# *CCAMLR SCIENTIFIC ABSTRACTS 2005*

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Preface

Abstracts of papers submitted to the 2005 meetings of the:

# 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 2005 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(iii)  scientific papers not intended for publication, which are listed as 'unpublished'; and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Unpublished papers must not be cited without written permission of the author(s).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.

## SC-CAMLR-XXIV/BG/4

**Marine debris survey at Cape Shirreff, Livingston Island, South Shetland Islands, Antarctica, in 2004/05.** C. Aguilar V. and *D. Torres N. (*Departamento Científico, Instituto Antártico Chileno, Plaza Muñoz Gamero 1055, Punta Arenas, Chile, dtorres@inach.cl), 11 pp. (Spanish, unpublished).

The results of the debris collection carried out during the 2004/05 season in Cape Shirreff, Livingston Island, are shown. A total of 1 023 items weighing 28 kg were collected. Of these, the highest percentage (95%) were made of plastic (539 items), mainly polystyrene foam pieces (PE) (2.7 kg), followed by paper (4%), glass and metal (0.7% each). From the total quantity of rope and plastic packaging bands (157), a number of bands were still in the form of a loop (5 = 3.1%), and partially burnt plastic was also present, in contravention of the conservation measures established by CCAMLR. It is assumed that such debris is generated by illegal fisheries. Total values in terms of quantity and weight of the debris collected in the last five seasons show a general decline, with variations between seasons, which are most likely due to the influence of marine currents and winds that scatter the debris still circulating in the waters of the Southern Ocean.

Also included are the results of opportunistic debris surveys of nine beaches at President Head Peninsula, Snow Island, located 6.4 km west of Livingston Island in the South Shetland Islands, Antarctica. A total of 252 items weighing 45 kg were collected. The items found were similar in nature to those found on the beaches at Cape Shirreff, notably, plastic (78%) comprising cables and rubber lids, and various bottles and buoys that represented the heaviest elements, followed by paper (8%) and metal and glass (7% each). The quantity of marine debris collected at President Head is significantly lower than at Cape Shirreff, despite periodic surveys being conducted at the latter location. This difference may be due to the different geographic location, Cape Shirreff being more exposed to marine currents, and to local conditions (wind and coastal currents) affecting transport of debris to different areas. Thus, it is evident that marine debris can be found on all beaches of the sub-Antarctic islands.

## SC-CAMLR-XXIV/BG/7

**Summary of scientific observation programs undertaken during the 2004/05 season.** CCAMLR Secretariat, 6 pp. (English, unpublished).

## SC-CAMLR-XXIV/BG/12

**Synopses of papers submitted to WG-EMM-05.** CCAMLR Secretariat, 45 pp. (English, unpublished).

## SC-CAMLR-XXIV/BG/13

**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 12 sites, mostly within Area 48. South Africa submitted data on beached marine debris for the first time from Marion Island (Subarea 58.7). There are four sites which have data for more than three consecutive years (ranging from 5 to 16 years), these are: 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 wooden items, reached a peak during the period from 1994 to 1996 at Bird Island and Signy Island, but has declined until recently. The number of debris items found has increased in the last season reported at Bird Island (2004), Signy Island (2005) and King George Island (2005). The majority of items found were packaging materials.

The level of marine debris found in grey-headed albatross, black-browed albatross and Wandering albatross colonies at Bird Island in 2005 has substantially declined from previous seasons. Fishing gear, such as lines and hooks, and miscellaneous broken plastics continue to form the major part of the debris associated with seabird colonies.

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 2005 season. Packaging bands, synthetic string and longline fragments continue to be the main entangling materials. Seabirds were reported entangled at Bird Island for the first time. The number of seabirds contaminated with hydrocarbons remains low.

**SC-CAMLR-XXIV/BG/14**
**Fishing equipment, marine debris and oil associated with seabirds at Bird Island, South Georgia, 2004/05.** I. Forster (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 16 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 2004 to 31 March 2005. It is the 12th such annual report. As in previous years, more items of fishing gear (mostly longlining gear) were found in association with wandering albatrosses than with any other species, although the total number has decreased significantly over the past two seasons. Entanglements continue to be observed, hooks being typical of those used in the Patagonian toothfish industry. Wandering albatrosses also collected the most marine debris, though again the total quantity is significantly down on previous years. The amount of debris and fishing gear associated with other species declined from the previous season. A high number of hydrocarbon and paint soiling events occurred, mostly around late March. Whilst the data indicate a reduction in fishing equipment and debris collected, there are still significant effects from human–avian interactions.

**SC-CAMLR-XXIV/BG/15**
**Beach debris survey – Main Bay, Bird Island, South Georgia, 2003/04.** H.F. Taylor, C.J. Green and S.L. Robinson (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 20 pp. (English, unpublished).

During the 14th year of standardised beach surveys of man-made debris at Bird Island, South Georgia, a total of 361 items was collected between April 2003 and March 2004. This represents an increase of 97% on the 183 items recorded in 2002/03 and the highest levels of summer beach debris (232 items) since the 1999/2000 season. The total weight of debris collected has also increased by 1.82 kg since last year to 5.39 kg. The highest proportion of marine debris collected comprised miscellaneous items; the largest annual amount of this type of debris since the surveys began in 1990. For the first time no nylon line was recorded compared to a peak of 546 items in 1995/96. However, 11 plastic packaging bands were recovered. Miscellaneous debris increased by 100% since last year (from 175 to 350 pieces), indicating that debris is still being lost by vessels into the marine environment. Therefore, all marine vessels operating in the region should continue to make efforts to comply with the correct waste disposal procedures.

**SC-CAMLR-XXIV/BG/16**

**Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Bird Island, South Georgia, during the 2004 winter and 2004/05 breeding season.**
S.L. Robinson (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 21 pp. (English, unpublished).

The number of entanglements in the 15th consecutive winter surveyed decreased by 64% from last year. For the first time since records started in 1990, none of the injuries were classified as severe. The 17th consecutive summer (2004/05) of reporting also saw a decrease of 64% compared to last year, the lowest number of entanglements recorded since 1989. As in previous years, most individuals observed entangled in debris were juveniles (80% of winter and 50% of summer observations). Of the entanglements where the animal could be sexed, males made up the majority in both seasons. After the high numbers in the previous winter it was encouraging to see no observations of entanglements in plastic packaging bands. Fishing nets were observed to have caused entanglements in both the winter and the summer, this is after an absence of three years from the winter records and two years from the summer. 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-XXIV/BG/17**

**Beach debris survey, Signy Island, South Orkney Islands, 2004/05.** H.F. Taylor (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 12 pp. (English, unpublished).

During the 2004/05 austral summer the 15th 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 38 items weighing 10.95 kg was collected. The number of items found was higher than the total found during the previous season, though the total mass of the waste recovered had declined (an increase of 85.71% and decrease of 8.31% since 2003/04 respectively). There was a rise in the number of plastic packaging bands (12) from the total recorded the previous season (5), this increase resuming the rise in packaging bands experienced over the previous three seasons with the exception of 2003/04 and marking a return to what has otherwise proved a declining trend since 1993/94. These findings highlight the fact that plastic packaging bands continue to appear as beach debris and indicate 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 71.01% of all items recorded, followed by wood at 13.16%. 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. The need for continued monitoring to ensure that vessels are aware of, and comply with, regulations prohibiting the disposal of debris at sea is paramount.

**SC-CAMLR-XXIV/BG/18**

**Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Signy Island, South Orkney Islands, 2004/05.** H.F. Taylor (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 10 pp. (English, unpublished).

The results of the ninth annual survey of entanglements of Antarctic fur seals at Signy Island, South Orkney Islands, are reported for the 2004/05 summer season. There were two sightings of seals wearing neck collars of man-made debris, both were sub-adult males entangled with fishing net. In one case the entangling material had become attached to a rock and the animal was tethered to the ground. The incidence of entanglement at Signy Island,

albeit very low, 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-XXIV/BG/20**
**Antarctic marine ecosystem research in the CCAMLR Area.** Submitted by ASOC, 5 pp. (English, unpublished).

**SC-CAMLR-XXIV/BG/21**
**Ecosystem management of the Antarctic krill fishery.** Submitted by ASOC, 21 pp. (English, unpublished).

**SC-CAMLR-XXIV/BG/22**
**Marine noise pollution – mitigation and the need for wider protection.** Submitted by ASOC, 10 pp. (English, unpublished).

Noise pollution continues to receive increasing attention in international fora. A number of significant developments since CCAMLR-XXIII are documented. The limitations of mitigation measures are discussed and the role of Marine Protected Areas and alternative technologies, as potential methods to ensure protection of cetaceans and other marine species from the wider impacts of noise pollution, are considered.

**SC-CAMLR-XXIV/BG/25**
**Scientific justification for a marine protected area designation around the Balleny Islands to protect ecosystem structure and function in the Ross Sea region, Antarctica: progress report.** Delegation of New Zealand, 25 pp. (English, unpublished).

In 2000, the New Zealand Delegation to CCAMLR proposed the designation of an Antarctic Specially Protected Area (ASPA) around the Balleny Islands. Since that time, research has continued to focus on the value of the area on and around the Balleny Islands, and the potential benefits of establishing a Balleny Islands Marine Protected Area (MPA). The ecological importance of the Balleny Islands can be aligned with both the CCAMLR ecosystem-wide conservation objectives and the values found in Article 3 of Annex V to the Protocol on Environmental Protection to the Antarctic Treaty. This paper's focus is on the CCAMLR values.

A review of existing information reveals that the Balleny Islands are uniquely situated to provide essential breeding and foraging habitat for large populations of top predator populations dependent on locally high abundances of Antarctic krill. Due to tight trophic coupling and the relative intactness of the Ross Sea ecosystem, disruption of predator foraging opportunities by human activities and/or competition between predators and fisheries for available prey can be expected to have considerable indirect effects on other aspects of the ecosystem. The area around the Balleny Islands also includes the only known habitat in the region for juvenile toothfish, and perhaps also for early developmental stages of Antarctic krill, both of which are critical for ecosystem function and for the sustainability of existing and potential fisheries in the region. A strategically located Balleny Islands MPA extending outward from the islands would provide a critical buffer between ecologically important populations and human activities (including existing and potential fisheries), and some measure of protection against unpredictable and potentially negative ecosystem impacts, consistent with the conservation mandate of the CAMLR Convention. Such a designation could also be highly valuable for the advancement of marine science, consistent with the principles of the Antarctic Treaty.

**SC-CAMLR-XXIV/BG/26**
**IMAF risk assessment of fisheries by statistical area.** Ad Hoc Working Group on Incidental Mortality Associated with Fishing (WG-IMAF), 28 pp. (English, unpublished).

**SC-CAMLR-XXIV/BG/27**
**Incidental mortality of seabirds during unregulated longline fishing in the Convention Area.** Ad Hoc Working Group on Incidental Mortality Associated with Fishing (WG-IMAF), 11 pp. (English, unpublished).

**WG-EMM-05/9**

**Seabird research at Cape Shirreff, Livingston Island, Antarctica, 2004/05.** A.K. Miller, E. Leung and W.Z. Trivelpiece (Antarctic Ecosystem Research Division, Southwest Fisheries Science Center, La Jolla, CA 92037, USA), 7 pp. *AMLR 2004/2005 Field Season Report*, in press (English).

The eighth complete consecutive season of data collection at Cape Shirreff has enabled us to examine trends in penguin population dynamics, as well as interannual variation in penguin diet and foraging behaviour. The chinstrap breeding population at Cape Shirreff has continued to decline over the past six years, and is at its lowest size in the past eight years of study, and fledging success was poor compared to earlier years of study. The gentoo breeding population, in contrast, has remained relatively stable and had similar fledging success in 2004 as the long-term mean. Fledging weights of both species decreased from last year, and were the lowest average weights seen over nine years. The diet of both chinstrap and gentoo penguins contained primarily adult female Antarctic krill, peaking in the 46–50 mm range, continuing a four-year trend of increasing proportions of female krill and increasingly larger krill. The diet of both species contained less fish than in other years on average. Total chick meal mass was larger for chinstrap penguins compared to the past seven years of study, primarily in the digested portion of the meal. The interpretation of these diet patterns may be aided by analysis of foraging location and diving behaviour data.

**WG-EMM-05/11**

**The BROKE-West acoustic krill biomass survey of 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), 4 pp. (English, unpublished).

This document updates plans by Australia to conduct an acoustic biomass survey for krill in CCAMLR Division 58.4.2 (the southwest Indian Ocean sector) in January–March 2006. The survey is intended to produce a new estimate of $B_0$ for this division so that a revised precautionary catch limit can be established by CCAMLR. The survey will be conducted from a single ship and will consist of 11 parallel transects between 30° and 80°E. The survey design was presented to WG-EMM for comment in 1995 and suggested improvements have been incorporated into the final design.

