (in place of black ones) and multiple (instead of single) streamer lines should also pave the way towards further refinements in the toothfish fishery beyond the Crozet and Kerguelen EEZs.

It should be noted that together these efforts have enabled bird mortality to be reduced by nearly 75% in 2003/04 (4 009 birds) as compared to 2002/03 (15 265 birds).

WG-FSA-04/89

Observer notes (Subarea 88.1). V.G. Prutko (YugNIRO, 2 Sverdlov Street, Kerch 98300, Crimea, Ukraine, vgprut@ker.post.crimea.ua), 11 pp. (English, unpublished).

This paper presents results of analyses of biological data on Antarctic fish species from catches of 117 bottom longline sets in Subarea 88.1 from 15 December 2003 to 10 March 2004. For the first time, Antarctic toothfish were found in longline catches over seamounts of the Pacific-Antarctic Ridge to the north up to 56°S. Patagonian toothfish found to be present in spawning aggregations of Antarctic toothfish would not lead to their interbreeding, as their gonads were at the early development stages at that time. Antarctic toothfish spawning takes place over the seamounts of the Pacific-Antarctic Ridge, located north of 70°S, during the whole winter season from April to November. Spawning aggregations are only formed by mature individuals: males with body lengths of over 100 cm, females of over 120 cm.

Gonads of individuals from the Continental Shelf and from the more southerly seamounts (south of 70°S) were considerably behind in maturation and had a lower value of GSI. Probably, as their gonads are maturing, part of the population migrates to the northern area of Subarea 88.1 for spawning. The wide variability of the Antarctic toothfish nutrition spectrum and its ability to travel across a considerable range of depths make it possible for this species to migrate over considerable distances. The majority of the Antarctic toothfish individuals forming spawning aggregations were found to be exhausted. Studies of the biology of the whole of the by-catch revealed, for the first time, the presence of *Macrourus whitsoni, Chionobathyscus dewitti, Cryodraco antarcticus* and *Chionodraco rastrospinosus* in the Ross Sea and *Muraenolepis microps* and *Lepidonotothen kempi* were found in pre-spawning or spawning condition. The ovaries of some fish contained transparent eggs, while the gonads of some fish were in post-spawning condition. Sizes of yolk and hydrated eggs are given, as well as absolute fecundity of these fish species. Size composition and biological data on Patagonian toothfish from the Argentine Basin area between 44 and 47°S are presented. Maturity length of females (85 cm) and males (80 cm) are given. According to available data, the longline fishery in this area is based on immature fish and those reaching maturity for the first time.

WG-FSA-04/90

Some peculiarities of *Chionobathyschus dewitti* biology in the Ross Sea. L.K. Pshenichnov (YugNIRO, 2 Sverdlov Street, Kerch 98300, Crimea, Ukraine, lkp@bikent.net), 6 pp. (English, unpublished).

Brief results of *Chionobathyschus dewitti* research which was based on data collected from by-catch of bottom longlines in *Dissostichus mawsoni* fisheries are presented. It is noted that the depths where the *D. mawsoni* fishery is carried out are inhabited by adult specimens of *C. dewitti,* aged from 5 to 13. The characteristic feature of *C. dewitti* reproductive biology was determined: ability of females to bear deposits of eggs on the ventral fin.

WG-FSA-04/91

Modifications to the Generalised Yield Model in 2004, version GYM501E.EXE. A.J. Constable (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@aad.gov.au), 3 pp. (English, unpublished).

The Generalised Yield Model (GYM) is used by WG-FSA in the assessments of *Champsocephalus gunnari*, *Dissostichus eleginoides* and *Euphausia superba*. Its current version is GYM501D.EXE. In the course of reviewing the methods for estimating the time series of recruitments of *D. eleginoides* for WG-FSA in 2004 an error in the calculation of the recruitment series from survey data was detected. This error does not affect the assessments undertaken in recent years. This paper presents the nature of the error and the manner in which it was corrected.

The recruitment series is the estimate of abundance of fish at the nominated 'recruitment age' (age 4 for toothfish) in each year. The first year in the time series of recruitments is determined as the oldest age observed in the surveys minus recruitment age. This was coded specifically for the case of surveys observing fish of ages one year younger than the recruitment age and greater. This calculation needed to be made general to allow for many years younger than the recruitment age. This has been corrected.

The calculation of the recruitment series relative to the first year remains unaltered and correct.

A new version, GYM501E.EXE, and installation software has been made available on the AAD website and at the Secretariat.

WG-FSA-04/92

Theoretical considerations for estimating the density of cohorts and mean recruitment of Patagonian toothfish (*Dissostichus eleginoides*) based on research trawl survey data. C.R. Davies, E.M. van Wijk and A.J. Constable (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, campbell.davies@antdiv.gov.auAustralia), 41 pp. (English, unpublished).

The current method used by WG-FSA for assessing the long-term yield for toothfish fisheries in CCAMLR uses estimates of density of juvenile toothfish derived from research trawl surveys as an estimate of absolute abundance of recruitment to the fishery. At the 2003 meeting of WG-FSA a number of inconsistencies were identified in the estimation of the recruitment series for Subarea 48.3. In light of this, the Scientific Committee agreed that there was an urgent need to review and revise the recruitment series for *Dissostichus eleginoides* in Subarea 48.3, recognising the importance of obtaining a consistent and reliable recruitment series for review at the 2004 meeting. This paper elaborates the issues surrounding how age information should be incorporated into CMIX analyses; which age groups should be included in the estimation of recruitment, and the need for a clear set of decision rules to guide those attempting CMIX analysis. It provides an overview of the theoretical issues involved with estimating cohort densities from length-density data from trawl surveys with examples for the survey series for Subarea 48.3. A checklist of issues to be considered when undertaking CMIX analyses to estimate recruitment of toothfish is provided.