**WG-EMM-05/12**

**Descriptive analysis of haul data from the FV *Atlantic Navigator* in the Elephant Islands (Subarea 48.1), South Georgia (Subarea 48.3) and South Orkney Islands (Subarea 48.2) krill fishery (summer 2004 to early winter 2005).** O. Pin, H. Nión, E. Delfino and P. Meneses (Instituto Nacional de Pesca de Uruguay (DINARA), Av. 8 de Octubre 2688, Depto. 403, Montevideo, Uruguay, opin@dinara.gub.uy), 14 pp. (English, unpublished).

Data from individual hauls carried out by the krill fishing vessel FV *Atlantic Navigator* operating in three fishing zones were analysed: Elephant Islands (Subarea 48.1), South Georgia (Subarea 48.3) and South Orkney Islands (Subarea 48.2). The fishing season was extended from 19 February 2004 (summer 2004) to 7 April 2005 (early winter 2005) with a total of 251 days of effective fishing. A descriptive study of the fishery operation was performed for the two fishing systems used: conventional fishing system (CON) and the continuous fishing system with air-bubbling suspension and suction of capture (CFS). Individual haul data were analysed to describe the different catch rates (catch per day and

catch per minute) of the three different fishing areas studied. The total catch registered was 41 837 tonnes; 50% of this was caught in the South Orkney Islands area. The highest catch rate was calculated for the same fishing area with CFS (293 kg/min) during summer 2005. The largest krill size also corresponded to this area and season – 50 mm total length. The proportion of sexes was determined when possible (summer 2005): males 65%, females 28% and immature individuals 7%. The predominant colour of sampled individuals was determined as IC for the 2004 winter season and IIC and IIB for the 2005 summer to winter seasons. All data were recorded in accordance with the CCAMLR Scheme of International Scientific Observation (SC-CAMLR, 1993).

## WG-EMM-05/13

**A krill–predator–fishery model for evaluating candidate management procedures.** G.M. Watters, J.T. Hinke, K. Reid and S. Hill (NOAA Fisheries, Southwest Fisheries Science Center, 1352 Lighthouse Avenue, Pacific Grove, CA 93950, USA, george.watters@noaa.gov), 55 pp. (English, unpublished).

CCAMLR has recognised the need to subdivide the precautionary krill catch limit for Area 48 amongst smaller spatial units in order to minimise the localised depletion of krill in predator foraging areas. These smaller spatial units, termed small-scale management units (SSMUs), have been defined, and six candidate procedures for subdividing the catch have been identified. It is now necessary to evaluate these procedures in terms of their likely effects on krill and predator populations as well as fishery performance. This evaluation must be conducted in the context of considerable uncertainty about how the krill–predator–fishery system operates. This paper describes a model designed to investigate the performance of these procedures and their sensitivity to numerical and structural uncertainty. The model is spatially resolved to the level of SSMUs and surrounding oceanic areas, and it includes the transport of krill between these areas. Krill and predator population dynamics are implemented with coupled delay-difference models, which are formulated to accommodate various assumptions about the recruitment and predation processes. The fishery is represented as a simultaneous and equal competitor for available krill. Straightforward Monte Carlo simulations are used to integrate the effects of numerical uncertainty, and structural uncertainty can be assessed by comparing and merging results from multiple such simulations. A range of performance measures that can be used to evaluate catch-allocation procedures and assess trade-offs between predator and fishery performance is presented. Basic instructions on running the model in S-Plus are provided and its use is illustrated. Finally, it is concluded that although the model presented here necessarily simplifies a complex system, and it provides a flexible framework for investigating the roles of transport, production, predation and harvesting in the operation of the krill–predator–fishery system.

## WG-EMM-05/14

**Modelling the impact of krill fishing on seal and penguin colonies.** É.E. Plagányi and D.S. Butterworth (Marine Resource Assessment and Management Group (MARAM), Department of Mathematics and Applied Mathematics, University of Cape Town, Private Bag, Rondebosch 7701, South Africa, eva@maths.uct.ac.za), 15 pp. (English, unpublished).

A key area of concern highlighted by the CCAMLR Scientific Committee concerns the potential overlap of the krill fishery with the foraging area of land-based predators, such as seals and penguins, in the Antarctic Peninsula region. The dynamics of krill in this region are strongly influenced by advective processes. A key question is therefore whether or not limitations on fishing activities (reducing their economic efficiency) are necessary, given that there is a flux of krill through this region with its islands inhabited by predator colonies. In order to estimate the krill production actually available for predator consumption, it is necessary not only to consider 'snapshot' survey estimates of krill abundance in the vicinity

of a breeding colony, but also the flux of krill through such areas. This paper outlines a proposed spatial modelling framework that could be used to couple flux estimates with estimates of removals by both the fishery and predators, in an attempt to quantify what level and localisation of the fishing effort might impact the predators negatively. The approach described represents work still in progress as the focus thus far has been on first developing a model of the possible impact of pelagic fishing on seal and penguin colonies on the South African west coast. The latter ecosystem shares a number of common features with the Antarctic Peninsula ecosystem in that there is a substantial advective flux of either pelagic fish or of krill, with both species serving as dominant prey items for colonies of land-based predators in the region concerned. Subject to the availability of data from both predator studies and krill surveys, the west coast model methodology could thus straightforwardly (initially at least) be adapted to the Antarctic Peninsula region. This would permit the evaluation of a wide range of management options pertaining to the issue of taking into account the needs of other species when setting precautionary krill catch limits at an appropriate spatial scale.

### WG-EMM-05/15
**Some additional data challenge the concept of the distribution of gravid krill females in relation to bottom depths.** V.A. Sushin, F.F. Litvinov, A.S. Sundakov and G. Andrianov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, sushin@atlant.baltnet.ru), 8 pp. (English, unpublished).

The distribution of krill females at various maturity stages was examined to reveal the preferred bottom depths for spawning. Calculations based on three wide-ranging scientific surveys and numerous data from observers revealed no statistically reliable tendency in the gravid females to move offshore to deeper waters. The possible factors affecting the spawning distribution of females are discussed. It is assumed that the most important factor determining the distribution of gravid females is food supply.

### WG-EMM-05/16
**Preliminary report of the Japanese RV *Kaiyo Maru* survey in the Ross Sea and adjacent waters, Antarctica, in 2004/05.** M. Naganobu, K. Taki and T. Hayashi (Southern Ocean Living Resources Research Section, National Research Institute of Far Sea Fisheries, 5-7-1, Shimizu-Orido, Shizuoka, 424-8633 Japan, naganobu@affrc.go.jp), 9 pp. (English, unpublished).

A survey of the Japanese RV *Kaiyo Maru* was carried out to collect data simultaneously on ecological interaction of environment–Antarctic krill–whales in the Ross Sea and adjacent waters during December 2004 and February 2005. Transect lines along 165°E, 175°E, 180°, 175°W, 170°W and 165°W were investigated to cover hot spots which suggest high concentrations of krill and whales such as the Scott Seamounts Island, the Balleny Islands, the shelf off Victoria Land and almost the entire Ross Sea. The 175°E and 170°W lines, especially, were surveyed in detail from the surface to near the sea bottom from 60°S to the edge of the Ross Ice Shelf on physical, chemical and biological parameters.

### WG-EMM-05/17
**Time series of Drake Passage Oscillation Index (DPOI) from 1952 to 2005, Antarctica.** M. Naganobu and K. Kutsuwada (Southern Ocean Living Resources Research Section, 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) had

assessed variability in krill recruitment and density in the Antarctic Peninsula area with an environmental factor: strength of westerly winds (westerlies) determined from sea-level pressure differences across the Drake Passage, between Rio Gallegos (51°32'S 69°17'W), Argentina and Base Esperanza (63°24'S 56°59'W), at the tip of the Antarctic Peninsula from 1982 to 1998. Fluctuations in the westerlies across the Drake Passage were referred to as the Drake Passage Oscillation Index (DPOI). They found significant correlations between krill recruitment and DPOI. Additionally, a new time series of DPOI from January 1952 to March 2005 was calculated.

**WG-EMM-05/18**

**Developing a carbon-budget trophic model of the Ross Sea, Antarctica: work in progress.** M. Pinkerton, S.M. Hanchet, J. Bradford-Grieve and P. Wilson (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, m.pinkerton@niwa.co.nz), 26 pp. (English, unpublished).

This paper reports on the development of a carbon-budget trophic model of the Ross Sea. The food web of the Ross Sea was provisionally defined as having the following functional compartments: birds, seals, toothed whales, baleen whales, large bentho-pelagic predatory fish (mainly adult Antarctic toothfish), pelagic and juvenile fish (mainly Antarctic silverfish), demersal fish (skates, rattails, notothenioids), cryopelagic fish, squid, macrozooplankton (including krill and salps), macrobenthos, meiobenthos, ice heterotrophs, water column zooplankton (ciliates, heterotrophic flagellates, mesozooplankton), three groups of bacteria (water column, ice and sediment), phytoplankton, epontic algae and three detritus groups (water column, ice and benthic). The simple trophic model requires well over a hundred parameters, each of which has been estimated by sifting published and unpublished information. Local information on organisms in the Ross Sea was used whenever available. Where no information in the literature was available, field measurements that have not been published, or estimated values using explicit assumptions, were sought out.

The model is not complete, and should be considered as a work in progress. A trial budget was created to quantify carbon flow through the conceptual model of the Ross Sea ecosystem. A first run of the model was carried out, and the initial set of parameters was not found to be self-consistent, i.e. they do not lead to a balanced model. The next step is to determine the range of ecosystem variables that are consistent with the current understanding of the constraints on ecosystem functioning within the bounds of uncertainty estimated for each parameter; this approach is termed *feasible parameter space mapping*.

**WG-EMM-05/19**

**By-catch of fish caught by the fishing vessel *Niitaka Maru* in the South Georgia area (August to September 2004).** T. Iwami, T. Hayashi, K. Taki and M. Naganobu (Laboratory of Biology, Tokyo Kasei Gakuin University, 2600 Aihara, Machida, Tokyo 194-0292, Japan, iwami@kasei-gakuin.ac.jp), 6 pp. (English, unpublished).

Scientific observations on fish incidentally caught in commercial krill fisheries by the FV *Niitaka Maru* (5 306 tonnes) were made to the north of South Georgia Island from 6 August to 9 September 2004. Among 100 net hauls quantitatively examined, a total of 12 species belonging to six families of fish by-catch occurred in 76 trawl catches. The family Myctophidae, the most abundant taxa during the present survey, was found in 61% of hauls examined. Although only one notothenioid species, *Lepidonotothen larseni*, was caught as by-catch, it was the next in abundance and found in 25% of hauls. The length-frequency distribution of by-catch of *L. larseni* showed that this species is comprised of at least three different year classes. A similar pattern is also found in *Gymnoscopelus nicholsi* of the Myctophidae family. At least in the net hauls of high krill CPUE (>20 tonnes/h), few or no

by-catch fish occurred.  The hauls of lower krill CPUE (<5 tonnes/h), however, did not always contain a large amount of incidental catch of fish.  The negative correlation between the abundance of by-catch fish and krill CPUE is not clear.

**WG-EMM-05/20**
**Quantifying within- and between-season variability in Adélie penguin fledgling weights: statistical and practical implications for detecting change.**  L.M. Emmerson, C. Southwell and J. Clarke (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, louise.emmerson@aad.gov.au), 19 pp.  *CCAMLR Science*, submitted (English).

Statistical models of Adélie penguin fledgling weight data collected at Béchervaise Island were developed and used in a power analysis as a continuation of the CEMP review.  The statistical models incorporate both within- and between-season variability of fledgling weights from first principles using raw data as recommended in Southwell et al. (2004). These models should be viewed as initial attempts at incorporating multiple sources of variability rather than final products because a number of issues need further consideration. Issues to be resolved include the form and direction of change of fledgling weights with a decline in resource availability, the consideration of total chick failure during severe food shortages and a possible change in variance associated with a change in the mean value.  With these issues kept in mind, the major findings from these statistical models are the potential for reducing to 30 the number of birds weighed in a single five-day period each year.  If practical, this outcome could have substantial benefits by simplifying data collection.  Some of the practical issues of continuing to measure fledgling weights at Béchervaise Island either by the current or the modified methodology are also discussed.

**WG-EMM-05/21**
**Do Adélie penguin fledgling weights provide an index of prey availability?** L.M. Emmerson, C. Southwell and J. Clarke (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, louise.emmerson@aad.gov.au), 15 pp.  (English, unpublished).

Fledgling weights measured over 11 years at Béchervaise Island were examined in relation to two assumed proxies of prey availability: breeding success and foraging trip duration. Concordance between the two proxies was apparent when considering guard stage foraging trip durations but this was not as strong for the crèche foraging trips later in the season. Fledgling weights which are measured at the end of the breeding season were more strongly correlated with later foraging trips than with earlier trips.  These results could be interpreted as an indication of variable resources between the guard and crèche stages of the breeding season.  In some seasons, there appeared to be constant levels of resources throughout the breeding season resulting in good breeding success with heavy fledglings or poor breeding success with light fledglings.  In other seasons, there was a disparity between breeding success and fledgling weight.  For example, low breeding success could occur in a season with heavy fledglings associated with long foraging trips during the guard period and relatively short trips during the crèche period.  The concerns raised by Williams and Croxall (1990) that fledgling weight may increase with an associated truncation of the distribution in poor seasons for seabirds with prolonged chick-rearing periods is unfounded for the Béchervaise Island Adélie penguin population.  It would be useful to determine the demographic consequences of variable fledgling weights in terms of subsequent chick survival for this population.

**WG-EMM-05/22**

**Detection of systematic change in Adélie penguin foraging trip duration: consequences of high interannual variability and usefulness of ice cover as a covariate.** J. Clarke, *C. Southwell and L.M. Emmerson (*Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, colin.southwell@aad.gov.au), 26 pp. *CCAMLR Science*, submitted (English).

Power analyses were carried out using a 12-year dataset from the Béchervaise Island Adélie penguin colony with the aim of determining minimum sample sizes required to detect systematic temporal change in CEMP parameter A5 (penguin foraging trip duration). Two different types of systematic change were investigated: (i) change occurring at a constant rate after a certain point in time, and (ii) a sudden step change in parameter values from one average level to another. Modelling showed that change of the latter form could be more quickly and powerfully detected at a range of effect sizes than could consistent rates of change occurring over longer periods of time. Sample sizes of 50 penguins carrying out three foraging trips each were required to detect a 35% step increase in foraging trip duration after three years or alternatively, with equal power, a 3.75% annual increase in trip duration after 12 years from the onset of change (55% overall increase). Inclusion of ice cover as a covariate in the analyses enhanced detection of change for birds monitored in the guard stage of chick rearing. However, caution must be exercised when incorporating covariates into power analyses, as inclusion of covariates to explain part of the natural interannual variability in a monitored parameter is only useful if the covariate itself is independent of the factors causing the systematic change.

**WG-EMM-05/23**

**Estimating the abundance of pack-ice seals off east Antarctica.** C. Southwell, D. Borchers, C. Paxton, W.K. de la Mare, P. Boveng, A.S. Blix and E.S. Nordoy (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, colin.southwell@aad.gov.au), 22 pp. (English, unpublished).

A survey was undertaken to provide estimates of the abundance of crabeater, Ross and leopard seal populations in $1\,500\,000$ km$^2$ of pack-ice off east Antarctica between longitudes 60 and 150°E. Sighting surveys were undertaken along almost 10 000 km of survey transect from an icebreaker and two helicopters to estimate the density of seals hauled out on the ice in survey strips. The probability of detecting seals in survey strips was estimated using double observer line transect methods, and satellite-linked dive recorders were deployed on a sample of seals to estimate the probability of seals being hauled out on the ice at any time of day. Due to non-random placement of survey transects, model-based inference, involving the fitting of a density surface as a function of geographic covariates, was used to extrapolate estimated densities in surveyed areas to the entire survey region. Estimating uncertainty in abundance estimates included consideration of uncertainties in species identification, estimation of detection probability, estimation of haulout probability, and extrapolation from sampled strips to the entire survey region.

**WG-EMM-05/24**

**Developments, considerations and recommendations by the land-based predator survey group: a summary and update.** C. Southwell, P. Trathan, W.Z. Trivelpiece, M.E. Goebel and P. Wilson (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, colin.southwell@aad.gov.au), 6 pp. (English, unpublished).

A summary of considerations and decisions made by the correspondence group on land-based predator abundance is provided for comment by WG-EMM. In order to complete specifications for future survey work, the correspondence group seeks advice from the

Working Group on the relevant spatial unit for estimation in Area 48 and the required precision for estimation in each unit. A workshop addressing survey design issues is proposed for 2006. Terms of reference for the workshop are provided for comment.

**WG-EMM-05/25**

**A GIS tool to assist in the planning and design of sample surveys of the abundance of colonial breeding species.** C. Southwell, R. Dreissen, S.G. Candy, G. McPherson and J. Clarke (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, colin.southwell@aad.gov.au), 14 pp. (English, unpublished).

A GIS tool to assist in the planning and designing of surveys of colonial breeding species is described. The tool could be applied to any region of Antarctica given available colony map and count data. The tool currently implements only very simple survey designs, but could be further developed to implement more complex and efficient designs. An example of its potential use is provided. In the example, the tool is used to sample a population of Adélie penguins in the Holme Bay region of East Antarctica as might occur in a pilot survey, and the resulting sample densities used to predict the number of sampling units required to estimate abundance for the entire region with a pre-determined precision.

**WG-EMM-05/26**

**Using carapace measurements to determine the sex of Antarctic krill (*Euphausia superba*).** J.D. Lipsky, *M.E. Goebel, C.S. Reiss and V. Loeb (*NOAA, NMFS, Southwest Fisheries Science Center, Antarctic Ecosystem Research Division, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, mike.goebel@noaa.gov), 25 pp. (English, unpublished).

Krill carapaces measurements have been used to reconstruct krill length frequencies in Antarctic fur seal diet. The discriminant function currently used to determine sex, and the sex-specific allometric equations for calculating total length from carapace length, were derived from South Georgia krill populations. The equations have been applied to fur seal diet studies in the South Shetland Islands but until now have not been validated using locally sampled krill. This study reports on a three-year study validating the use of discriminant functions to determine the sex of krill based on carapace length and width and independently derives sex-specific regression models for krill collected in the South Shetland Islands. Allometric equations derived from South Georgia krill overestimated total length. Applying a discriminant function derived from mature krill in years following significant recruitment events with large proportions of immature krill resulted in significant bias towards male krill and an overestimation of krill length. Some standard guidelines for applying discriminant functions, allometric equations and for interpreting results are proposed.

**WG-EMM-05/27**

**Modelling growth of Antarctic krill: a new approach to describing the growth trajectory.** S.G. Candy and S. Kawaguchi (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, steve.candy@aad.gov.au), 39 pp. (English, unpublished).

Von Bertalanffy (VB) growth models for Antarctic krill have in the past been calibrated from population-level data consisting of modal lengths obtained from a time sequence of length-frequency samples. An alternative approach was developed to predict the trajectory of length over time using a step-growth function that combines models of instantaneous growth rate (IGR) at moult calibrated from direct measurements of individual pre- and post-moult krill sampled from the wild with a model of temperature-dependent intermoult period. Using summer and early autumn data for juveniles and males sampled from the Indian Ocean sector, IGR was modelled as a function of pre-moult length and season using linear mixed models

incorporating cubic smoothing splines.  A number of growth trajectories was generated starting from an age 1+ mean length for different scenarios of winter and spring growth. Convenient parametric approximations were then provided to these step trajectories using either punctuated-growth or seasonal-growth VB models.  These models indicate that, allowing for shrinkage, age 6+ mean length for the Indian Ocean sector was close to 53 mm compared to 57 mm obtained from studies for the Atlantic Ocean sector.

**WG-EMM-05/28**

**Fishing ground selection in the krill fishery: trends in its patterns across years, seasons and nations.**  S. Kawaguchi, K. Taki and M. Naganobu (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, so.kawaguchi@aad.gov.au), 18 pp.  *CCAMLR Science*, submitted (English).

Patterns of fishing ground selection were characterised using STATLANT and CCAMLR fine-scale data.  Among the 15 SSMUs within Subareas 48.1, 48.2 and 48.3, including the pelagic SSMUs, only one-third were identified as the main contributors to the total catch.  A shift of operational timing towards later months within fishing seasons was observed in Subarea 48.1 (December–February to March–May).  However, operational timing stayed relatively constant in Subareas 48.2 (March–May) and 48.3 (June–August).  During 25 years of krill fishing operations in Area 48, patterns of SSMU usage have changed.  Three different patterns of seasonal SSMU selection were characterised by following the result of cluster analysis.  Frequently used SSMUs did not always match the areas of high krill densities observed by scientific surveys, and possible reasons for this mismatch were further discussed. Desire for revised data submission formats was also recognised in order to accommodate any possible development of the fishing techniques.

**WG-EMM-05/29**

**Modelling growth of Antarctic krill: growth trends with sex, length, season and region.** S. Kawaguchi, S.G. Candy, R. King, M. Naganobu and S. Nicol (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, so.kawaguchi@aad.gov.au), 29 pp.  (English, unpublished).

Growth trends of Antarctic krill with sex, length, season and region using over 10 years accumulation of instantaneous growth rate (IGR) measurements were modelled using a linear mixed model (LMM).  A model of inter-moult period (IMP) as a function of temperature, required to convert IGR to specific growth rate, was fitted to data from published constant-temperature rearing studies and this model was used to predict seasonal IMP using a model of the average seasonal trend of sea-surface temperature for each region.  Smaller krill exhibited higher growth rates and a progressive decrease in the IGR with increasing size was generally observed.  This trend decreased from summer to autumn with small to negative values of IGR predominating across all size classes by autumn.  The period of rapid growth was December in the Indian Ocean sector, whereas in the Scotia Sea sector it appeared to be a few months earlier than this.  Significantly lower growth rates were exhibited by females in January and February relative to males.  Seasonal specific growth rates estimated in this study were compared to previous studies, and suggested that wild krill show more rapid growth over a shorter growth period than was traditionally thought.

**WG-EMM-05/30**

**A conceptual model of the Japanese 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), 15 pp. *CCAMLR Science*, submitted (English).

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 were sent out to Japanese fishing vessels since the 1989/90 fishing season. There were many reasons for changing fishing grounds: krill density, krill size, ice condition, transhipment and salp by-catch. These reasons 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 other nations' vessels. A conceptual model for the Japanese krill fishing operation is proposed.

**WG-EMM-05/31**

**CCAMLR *Scientific Observers Manual* questionnaires: summary of results of a preliminary analysis during its introductory period.** S. Kawaguchi and S. Nicol (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, so.kawaguchi@aad.gov.au), 9 pp. (English, unpublished).

A preliminary analysis of data from the questionnaires in the CCAMLR *Scientific Observers Manual* on krill fishery behaviour was undertaken. The analysis revealed possible inconsistencies in the definitions of event codes among different skippers. Some suggestions were made to improve the quality of the questionnaire format to better understand the nature of the fishery.

**WG-EMM-05/33**

**Implementing plausible ecosystem models for the Southern Ocean: an ecosystem, productivity, ocean, climate (EPOC) model.** A.J. Constable (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@aad.gov.au), 20 pp. (English, unpublished).

An ecosystem, productivity, ocean, climate (EPOC) model has been developed in the R statistical language to help explore topical issues on Antarctic marine ecosystems, including impacts of climate change, consequences of overexploitation, conservation requirements of recovery and interacting species, and the need to evaluate whether harvest strategies are ecologically sustainable. As such, it can be used to facilitate the development of plausible ecosystem models for evaluating management procedures for krill following the recommendations of the workshop held by WG-EMM in 2004. EPOC has been designed as an object-oriented framework currently built around the following modules: (i) biota, (ii) Environment, (iii) human activities, (iv) management, (v) outputs, and (vi) presentation, statistics and visualisation. Each element within a module is an object carrying all its own functions and data. EPOC is designed to be a fully flexible plug-and-play modelling framework. This is because of the need to easily explore the consequences of uncertainty in model structures but, more importantly, to enable ecosystem modelling to proceed despite widely varying knowledge on different parts of the ecosystem and avoiding the need to guess model parameters for which no information exists. EPOC provides these opportunities as well as examining the sensitivity of outcomes to changes in model structures, not only in the magnitude of parameters but in the spatial, temporal and functional structure of the system. A case study for Antarctic krill is presented as an example.

**WG-EMM-05/34**

**Modelling the predator–prey interactions of krill, baleen whales and seals in the Antarctic ecosystem.** M. Mori and D.S. Butterworth (Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa, mmori@maths.uct.ac.za), 52 pp. *CCAMLR Science*, submitted (English).

The history of human harvests of seals, whales, fish and krill in the Antarctic is summarised briefly, and the central role played by krill emphasised. The background to the hypothesis of a krill surplus in the mid-20th Century is described, and the information on population and trend levels that has become available since the postulate was first advanced is discussed. The objective of the study is to determine whether predator–prey interactions alone can broadly explain observed population trends without the need for recourse to environmental change hypotheses. A model is developed including krill, four baleen whale (blue, fin, humpback and minke) and two seal (Antarctic fur and crabeater) species. The model commences in 1780 (the onset of fur seal harvests) and distinguishes the Atlantic/Indian and Pacific Ocean sectors in view of the much larger past harvests in the former. A reference case and five sensitivities are fit to available data on predator abundances and trends, and the plausibility of the results and the assumptions on which they are based is discussed, together with suggested further areas for investigation. Amongst the key inferences of the study are that: (i) species interaction effects alone can explain observed predator abundance trends, though not without some difficulty; (ii) it is necessary to consider other species in addition to baleen whales and krill only to explain observed trends, with crabeater seals seemingly playing an important role and constituting a particular priority for improved abundance and trend information; (iii) the Atlantic/Indian Ocean region shows major changes in species abundances, in contrast to the Pacific Ocean region which is much more stable; (iv) baleen whales have to be able to achieve relatively high growth rates to explain observed trends; and (v) Laws' (1977) estimate of some 150 million tonnes for the krill surplus may be appreciably too high as a result of his calculations omitting consideration of density-dependent effects in feeding rates.

**WG-EMM-05/36**

**Preliminary report of sound-speed contrast and density of krill measured on board the RV *Kaiyo Maru*.** Y. Takao, H. Yasuma , R. Matsukura and M. Naganobu (National Research Institute of Fisheries Engineering, Fisheries Research Agency, Ebidai 7620-7, Hasaki, Ibaraki, 314-0421 Japan, ytakao@affrc.go.jp), 9 pp. (English, unpublished).

The target strength (TS) of Antarctic krill (*Euphausia superba*) is a scaling factor to convert the acoustic backscattering strength into the population density. Therefore, it is important to improve the accuracy and precision of the TS value. Since *in situ* and experimental TS measurements of small animals like krill are difficult, theoretical scattering models are used to predict the characteristics of the TS. For calculation by the acoustical scattering model, the information of size, morphology, orientation, and material properties of krill are required. There are two important material properties: one is the ratio of the density of the animals to that of the surrounding water (density contrast) and the other is the ratio of the sound speed in animals to that in the surrounding water (sound-speed contrast). Although these parameters are inevitable for the model calculation, reports of them are still few. During Antarctic surveys by the Japanese RV *Kaiyo Maru* in 2000 and 2004/05, measurements of sound speed and density of krill were carried out. Preliminary results are reported in this paper. The mean total length and mean density were 43.5 mm and 1.0562 g·cm$^{-3}$ respectively in the 2000 survey, and were 41.7 mm and 1.0720 g·cm$^{-3}$ in the 2005 survey. The corresponding sound-speed contrasts of mean total length of 25.1 and 48.6 mm were 1.0442 and 1.0348 respectively.

**WG-EMM-05/37**

**Mortality of macaroni penguins (*Eudyptes chrysolophus*) at Marion Island caused by avian cholera (*Pasteurella multocida*) in 2004/05.** R.J.M. Crawford, B.M. Dyer, M.S. De Villiers, G.J.G. Hofmeyr and D. Tshingana (Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Rogge Bay 8012, South Africa, crawford@deat.gov.za), 3 pp. (English, unpublished).

At Marion Island, an outbreak of avian cholera (*Pasteurella multocida*) killed about 2 000 macaroni penguins (*Eudyptes chrysolophus*) at the colony at Kildalkey Bay during November 2004. Other colonies of macaroni penguins and other species of seabirds were not affected. In March 1993, an unknown disease killed several thousand macaroni penguins at Bullard Beach, but also did not affect other colonies or other species of seabirds.

**WG-EMM-05/38**

**Breeding numbers and success of *Eudyptes* penguins at Marion Island, and the influence of arrival of adults.** R.J.M. Crawford, J. Cooper, B.M. Dyer and L.G. Underhill (Marine and Coastal Management, Department of Environmental Affairs and Tourism, Private Bag X2, Rogge Bay 8012, South Africa, crawford@deat.gov.za), 23 pp. *CCAMLR Science*, submitted (English).

At Marion Island, there was considerable correlation in numbers of adults breeding at study colonies for both macaroni (*Eudyptes chrysolophus*) and eastern rockhopper (*E. chrysocome filholi*) penguins, over 26 and 22 years respectively, suggesting overwintering conditions may influence the proportions of birds breeding. For both species the time of arrival of females for breeding, and for rockhopper penguins the mass of females on arrival, was significantly related to breeding success. Therefore, overwintering conditions may also affect breeding success. Trends in breeding success at study colonies were more strongly correlated for macaroni than for rockhopper penguins. Macaroni penguins have a greater foraging range than rockhopper penguins when breeding, and may be more influenced at this stage by wider-scale environmental phenomena. For macaroni penguins, breeding success was significantly correlated with mass of chicks at fledging. For both species, mass on arrival of males was significantly correlated with that of females. Although both species had low weights on arrival after the El Niño Southern Oscillation event of 1997/98, there was no significant correlation in mass on arrival between the two species. It is likely that at Marion Island their overwintering grounds are different.

**WG-EMM-05/41**

**Some characteristics of krill transport in the Scotia Sea based on Russian survey data.** S.M. Kasatkina, V.N. Shnar and O.V. Berezhinsky (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, ks@atlant.baltnet.ru), 17 pp. *CCAMLR Science*, submitted (English).

In this paper the characteristics of krill transport across SSMUs, determined on the basis of long-term Russian research in Area 48, are considered. Estimates of mean current velocities based on long-term data from 3 012 stations and respective time intervals when the water mass in the study area was totally replaced, are presented. It is shown that in SSMUs the multiple total replacement of water masses is possible during one fishing season. These processes of water mass replacement will be accompanied with krill biomass transport across the boundaries of SSMUs. Estimates of krill flux out of SSMUs during the fishing season appeared incomparable with either the historical annual catch within SSMUs, or with the total catch from the Scotia Sea for any fishing season during the last 20 years. It is shown that the total krill biomass of 3.392 million tonnes transported by water mass out of three SSMUs is

comparable to the total precautionary yield value in the Scotia Sea comprising 3.17 million tonnes. It is concluded that krill transport estimates should be taken into consideration in the scheme developed by CCAMLR for allocating the krill catch limit among SSMUs in the Scotia Sea. This is primarily referred to the fourth option of the scheme (Hewitt et al., 2004).

**WG-EMM-05/42**

**A quantified Bayesian maximum entropy estimate of Antarctic krill abundance across the Scotia Sea and in small-scale management units from the CCAMLR-2000 Survey.**
B.G. Heywood, S.F. Gull and A.S. Brierley (Gatty Research Laboratory, University of St Andrews, St Andrews, Fife KY16 8LB, United Kingdom, bgh@st-and.ac.uk), 25 pp. *CCAMLR Science*, submitted (English).

This paper presents the results of an alternative method of estimating krill abundance, and producing maps of krill distribution, from the data collected during the CCAMLR-2000 Survey of the Scotia Sea. Using a probabilistic Bayesian Maximum Entropy (MaxEnt) technique, density values for the unsurveyed off-transect portions of the survey area were found by interpolation, and thus values for total biomass across the survey area, and within individual small-scale management units (SSMUs), can be inferred. The MaxEnt formalism allows an objective choice of the parameters of the interpolation, and hence an objective choice of the most probable reconstruction of krill distribution, given the data. The Bayesian framework also allows an intrinsic calculation of the error in any resulting density estimate. During the survey, data were integrated at approximately 1 n mile intervals, resulting in 9 586 observed data points. Therefore the krill density was inferred on a $1 \times 1$ n mile grid of pixels. Density values ($g \cdot m^{-2}$) were calculated for all 1 726 332 pixels in the reconstructed area. The MaxEnt maps of the density distribution of krill across the survey area are presented. The resulting total biomass inferred for the survey area was 207.98 million tonnes, with a standard deviation of 10.08 million tonnes. The inferred biomass of krill in each of the SSMUs was: Antarctic Peninsula Pelagic Area (APPA) 65.192 million tonnes; Antarctic Peninsula West (APW) 0.753 million tonnes; Drake Passage West (APDPW) 35.874 million tonnes; Drake Passage East (APDPE) 0.397 million tonnes; Bransfield Strait West (APBSW) 0.167 million tonnes; Bransfield Strait East (APBSE) 1.381 million tonnes; Elephant Island (APEI) 10.496 million tonnes; Antarctic Peninsula East (APE) 0.003 million tonnes; South Orkney Pelagic Area (SOPA) 30.799 million tonnes; South Orkney West (SOW) 0.988 million tonnes; South Orkney North East (SONE) 0.005 million tonnes; South Orkney South East (SOSE) 0.243 million tonnes; South Georgia Pelagic Area (SGPA) 57.194 million tonnes; South Georgia West (SGW) 1.742 million tonnes; South Georgia East (SGE) 1.742 million tonnes.

**WG-FSA-SAM-05/5 Rev. 1**
**Exploring the ASPM as an alternative method to estimate the Patagonian toothfish biomass in CCAMLR Subarea 48.3.** O.C. Wöhler, P.A. Martínez and A. Aubone (INIDEP, Paseo Victoria Ocampo No. 1, 7600 Mar del Plata, Argentina, owohler@inidep.edu.ar), 25 pp. (English, unpublished).

The ASPM has been proposed and applied for Patagonian toothfish stock assessment in CCAMLR Subarea 48.3. The latest results obtained from this model and discussed at WG-FSA-04, do not show an acceptable fit with the standardised CPUE series and observed length proportions in the catches.

In this paper, some of the problems related to available CPUE data are discussed and new vulnerability patterns are estimated to produce a good fit of the model both the CPUE series and proportion-at-length data from the CCAMLR datasets.

**WG-FSA-SAM-05/6 Rev. 1**
**Investigation of bias in the mark–recapture estimate of toothfish population size at South Georgia.** D.J. Agnew, G.P. Kirkwood, J. Pearce and J. Clark (MRAG, 18 Queen Street, London W1J 5PN, United Kingdom, d.agnew@imperial.ac.uk), 15 pp. *CCAMLR Science*, submitted (English).

This paper investigates the influence of mixing of fish, and the uneven distribution of tag placements and recapture effort, on bias in the Petersen estimate. It does so by constructing a linear model of the South Georgia toothfish fishery, simulating fish movements within this system and overlaying various combinations of tagging and recapture effort to investigate bias. The fishable grounds around South Georgia were divided into 77 very small-scale boxes lying along the 1 000 m contour. The uneven distribution of animals was simulated by adjusting an average movement rate downwards when animals encountered a high CPUE box and upwards in a low CPUE box so that they were retained in high CPUE boxes. The model incorporates the facility for releases by box over a number of years.

The model performed as expected with test situations. It produced a near-perfect estimate of stock size when there was an ideal distribution of tags and/or fishing effort; by ideal it is meant that either tagging or fishing effort was in direct proportion to CPUE. When both tagging and fishing effort were non-ideal, e.g. when effort was concentrated away from tag concentrations, or overly concentrated in them, the Petersen estimator either overestimated or underestimated (respectively) the true population size. When run on the real tag–release data, and using CPUE from 2002–2004 and recapture effort in 2003 and 2004, the model indicated that the Petersen equation produced an underestimate of true population size. Although using the magnitude of the estimated bias to correct the tagging estimate made last year for Subarea 48.3 is not advocated, it is concluded that the particular distribution of tag releases and recapture effort at South Georgia is likely to lead to an underestimate of the true population size rather than an overestimate of it.

**WG-FSA-SAM-05/7**

**Implementation of the modified Petersen mark–recapture method in S-plus.** A. Payne, D.J. Agnew and R. Hillary (RRAG, Royal School of Mines Building, Imperial College, Prince Consort Road, London SW7 2BP, United Kingdom), 6 pp. (English, unpublished).

The mark–recapture method of estimating toothfish population size described last year, which uses a modification of the Petersen estimator to take account of mortality and selectivity, is implemented here in S-Plus code.

**WG-FSA-SAM-05/8**

**Stratification of catch-at-length data using tree-based regression: an example using Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea.** N.L. Phillips, A. Dunn 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), 16 pp. (English, unpublished).

This paper presents a new approach to the stratification of catch-at-length data of Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea.

Tree-based regression techniques were used to stratify the sampled catch based on the median length of Antarctic toothfish for each set using the observer length-frequency data. The median lengths were weighted within the regression by the inverse of the variance, rather than giving equal weights to all tows. Two variables (*depth* and *SSRU*) were used by the tree regression model to determine the strata.

The resulting stratification effectively split the fishery into four regions, consisting of shallow inshore regions where predominantly smaller fish were found, to deeper offshore regions where only larger fish were found. The paper presents the new estimates of Antarctic toothfish catch-at-length and catch-at-age from the Ross Sea up to the end of the 2003/04 fishing season.

**WG-FSA-SAM-05/9**

**Simulation experiments and CCAMLR yield estimates using CASAL.** A. Dunn (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, a.dunn@niwa.co.nz), 18 pp. (English, unpublished).

This paper describes an approach, using CASAL, to undertake operating model/estimation model experiments for *Dissostichus* spp., and methods for calculating CCAMLR yields using CASAL. An example model is presented for the fictitious fishery on a fictitious species *Dissostichus spurious* (Everson, 2004) and model performance is investigated from alternative types of observations. In general, most models were fitted with an expected percent root mean squared error (%RMSE) of less than 20%. The inclusion of additional data (i.e. more observation types) assisted in providing better estimates.

Further research on the expected performance of integrated models is required that investigates a range of alternative 'true' states with data that includes bias and variance in observations, as well as the robustness of the estimation model to alternative operating model assumptions. In addition, the expected uncertainty that may arise from a Monte Carlo Markov Chain (MCMC) approach has not been considered here.

In general, operating/estimation modelling experiments provides a means of evaluating alternative approaches to the assessment of stocks, however it should be noted that simulation studies often underestimate the uncertainty that would be found in a real assessment.

**WG-FSA-SAM-05/10**

**Descriptive analysis of the Antarctic toothfish (*Dissostichus mawsoni*) tagging scheme in the Ross Sea for the years 1997/98 to 2003/04.** A. Dunn, S.M. Hanchet and K. Maxwell (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, a.dunn@niwa.co.nz), 18 pp. (English, unpublished).

A descriptive analysis of the toothfish tagging program carried out in the Ross Sea since 2001 is presented for the first time. Tag–release and tag–recapture data are presented for both toothfish species for Subareas 88.1 and 88.2 for New Zealand vessels only. This is because data from non-New Zealand vessels were unavailable at the time of the analysis. A total of 4 903 Antarctic toothfish have been released and 89 recaptured, and 443 Patagonian toothfish released and 9 recaptured. For the last two years, when tagging has been part of the conservation measure, New Zealand vessels have tagged between 1.0 and 1.37 toothfish per tonne of catch. Tagging rates by area over the past three years have been in the same proportion as the catch by area. However, recapture rates have tended to be higher in the northern and eastern SSRUs 881C and 882E.

The maximum movement of Antarctic toothfish from the New Zealand dataset has been about 200 km. However, most (80%) Antarctic toothfish have moved less than 50 km. Consequently, nearly all fish have been recaptured from the same SSRU where they were released. The mean size of tagged Antarctic toothfish has increased since 2001, but is still smaller than the mean size of fish taken in the commercial catch. Larger toothfish (>35 kg) are difficult to tag without significant damage to fish, and there appears to be a trade-off between maximising size of released fish and minimising tagging mortality. Growth rates of Antarctic toothfish that have been at liberty for 2–3 years have averaged 5–7 cm per year, which is consistent with growth rates predicted from the von Bertalanffy growth curve. The preliminary estimate of tag loss from double tagging experiments is 13% per year.

**WG-FSA-SAM-05/11**

**Computer program for the calculation and validation of Verhoeff check digits.** A. Dunn (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, a.dunn@niwa.co.nz), 11 pp. (English, unpublished).

Abundance estimates from tag–release and tag–recapture data require that the number and type of errors in data for analysis are minimised. Accurate recording of the sequence numbers on tags at the time of release and recapture form an important part of data accuracy. Checking digits, as a part of the tag sequence number, can assist in the identification of errors in recorded data.

A computer program to calculate, check, and validate a check digit scheme based on Verhoeff's Dihedral Group $D_5$ check algorithm (Mohr, 2005; Verhoeff, 1969) is described.

**WG-FSA-SAM-05/12**

**Further development and progress towards evaluation of an Antarctic toothfish (*Dissostichus mawsoni*) stock model for the Ross Sea.** A. Dunn, D.J. Gilbert and S.M. Hanchet (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, a.dunn@niwa.co.nz), 24 pp. (English, unpublished).

This report outlines the development of a Bayesian sex and age structured population model for the assessment of Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea (Subareas 88.1 and 88.2), and initial progress towards evaluation of spatially explicit models. Three model scenarios were investigated. The first scenario considered the Ross Sea fishery as a single homogeneous area (single-area). The second and third scenarios (2-area and 3-area respectively) split the Ross Sea into either two or three discrete areas, with migrations of fish between areas. The 2-area model appeared to provide a better representation of some

of the observations, although there was a lack of any observations defining migration between areas.  The 3-area model showed many problems in fitting the data adequately.  In both the spatial models, there was a lack of useful data on area splits, migration rates or migration patterns.

Simulations experiments suggested that reliable, albeit uncertain, estimates of biomass could be obtained from each model when the operating model was the same as the estimation model.  However, the single-area estimation model was strongly negatively biased when using tag–recapture data simulated from the 2-area model.

All the multi-area models investigated here could do with considerable improvement.  The choice of area (i.e. the boundary between areas), selectivity functions (i.e. either domed or logistic), selectivity types (i.e. either age based or length based), and migration ogives need further investigation.  Additional tag–recapture data, specifically data that allows movement rates between areas to be quantified, are required to develop more realistic stock structure hypotheses.

**WG-FSA-SAM-05/13**
**Fitting a von Bertalanffy growth model to length-at-age data accounting for length-dependent fishing selectivity and length-stratified sub-sampling of length-frequency samples.**  S.G. Candy (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, steve.candy@aad.gov.au), 51 pp.  (English, unpublished).

Response-biased sampling in the context of regression modelling occurs when sample units are selected with a probability that is a function of the response.  In sampling to obtain fish to both age and measure for length there are two potential response-biased sampling processes when length is the response and age is the predictor variable.  These sample processes are: (i) the actual fishing process involving a particular gear, and (ii) the method of on-deck sub-sampling fish for ageing from the random length-frequency sample.  When the selectivity of the gear combined with availability of fish to be caught is length dependent in (i) and when fixed sample sizes per length bin or class are employed in (ii) then both these sampling processes are response-biased.  Response-biased sampling and its effect on parameter estimation has been studied for linear, generalised linear, and linear mixed models, but since population-average length, given age is assumed to follow the von Bertalanffy growth relationship, this work extends previous work to general nonlinear models and combines two response-biased sampling processes.  Maximum likelihood, naïve least-squares, and inverse probability weighted least-squares estimation are used to estimate the von Bertalanffy parameters for simulated and real data on the growth of Patagonian toothfish (*Dissostichus eleginoides*) given a known selectivity function.

**WG-FSA-SAM-05/14**
**Testing the performance of a recompiled version of TrawlCI to calculate confidence intervals of abundance in surveys of Patagonian toothfish (*Dissostichus eleginoides*) and mackerel icefish (*Champsocephalus gunnari*).**  T.D. Lamb, W.K. de la Mare and A.J. Constable (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, tim.lamb@aad.gov.au), 5 pp. (English, unpublished).

A version of the confidence interval calculating program TrawlCI 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 TrawlCI produced very similar, though not identical, results to the original version.  This is attributed to differences in the minimisation routines of the

recompiled version.  It is concluded that the differences evident from these tests are unlikely to significantly influence the estimated long-term yield of *Dissostichus eleginoides* or *Champsocephalus gunnari*.

**WG-FSA-SAM-05/15**

**Initial development of operating models for testing management procedures for 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).

Three operating models reflecting an optimistic, an intermediate, and a pessimistic current status for the toothfish resource in the Prince Edward Islands are developed.  These are planned for use in initial trials of candidate management procedures to provide future catch limit recommendations for this resource.  These will aim to provide an appropriate balance between avoiding risk of severe depletion and utilising potential harvest from the resource, in circumstances where the resource status is very uncertain.

**WG-FSA-SAM-05/16**

**Developing integrated assessments for *Dissostichus eleginoides* based on the CCAMLR precautionary approach.** I. Ball and A.J. Constable (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, ian.ball@aad.gov.au), 16 pp.  *CCAMLR Science*, submitted (English).

This paper describes a possible method for implementing the precautionary approach in assessments of *Dissostichus* spp. stocks when a number of different datasets are being integrated for estimating current biomass and age structure.  Consideration is given to its application to the assessment of *Dissostichus eleginoides* in Division 58.5.2.  CASAL and GYM are key elements in the implementation described in this paper but the methodology is laid out in such a way that alternative software solutions could be used in either or both their places.  The framework for this procedure has four main components.  The first is the integrated assessment, undertaken external to the GYM by software such as CASAL.  The second step is the sampling of the 'current state' and associated parameters to provide inputs to the GYM.  The third step is to use the GYM to undertake a number of projection trials, determining the median pre-exploitation spawning biomass and future states of the stock under the nominated harvest strategy.  The fourth step is to test the performance of the harvest strategy against the decision rules.  A controller is proposed to be used to manage the entire process including calling the CASAL or other software, the GYM, and for evaluating the harvest strategy.  The structure of this approach will help explore the value of integrating the datasets for *D. eleginoides* assessments such as are available for Division 58.5.2, which include recruitment surveys, commercial catch data from trawl and longline activities (biomass, length composition and age), and mark–recapture data.  This method is an extension of current practice, although the framework is newly described and better coordinates the integration of the different steps in the precautionary approach used by WG-FSA.  It is recommended that this approach be implemented for use by WG-FSA at its next meeting.

**WG-FSA-SAM-05/17**

**Examination of the characteristics of the fishery for *Dissostichus eleginoides* in CCAMLR Subarea 48.3 and its implications on estimating trends in catch per unit effort.** A.J. Constable, S.G. Candy and B. Raymond (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@aad.gov.au), 35 pp. *CCAMLR Science*, submitted (English).

This paper investigates the spatial and temporal (i.e. fishing season) variation, both systematic and random, in haul-by-haul catch and effort data from the longline fishery for *Dissostichus eleginoides* in Subarea 48.3. It concentrates on presenting the results of preliminary work on the potential effects of changing fishing patterns on the standardisation of the CPUE time series. Also, it was considered whether the spatial pattern of fishing might have changed over the years, whether the current measure of fishing effort (number of hooks on a line) has changed in its fishing properties over time, and if soak time is a useful additional measure of effort. It was then considered how these results might impact on the assessments, particularly the standardisation of the CPUE series. The results indicate that fishing for *D. eleginoides* is not uniformly distributed in its range. In some years, though not all, the fishery becomes concentrated into distinct grounds. In the CPUE standardisation procedure it was found that although soak time was a significant predictor of catch, the fitted relationship was not consistent with using soak time as a co-measure of effort by expressing CPUE as kg per hook-hour. In contrast, the fitted log-linear relationship between catch and number of hooks set was consistent with using this variable directly as the measure of effort. The analysis of the interaction between the fishing season and the fitted coefficient for log(Hooks Set) in the regression model for catch suggested a declining trend in the coefficient over time. This may indicate that catchability has been changing and has perhaps become greater over time as a result of effort concentrating in productive locations. Further consideration of the spatial characteristics of the fishery and its implications for using CPUE as an indicator of abundance is recommended.

**WG-FSA-SAM-05/18**

**Age-structured production model for toothfish at South Georgia.** A. Payne, G.P. Kirkwood, R. Hillary and D.J. Agnew (RRAG, Royal School of Mines Building, Imperial College, Prince Consort Road, London SW7 2BP, United Kingdom), 10 pp. *CCAMLR Science*, submitted (English).

The ASPM model used by Agnew and Kirkwood (2004, WG-FSA-04/82) has been modified through the introduction of a new annual selectivity function, modelled as a unimodal, algebraically decaying function of age, with three easily interpretable parameters.

When only a single selectivity curve was fitted for all years, the change to the new selectivity function improved the fit to length-frequency data achieved last year, but the fit was still poor. The fit to the CPUE was also poor.

With selectivity parameters allowed to be estimated on an annual basis, the fits are substantially improved. However, by allowing all parameters to be estimated in this way the model is over-parameterised and regularly reaches preset parameter boundaries. With one or two parameters of the selectivity estimated only once, the fit to length frequencies is good but infinite populations are estimated. If the CPUE data are given high weight in the fitting, then the model has sufficient flexibility to change the selectivity to fit the CPUE very closely. Convergence problems were noted for the highly parameterised versions of this model.

Revisions to the selectivity model this year have led to an ASPM with superior performance. However, this study demonstrates that the ASPM is still not suitable for use when assessing South Georgia toothfish populations by fitting to the available catch-length frequency data and CPUE data.

**Selectivity-induced bias in growth parameter estimates.**  G.P. Kirkwood (RRAG, Royal School of Mines Building, Imperial College, Prince Consort Road, London SW7 2BP, United Kingdom, g.kirkwood@imperial.ac.uk), 6 pp.  (English, unpublished).

A short simulation study has been carried out to investigate the size of the bias in estimates of growth parameters resulting from fish of different sizes having different probabilities of being included in catch samples.  Fish were included in catch samples from the population with probability equal to an assumed relative selectivity at length.  Both the mean growth parameters and the selectivity function used in the simulations closely matched those used for current toothfish assessments in Subarea 48.3.  Substantial selectivity-induced bias was demonstrated, with the simulated catch sample data producing considerably lower estimates of $L_\infty$ and higher estimates of $K$ than in the true population.  The simulated catch sample data and the growth parameter estimates were similar to those reported by Belchier (2004).  This suggests that the growth parameters used in the current toothfish assessments in Subarea 48.3 are not incompatible with the Belchier (2004) data.

**WS-MPA-05/4**
**Marine protected areas in the context of CCAMLR: a management tool for the Southern Ocean.** IUCN information paper. Submitted by IUCN, 19 pp. (English, unpublished).

**WS-MPA-05/5**
**A compilation of abstracts relating to Marine Protected Areas and fisheries management.** IUCN information paper. Submitted by IUCN, 31 pp. (English, unpublished).

**WS-MPA-05/6**
**Guidelines for establishing the [Australian] National Representative System of Marine Protected Areas.** Submitted by the Delegation of Australia. ANZECC TFMPA 1998. Australian and New Zealand Environment and Conservation Council, Task Force on Marine Protected Areas. Environment Australia, Canberra, ciu@ea.gov.au. This document is available on the Internet at: www.erin.gov.au/marine/or2000/mpa/mpa.html.

**WS-MPA-05/7**
**The Heard and McDonald Islands Marine Reserve.** Delegation of Australia, 13 pp. (English, unpublished).

**WS-MPA-05/8**
**Royal Society for Protection of Birds (RSPB) – The economics of marine protected areas.** Executive Summary. (Contact – Paul Morling, RSPB, The Lodge, Sandy, Bedfordshire SG19 2DL, United Kingdom, paul.morling@rspb.org.uk), 17 pp. (English, unpublished).

There is a growing recognition that human activities, which damage marine habitats, can undermine ecological stability and the ecosystem services they facilitate. This awareness, combined with the deterioration in fisheries worldwide has led to calls for action on developing Marine Protected Areas (MPAs), at the World Summit on Sustainable Development (2002), the World Parks Congress (2003) and the UNGA.

This paper outlines a framework for assessing the total economic value of the world's oceans and highlights the reasons why human exploitation of marine environments exceeds what is socially optimal.

The high seas pose special problems for governance because they are still essentially treated as common access global commons. The paper finishes with a brief review of possible financing options to sustain MPAs for the high seas.

**WS-MPA-05/9**
**Improving the process for the establishment of marine protected areas by CCAMLR and Antarctic Treaty Parties.** Delegation of Australia, 6 pp. (English, unpublished).

This paper examines the obligations on CCAMLR and Antarctic Treaty Consultative Parties (ATCPs) in respect of marine protected areas (MPAs) and some legal and administrative reasons why these two groups need to cooperate in the establishment and implementation of MPAs in the Southern Ocean. It also examines the current process for declaring MPAs in the areas of application of the Antarctic Treaty and the Convention on the Conservation of Antarctic Marine Living Resources (the Convention) and suggests improvements, including the adoption of a 'southern geographic reference line', to ensure the interactions between the Parties to those Agreements follow a mutually agreed, timely and efficient process.

**WS-MPA-05/10**

**Progress on Antarctic Specially Managed Area: Southwest Anvers Island and vicinity.**
Delegation of the USA, 7 pp.  (English, unpublished).

**WS-MPA-05/11**

**Scientific justification for a marine protected area designation around the Balleny Islands to protect ecosystem structure and function in the Ross Sea region, Antarctica: progress report.**  Delegation of New Zealand, 25 pp.  (English, unpublished).

In 2000, the New Zealand Delegation to CCAMLR proposed the designation of an Antarctic Specially Protected Area (ASPA) around the Balleny Islands.  Since that time, research has continued to focus on the value of the area on and around the Balleny Islands, and the potential benefits of establishing a Balleny Islands Marine Protected Area (MPA).  The ecological importance of the Balleny Islands can be aligned with both the CCAMLR ecosystem-wide conservation objectives and the values found in Article 3 of Annex V to the Protocol on Environmental Protection to the Antarctic Treaty.  This paper's focus is on the CCAMLR values.

A review of existing information reveals that the Balleny Islands are uniquely situated to provide essential breeding and foraging habitat for large populations of top predator populations dependent on locally high abundances of Antarctic krill.  Due to tight trophic coupling and the relative intactness of the Ross Sea ecosystem, disruption of predator foraging opportunities by human activities and/or competition between predators and fisheries for available prey can be expected to have considerable indirect effects on other aspects of the ecosystem.  The area around the Balleny Islands also includes the only known habitat in the region for juvenile toothfish, and perhaps also for early developmental stages of Antarctic krill, both of which are critical for ecosystem function and for the sustainability of existing and potential fisheries in the region.  A strategically located Balleny Islands MPA extending in the region of 50 n miles from the islands would provide a critical buffer between ecologically important populations and human activities (including existing and potential fisheries), and some measure of protection against unpredictable and potentially negative ecosystem impacts, consistent with the conservation mandate of the CAMLR Convention.  Such a designation could also be highly valuable for the advancement of marine science, consistent with the principles of the Antarctic Treaty.

**WS-MPA-05/12**

**Legal considerations surrounding the establishment of marine protected areas in Antarctica.**  Delegation of New Zealand, 6 pp.  (English, unpublished).

**WS-MPA-05/14**

**Issues to consider before jumping on the marine protected area (MPA) bandwagon.**
R.J. Brock and J.A. Uravitch (NOAA Fisheries Science, Office of Science and Technology, 1315 East-West Highway (F/ST7), Silver Spring, MA 20910-3282, USA, robert.brock@noaa.gov, USA), 9 pp.  (English, unpublished).

**WS-MPA-05/15**

**Progress towards the declaration of a large marine protected area around South Africa's sub-Antarctic Prince Edward Islands.**  D. Nel, A. Lombard, T. Akkers, J. Cooper and B. Reyers (WWF South Africa, Private Bag X2, Die Boord 7613, South Africa, dnel@wwfsa.org.za), 11 pp.  (English, unpublished).

**WG-FSA-05/11**
**Interactions between cetaceans and fisheries in the Southern Ocean.** K.-H. Kock,
M. Purves and G. Duhamel. *Polar Biology*, Online First (2005) (English).

Soon after longlining on Patagonian toothfish (*Dissostichus eleginoides*) started in the
Southern Ocean in the second half of the 1980s, interactions of cetaceans with these fisheries
became apparent. The two species primarily involved were orcas (killer whales) (*Orcinus
orca*) and male sperm whales (*Physeter macrocephalus*). Both species took a substantial
number of fish from the line primarily during daylight hours. Catch rates of longliners
declined to less than 50% when orcas occurred close to longline vessels while the loss to
sperm whales was much less obvious. They were seen diving close to the line down to 400 m
where they apparently took fish. Their impact on catch rates was much less notable. Sperm
whales became frequently entangled in the line and part of the line was lost in a number of
cases. Other cetaceans were rarely seen in the vicinity of longline vessels. They became
entangled in the line only occasionally and one whale (presumably a minke whale) died.

**WG-FSA-05/12**
**Program of research to improve the seabird by-catch mitigation effectiveness of the
Spanish system of longline fishing.** G. Robertson and C. Moreno (Australian Antarctic
Division, Department of Environment and Heritage, Channel Highway, Kingston 7050,
Tasmania, Australia, graham.robertson@aad.gov.au), 8 pp. (English, unpublished).

This document seeks the approval of CCAMLR for a research plan to improve the seabird
by-catch mitigation effectiveness of the Spanish system of longline fishing. The plan also
aims to reduce the amount of fishing gear (and ghost fishing) lost in benthic habitats by
Spanish system vessels in the Convention Area and, potentially, in other fisheries where
Spanish system vessels operate. A step-wise approach will be taken using a chartered fishing
vessel in Chile to trial various line-weighting systems, including replacing the bags of rocks
that are traditionally used by Spanish system vessels with steel sinker weights. The objectives
are to: (i) reduce the degree of lofting in hook lines between line weights that occurs with the
CCAMLR line-weighting regime to expedite sink rates in surface waters, and (ii) reduce the
incidence of line weight hook-ups on the seabed. A line-weighting system that improves sink
profiles (and reduces frequency of line breakage) will then be trialled in normal fishing
operations in southern Chile to determine effectiveness (along with the use of streamer lines)
as a deterrent to black-browed albatrosses. The operational effectiveness of the new regime
will also be determined. Assuming the new regime is practical to use, the intention will then
be to seek permission from CCAMLR to trial the improved mitigation measures against
white-chinned petrels in Subarea 48.3 at a high-risk time of year.

**WG-FSA-05/13**
**Notification of research-in-progress in an Australian tuna fishery of relevance to the
conservation of Convention Area seabirds.** G. Robertson, B. Wienecke, K. Lawton and
B. Baker (Australian Antarctic Division, Department of Environment and Heritage, Channel
Highway, Kingston 7050, Tasmania, Australia, graham.robertson@aad.gov.au), 9 pp. (English,
unpublished).

The purpose of this document is to inform CCAMLR of work-in-progress in the Australian
eastern tuna and billfish fishery (ETBF) of potential relevance to the conservation of
Convention Area seabirds. The research plan includes: (i) a line-weighting experiment on a
chartered tuna vessel to determine the effect of line-weighting regimes and bait type on the

sink rate of longlines (this experiment was completed in April 2005); (ii) a manipulative experiment testing the effectiveness of various combinations of line weighting and streamer lines as deterrents to fleshy-footed shearwaters. This experiment is scheduled for October and November 2005 when fleshy-footed shearwaters (the main seabird species taken in the fishery) are most abundant on fishing grounds. A summary of findings of the line-weighting experiment is presented in this paper. The experiment examined the effect of bait type, swivel weight and bottom length (distance between weighted swivel and hook) on the sink rate of branch lines used in Australia's ETBF.

**WG-FSA-05/14**

**Satellite tracking of black-browed and light-mantled sooty albatrosses from Heard Island and potential interactions with fisheries.** K. Lawton, R. Kirkwood and G. Robertson (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, kieran.lawton@aad.gov.au), 10 pp. (English, unpublished).

The purpose of this document is to inform CCAMLR of the results of a satellite-tracking program on black-browed albatrosses and light-mantled sooty albatrosses at Heard Island (Division 58.4.2). This was the first time the movements of either species from the island had been studied. Ten black-browed albatrosses and five light-mantled sooty albatrosses were tracked between December 2003 and February 2004, yielding 90 and 28 foraging trips from each species respectively. Black-browed albatrosses foraged on the shelf break within 150 km of Heard Island, and focused 75% of their foraging time in waters over submarine canyons on Gunnari Ridge, northeast of the island. There was considerable spatial overlap between these foraging grounds and the Heard Island EEZ trawl and longline Patagonian toothfish fisheries. These fisheries have a history of a low incidental seabird by-catch (no fatalities recorded to date in the longline fishery), although in 2005 seven black-browed albatrosses were killed in the mackerel icefish trawl fishery. Seventeen percent of black-browed albatross foraging trips entered the Kerguelen EEZ and a further 5% went beyond either EEZ into the high seas north and east of Heard Island. In contrast, light-mantled sooty albatrosses foraged along the boundary of the continental shelf break and northern boundary of the pack-ice 1 200–1 600 km south of Heard Island.

**WG-FSA-05/16**

**An assessment of toothfish in Subarea 48.3 using CASAL.** R.M. Hillary, G.P. Kirkwood and D.J. Agnew (RRAG, Royal School of Mines Building, Imperial College, Prince Consort Road, London SW7 2BP, United Kingdom, r.hillary@ic.ac.uk), 49 pp. *CCAMLR Science*, submitted (English).

The CASAL software has been successfully applied to an assessment of the stock of toothfish around South Georgia in Subarea 48.3. Both point estimate (MPD) and Monte Carlo Markov Chain (MCMC) runs were carried out, with an extensive range of sensitivity tests and examination of diagnostics.

A baseline assessment model was selected to best represent the fishery and the available data sources. This incorporated two fleets with different selectivities, and fitted to catch length frequencies, tag–recapture data, CPUE data, and the survey recruitment series (treated as a relative index). This produced excellent fits to the catch length frequencies, but a poor fit to the early CPUE data, for which a substantial process error CV was estimated (0.39). A possible alternative assessment model was also identified using a single fleet, as it is possible that overall trends in the CPUE series were not fully taken into account in the two-fleet assessment. This alternative assessment produced worse fits to the catch length frequencies, and a poor fit to the CPUE data, for which an even higher process error CV was estimated (0.46).

For the baseline assessment incorporating two fleets, the 2005 vulnerable biomass was estimated to be 45 893 tonnes, and the spawning stock biomass was estimated to be 120 360 tonnes, around 67% of its unexploited level.  For the alternative single-fleet assessment, the 2005 vulnerable biomass was estimated to be 49 943 tonnes, and the spawning stock biomass was estimated to be 100 657 tonnes, some 64% of its unexploited level.  These estimates of current biomass are somewhat lower than the modified Petersen tagging estimates alone, which were 53 600 and 55 600 tonnes respectively (Agnew and Payne, 2005: WG-FSA-05/17) but the confidence intervals for the estimates overlap.

The current implementation of CASAL is unable to reproduce all the features of GYM projections to estimate long-term yields according to the CCAMLR decision rules.  Using GY, the estimated long-term yield is 4 910 tonnes for the baseline two-fleet assessment, while for the one-fleet assessment, the estimated long-term yield is 4 560 tonnes.

**WG-FSA-05/17**
**Results of the mark–recapture experiment in Subarea 48.3 in 2005.**  D.J. Agnew and A. Payne (RRAG, Royal School of Mines Building, Imperial College, Prince Consort Road, London SW7 2BP, United Kingdom, d.agnew@imperial.ac.uk), 12 pp.  *CCAMLR Science*, submitted (English).

The mark–recapture experiment continued at South Georgia in 2005.  In total some 8 000 fish have now been tagged in Subarea 48.3, and both tagging effort, fishing effort and recaptures were well distributed over all the fishable grounds in Subarea 48.3 this year.  The Petersen mark–recapture estimator, which has been applied previously and described in detail by Agnew et al. (2004) and Payne et al. (2005), was recalculated for Subarea 48.3 based on updated parameter estimates and four different selectivity regimes: the historically used Kirkwood shallow selectivity, the single- and double-fleet selectivity estimates by CASAL (see WG-FSA-05/16), and a selectivity estimated directly from the tagging data.

Estimates from 2004 and 2005 were very similar to each other, whichever selectivity was used:  about 62 000 tonnes of vulnerable biomass using the Kirkwood shallow selectivity; 52–55 000 tonnes using the CASAL-derived selectivity functions; and 41 000 tonnes using the tag-derived selectivity function.  Current vulnerable biomass (BV2005) was (naturally) lower when CASAL-determined selectivity and tag-derived selectivity were used, since these selectivity functions are more peaked than the Kirkwood shallow selectivity used in 2004. Estimates of sustainable yield, made adjusting mean recruitment in the GYM so that BV2005 corresponded to the current estimates of vulnerable biomass, resulted in consistent estimates of sustainable yield of about 4 800 tonnes, irrespective of the selectivity used.

**WG-FSA-05/18**
**Parameters for the assessment of toothfish in Subarea 48.3.**  D.J. Agnew, G.P. Kirkwood, A. Payne, J. Pearce and J. Clarke (RRAG, Royal School of Mines Building, Imperial College, Prince Consort Road, London SW7 2BP, United Kingdom, d.agnew@imperial.ac.uk), 19 pp. (English, unpublished).

The derivation of all parameters used in the assessments of toothfish using CASAL and the Petersen mark–recapture estimator in WG-FSA-05/16 and 05/17 are described.

**WG-FSA-05/19**

**A study of Patagonian toothfish (*Dissostichus eleginoides*) post-tagging survivorship in Subarea 48.3.** D.J. Agnew, J. Moir Clark, P.A. McCarthy, M. Unwin, M. Ward, L. Jones, G. Breedt, S. Du Plessis, J. Van Heerdon and G. Moreno (Marine Resources Assessment Group, 18 Queen Street, London W1J 5PN, United Kingdom, enquiries@mrag.co.uk), 11 pp. *CCAMLR Science*, submitted (English).

During the 2005 fishing season experiments on the survivorship of post-tag toothfish were carried out on eight different vessels fishing in Subarea 48.3. Toothfish were selected for tagging as normal, and then were kept in tanks with varying degrees of seawater replacement for at least 12 hours after tagging. On one vessel, fish with a variety of injuries were selected to see if this affected recovery. In the final analysis, 395 animals were included, with an overall survivorship of 89%. There were significant differences between vessels, and smaller animals and animals in better initial condition had a slightly higher survivorship.

There are indications that survivorship rates may be lower while observers are learning how to tag effectively and, perhaps, in experiments such as this if handling stress is increased. The results suggest that experienced observers using animals in good condition would normally achieve a survivorship of 95% or more. An assumption of 90% post-tagging survivorship would appear to be an appropriate, conservative, parameter to use in population estimators such as CASAL and mark–recapture.

**WG-FSA-05/20**

**Age estimation and maturity of the ridge-scaled macrourid (*Macrourus whitsoni*) from the Ross Sea.** P.M. Marriott, M.J. Manning and P.L. Horn (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Wellington, New Zealand, p.marriott@niwa.co.nz), 18 pp. *CCAMLR Science*, submitted (English).

Juveniles of the macrourid rattail (*Macrourus whitsoni*) were collected by the NIWA research vessel *Tangaroa* during the BioRoss survey of the western Ross Sea and Balleny Islands, with the purpose of analysing the otoliths to generate more accurate age estimates for this species. Intensive analysis of otoliths from small specimens greatly increased confidence in the interpretation of the zone structure displayed in the early growth rings. The findings supported the interpretation protocols used in previous work on this species. Von Bertalanffy growth curves were generated and compared to previous results finding no significant differences between the years. Von Bertalanffy parameters for the pooled dataset with unsexed juveniles are $L_\infty$ 76.12, $K$ 0.065 and $t_0$ –0.159 for males and $L_\infty$ 92.03, $K$ 0.055 and $t_0$ 0.159 for females. Revised estimates of the mean total length-at-maturity (38.8 and 46.4 cm) and mean age-at-maturity (10.6 and 13.6 years) are presented for males and females respectively, using a reduced probit model.

**WG-FSA-05/21**

**Risk categorisation for *Macrourus whitsoni* and *Amblyraja georgiana* in the Ross Sea.** R.L. O'Driscoll (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, r.odriscoll@niwa.co.nz), 10 pp. (English, unpublished).

This report presents risk categorisation tables for *Macrourus whitsoni* and *Amblyraja georgiana*, which are the major by-catch species in the exploratory fishery for toothfish in the Ross Sea.

*Amblyraja georgiana* were categorised as risk status 3 – species that are exploited as by-catch, and have a limited reproductive potential, and/or other life history characteristics that make them especially vulnerable to overfishing. The risk to *A. georgiana* is mitigated due to a CCAMLR program to cut all skates from longlines whilst still in the water and release them. *Macrourus whitsoni* were categorised as between risk status 2 and 3 – although

life history characteristics may make this species vulnerable to overfishing, catch rates in the toothfish fishery have not declined, juveniles are not selected by the fishery, and comparison of longline and trawl catch rates with other Antarctic areas suggest that the population in the Ross Sea may be relatively large.

**WG-FSA-05/22**
**Approaches to monitoring and assessing the abundance of rattails (*Macrourus* spp.) and skates in the Ross Sea.** R.L. O'Driscoll, S.M. Hanchet and B.A. Wood (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, r.odriscoll@niwa.co.nz), 23 pp.  (English, unpublished).

This report presents results from a desktop study to consider approaches to monitoring and assessing rattails and skates, which are major by-catch species in the exploratory fishery for toothfish in the Ross Sea.  Standardised CPUE analysis, quantitative research longline surveys, experimental manipulation of fishing effort, catch-curve analysis, tagging programs, bottom trawl surveys and acoustic surveys are reviewed.

It is recommended that a random bottom trawl survey would be the best approach towards obtaining abundance estimates for rattails and skates in the Ross Sea.  The major advantage of this approach is that preliminary stock assessments could be carried out for both species groups after only one successful trawl survey.  Simulations have indicated that only 35–40 trawls would be required in the depth range 600–1 500 m to obtain a precise estimate of by-catch abundance in the area of highest densities (SSRUs 881E, G, H, I, J and K).  A trawl survey could also be used in conjunction with other methods of monitoring abundance, e.g. skates caught during the trawl survey could be tagged and released, rattails could be aged for catch-curve analysis.  The main limitations of this approach are the variable ice cover in the Ross Sea, which may restrict access to some areas, the rough bottom topography, and concerns about the environmental impact of bottom trawling on benthic communities.  Tag–recapture experiments for skates and experimental manipulation of fishing effort are alternative methods which show some promise for monitoring abundance.

**WG-FSA-05/23**
**Towards a validation of ageing in mackerel icefish (*Champsocephalus gunnari*) – can we estimate age more accurately?** K.-H. Kock and Zh.A. Frolkina (Institut für Seefischerei, Bundesforschungsanstalt für Fischerei, Palmaille 9, D-22767 Hamburg, Germany, karl-hermann.kock@ish.bfa-fisch.de), 24 pp.  (English, unpublished).

Age estimates of mackerel icefish from different laboratories obtained during a CCAMLR ototlith exchange program in the late 1980s revealed considerable differences between readers when fish older than 3 or 4 years were aged.  These differences could not be reconciled at the end of the exchange.  A second age determination workshop on mackerel icefish to improve the accuracy of age determination was agreed on at the last meeting of the Working Group on Fish Stock Assessment.  This report briefly summarises the state of knowledge on age determination in mackerel icefish and assesses the validity of ageing.  Possible ways forward were described to improve the validity of age determinations of the species.

**WG-FSA-05/24**
**A review of rattail (*Macrourus* spp.) and skate by-catch and analysis of standardised CPUE, for the exploratory fishery in the Ross Sea (CCAMLR Subareas 88.1 and 88.2) from 1997/98 to 2004/05.** S.L. Ballara and R.L. O'Driscoll (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, s.ballara@niwa.co.nz), 30 pp.  (English, unpublished).

A standardised CPUE analysis was used to determine factors affecting by-catch rates of rattails (*Macrourus* spp.) and skates in the exploratory fishery for toothfish in the Ross Sea

(CCAMLR Subareas 88.1 and 88.2). The analysis was based on fine-scale haul-by-haul (C2) data and observer data from all vessels in the fishery from 1997/98 to 2004/05. The major factors influencing rattail by-catch were vessel, area and depth. Catch rates of rattails were highest along the shelf edge (SSRUs 881E, 881I, 881K and 882E) in depths from 600 to 1 000 m, and there was an order of magnitude difference in rattail catch rates between different vessels. Examination of vessel characteristics showed that catch rates of rattails were lower with the Spanish line system than with the autoline system. Russian and Korean vessels had extremely low catch rates compared to other vessels. Standardised CPUE of rattails has shown a general increasing trend since 1998/99, with a peak in 2002/03.

It was not possible to reliably determine factors influencing catch rates of skates from either C2 or observer data because a proportion of skates are cut free and released at the surface and these are not accurately recorded or reported in either dataset. There are a number of inconsistencies within the observer data which need to be resolved before these data can be used for estimating by-catch. These include a consistent definition of a set across the observer and C2 datasets, accurate recording of the number of hooks observed for by-catch, and completion of the L11 form on the fate of skates for all sets.

**WG-FSA-05/27**
**The Patagonian toothfish fishery (*Dissostichus eleginoides*) in the Kerguelen Islands (Indian Ocean sector of the Southern Ocean).** C. Lord, G. Duhamel and P. Pruvost (Muséum national d'histoire naturelle, Département des milieux et peuplements aquatiques, USM 403, CP 26, 43 rue Cuvier, 75231 Paris Cedex 05, France, claralord@mnhn.fr). 32 pp. *CCAMLR Science*, submitted (French).

Patagonian toothfish (*Dissostichus eleginoides*) have been fished in the Kerguelen Islands zone for 20 years, firstly with trawlers and more recently with longliners. It is the oldest fishery in the Indian Ocean sector of the Southern Ocean. However, IUU fishing has appeared since 1997. A GLM analysis was performed using statistical data from the legal fishery to evaluate the factors affecting catch per unit effort (CPUE) in both the trawl and the longline fisheries. Recent trends show a decrease in CPUE, probably indicating local overfishing. The expansion of the bathymetric range of the fishery seems to have partially masked this situation. In addition, some biological factors (such as depth distribution, timing and area of spawning, movements between geographical sectors) of the adult part of the population have been obtained from scientific observation programs conducted by fishery observers on board fishing vessels.

**WG-FSA-05/28**
**New data on the fecundity of Antarctic toothfish and some other by-catch fishes with gonads: histological pictures from the Ross Sea region and data on Patagonian toothfish from the Argentina Sea.** V.G. Prutko and L.A. Lisovenko (YugNIRO, 2 Sverdlov Street, Kerch 98300, Ukraine, vgprut@ker.post.crimea.ua), 39 pp. (English, unpublished).

The authors present results of the processing of samples taken in Subarea 88.1 during the 2003/04 season on board the FV *Yantar* operating in the exploratory fishery.

According to the results of an investigation of oocyte size composition and histological studies of ovaries at different maturation stages, it was ascertained that intermittent oogenesis type and synchronic development of the portion of oocytes corresponding to the nearest spawning is characteristic of Antarctic toothfish. Absolute calculated fecundity was averaged approximately 1 million eggs and relative fecundity was approximately 25 eggs per 1 g of body weight.

It was confirmed that the predominant proportion of pre-spawning individuals was concentrated over isolated sea-mounts to the north of 70°S. It was demonstrated that a certain proportion of females did not participate in spawning every season.

Data on the fecundity of some by-catch species are given. Maturity stages of Patagonian toothfish gonads in the Argentina Sea in March 2004 is discussed.

**WG-FSA-05/29**

**A characterisation of the toothfish fishery in Subareas 88.1 and 88.2 from 1997/98 to 2004/05.** S.M. Hanchet, M.L. Stevenson, N.L. Phillips and A. Dunn (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, s.hanchet@niwa.co.nz), 27 pp. (English, unpublished).

The exploratory fishery for Antarctic toothfish (*Dissostichus mawsoni*) has been operating for eight years in Subarea 88.1 and for four years in Subarea 88.2 with a large amount of data collected on toothfish and the associated by-catch.

The 2005 *D. mawsoni* catch was the highest on record with a total of 3 477 tonnes against a catch limit of 3 625 tonnes. The catch limit was almost reached in Subarea 88.1 and exceeded in Subarea 88.2. *D. mawsoni* was the dominant catch in all 11 SSRUs fished. The main by-catch species were rattails, which contributed 12% of the catch, and skates which contributed to about 2% of the total catch[1].

Comparison of the location of fishing effort with ice distribution over the past six years has clearly demonstrated the strong influence of ice on this fishery. In 2001, 2003 and 2004, ice conditions were particularly bad and fishing was restricted to sub-optimal areas. However, in 2005, ice conditions were very good, allowing vessels access to most of the main fishing grounds in both subareas. This resulted in the closure of all SSRUs due to catch limits for toothfish, or by-catch limits for rattails, being reached by 18 March 2005.

The change in fishing patterns between seasons is reflected in the mean length and age composition of the catch. During the development of the fishery there has been a steady increase in depth fished, which peaked in 2003, but decreased slightly in 2004 and 2005. This is reflected in the mean length and age composition of the catch, which also declined slightly in 2004 and 2005.

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

**WG-FSA-05/30**

**Preliminary assessment of long-term yield of Patagonian toothfish (*Dissostichus eleginoides*) for the Heard Island region (CCAMLR Division 58.5.2) based on a random stratified trawl survey in June 2005.** A.J. Constable, T.D. Lamb and R. Williams (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@aad.gov.au), 16 pp. (English, unpublished).

Results of an annual random stratified trawl survey by Australia in June 2005 were used to provide a preliminary assessment of yield for Patagonian toothfish in Division 58.5.2 to the west of 79°20'E using standard CCAMLR methods. Sensitivity trials were undertaken to: (i) further consider the survey series and the sensitivity of the assessments to exclusion of observations and surveys that have data substantially inconsistent with other observations in recent surveys, (ii) understand the implications of better estimates of growth parameters, especially the use of a length-at-age vector, (iii) consider the changes to the assessment that will need to occur to account for changes in the proportion of catch to be taken by different gears, which will result in an overall change in the vulnerability function for future projections, and (iv) examine the consequences of reducing the range of natural mortality from 0.13–0.2 to 0.13–0.165, consistent with slower growth rates of fish. Although some changes would result in lowering the estimate of yield, most would result in an increase of

around 5%.  The most significant forecast change could be an increase if the natural mortality rate was reduced along with a changing vulnerability function that included more of the larger fish.

**WG-FSA-05/31**

**A single-area stock assessment model of Antarctic toothfish (*Dissostichus mawsoni*) in SSRU 882E for the 2004/05 season.**  A. Dunn, D.J. Gilbert and S.M. Hanchet (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, a.dunn@niwa.co.nz), 19 pp.  (English, unpublished).

This report outlines a Bayesian sex- and age-structured population stock assessment model for Antarctic toothfish (*Dissostichus mawsoni*) in SSRU 882E.  The model structure was assumed to be the same as used for Antarctic toothfish in the Ross Sea (Dunn et al., 2005b), except that catch removals were modelled as a single fishery.

Model fits to the data were adequate, with the tag–release and recapture data providing the most information on stock size, but with the catch-at-age data preventing very low estimates of stock size.  Monte Carlo Markov Chain (MCMC) diagnostics suggested some evidence of non-convergence, particularly in the declining right-hand limb of the fishing selectivity parameters.

MCMC estimates of initial (equilibrium) spawning stock abundance ($B_0$) were very uncertain, with the median estimated as 7 720 tonnes (95% credible intervals 3 760–22 240 tonnes), and current ($B_{2005}$) biomass estimated as 91.8% $B_0$ (95% CIs 83.1–97.1%).

Estimated yields, using the CCAMLR decision rules, were estimated to be 670 tonnes. However, as the fishing selectivity was estimated to be to the right of the maturity ogive, there was a significant biomass of mature, but 'invulnerable' fish in the projection period. Moreover, the mean catch that could actually be taken under this scenario was 450 tonnes. Hence, two revised methods for assessing risk are also considered.  The first assumed that the future fishing selectivity was equal to the maturity ogive, and hence the yield was calculated as 273 tonnes.  The second used the model estimate of the vulnerable biomass as the reference biomass in the risk evaluation, and hence the yield was calculated as 218 tonnes.

**WG-FSA-05/32**

**Standardised CPUE analysis of the Antarctic toothfish (*Dissostichus mawsoni*) fishery in the Ross Sea for the years 1997/98 to 2004/05.**  A. Dunn and N.L. Phillips (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, a.dunn@niwa.co.nz), 15 pp.  (English, unpublished).

The Ross Sea toothfish fishery has operated during the Antarctic summer (November–May) since 1997 in CCAMLR Subareas 88.1 and 88.2.  Previously, standardised analysis of toothfish CPUE (catch per hook), carried out in 2004, calculated CPUE indices for the 1997/98 to 2003/04 fishing seasons in Subareas 88.1 and 88.2.  This report revises and updates the previous analysis with the addition of data from the 2005 season for the Ross Sea (Subarea 88.1 and SSRUs 882A–B) using datasets based on: (i) all vessels, and (ii) the two main New Zealand vessels that have been in the fishery over most of the period.  Indices were estimated using both lognormal generalised linear models and a Tweedie mixed model, in which data were modelled using the methods described by Candy (2003).

The variables included in the analysis appeared reasonable and were consistent between the models presented here and CPUE analyses for previous years.  The yearly indices were relatively stable between 1998 and 2003, with a decline in 2004, and a sharp increase in 2005. Possible explanations for the decline in 2004 were described by Phillips et al. (2004) as gear conflict and competition between vessels to set lines, in addition to extreme ice conditions that limited where lines could be set.  None of these factors were believed to be important in 2005.

Investigation of additional explanatory terms included an index of ice cover and an index of vessel crowding.  Neither of these terms was found to be significant or explain the decline in 2004 or the increase in 2005.  Lack of a balanced experimental design and possibly the choice of parameterisation of the variables are likely to be the reasons why neither of these terms were found to be significant.

**WG-FSA-05/33**

**A single-area stock assessment model of Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea for the 2004/05 season.**  A. Dunn, D.J. Gilbert and S.M. Hanchet (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, a.dunn@niwa.co.nz), 38 pp.  (English, unpublished).

This report outlines a Bayesian sex- and age-structured population stock assessment model for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea (Subarea 88.1 and SSRUs 882A–B).  A range of model sensitivities were examined, with the base-case assuming the Ross Sea fishery as a single homogeneous area (single-area) with catch removals from three spatially based fisheries (shelf, slope and north).

Model fits to the data were adequate, with the tag–release and recapture data providing the most information on stock size.  Monte Carlo Markov Chain (MCMC) diagnostics suggested some evidence of non-convergence, particularly in the declining right-hand limb of the fishing selectivity parameters.  However, multi-chain comparisons and sensitivities with fixed selectivity ogives suggested that this would have little impact on the estimates of key model parameters and yield estimates.

MCMC estimates of initial (equilibrium) spawning stock abundance ($B_0$) were 69 400 tonnes (95% credible intervals 47 700–111 900 tonnes), and current ($B_{2005}$) biomass was estimated as 88% $B_0$ (95% CIs 83–93%).  Estimated yields, using the CCAMLR decision rules, were estimated to be 2 964 tonnes although continued catch at current levels (3 207 tonnes) would not be expected to breach the 50% $B_0$ threshold until 2029.

**WG-FSA-05/34**

**An updated descriptive analysis of the Antarctic toothfish (*Dissostichus mawsoni*) tagging scheme in the Ross Sea for the years 1997/98 to 2004/05.**  A. Dunn, S.M. Hanchet and K. Maxwell (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, a.dunn@niwa.co.nz), 18 pp.  (English, unpublished).

An updated descriptive analysis of the toothfish tagging program carried out in Subareas 88.1 and 88.2 since 2001 is presented.  Tag–release and tag–recapture data are presented for both toothfish species for the Ross Sea (Subarea 88.1 and SSRUs 882A–B), and SSRU 882E for New Zealand vessels.  A total of 4 903 Antarctic toothfish have been released and 89 recaptured, and 443 Patagonian toothfish released and 9 recaptured.  For the last two years, when tagging has been part of the conservation measure, New Zealand vessels have tagged between 1.0 and 2.77 toothfish per tonne of catch.  Tagging rates by area over the past three years have been in the same proportion as the catch by area.  However, recapture rates have tended to be higher in the northern and eastern SSRUs 881C and 882E.

The maximum movement of Antarctic toothfish from the New Zealand dataset has been about 200 km.  However, most (80%) Antarctic toothfish have moved less than 50 km.  Consequently, nearly all fish have been recaptured from the same SSRU where they were released.  The mean size of tagged Antarctic toothfish has increased since 2001, but is still smaller than the mean size of fish taken in the commercial catch.  Larger toothfish (>35 kg) are difficult to tag without significant damage to fish, and there appears to be a trade-off

between maximising size of released fish and minimising tagging mortality. Growth rates of Antarctic toothfish that have been at liberty for 2–3 years have averaged 5–7 cm per year, which is consistent with growth rates predicted from the von Bertalanffy growth curve.

## WG-FSA-05/35
**Project of a software catalogue of skeletal elements from Antarctic fish species, including some identification facilities.** J. von Busekist, M. Vacchi and G. Albertelli (Museo Nazionale dell'Antartide, Università di Genova, Italy), 8 pp. (English, unpublished).

In this study skeletal elements from fish species of the Antarctic waters were extracted by bioenzyme and compared, with the aim to provide a computer-supported identification system, including a database of bone pictures and, in the near future, various identification keys, completed by a simple tool to compare the same skeletal elements of different species. In the database, most of the skeletal elements of the cranial and axial skeleton (apart from a few bones of the neurocranium) are represented by pictures, otoliths and vertebrae included. Furthermore, cooperation with other institutions is needed to extend the existing work.

## WG-FSA-05/36
**Seabird avoidance measures for small Alaskan longline vessels.** E.F. Melvin and M. Wainstein (Washington Sea Grant Program, University of Washington, Box 355020, Seattle, WA 98195-5020, USA, emelvin@u.washington.edu), 35 pp. (English, unpublished).

Given the lack of information on appropriate seabird avoidance measures for small Alaskan longline vessels, the '2-m access window', or the distance astern that longline hooks were accessible to surface-foraging Alaska seabirds, was determined for eight fishing vessels >7.9–16.8 m (>26–55 feet) using two gear types: snap-on gear and fixed gear. Also determined was the capability of these vessels to deploy streamer lines and/or buoy lines according to performance standard guidelines. Vessel speed was found to be a primary determinant of both the distance astern that longline hooks were accessible to surface-foraging seabirds, and the performance standards of streamer lines. Vessels deploying snap-on gear at 2 to 3.5 knots produced mean access windows of 28 to 38 m, while the mean access window produced by vessels deploying fixed gear at faster speeds averaged 90 m. Gear sink rates among vessels and gear types were similar (0.09 to 0.13 for snap-on gear vessels and 0.07 m/s for fixed gear). It was determined that the current single streamer line requirement for snap-on gear vessels over 16.8 m and with infrastructure (a 45-m streamer line with a minimum aerial distance of 20 m) was achievable and practical regardless of vessel size, especially with a lighter streamer line design. However, the current requirement for small vessels using fixed gear of a single streamer line with no mandatory material or performance standards is unlikely to provide sufficient protection to seabirds. Specific recommendations for seabird avoidance requirements are proposed for these small vessels based on these results.

## WG-FSA-05/37
**Pilot test of techniques to mitigate seabird interactions with catcher processor vessels in the Bering Sea pollock trawl fishery: final report.** E.F. Melvin, K.S. Dietrich and T. Thomas (University of Washington, Washington Sea Grant Program, USA, emelvin@u.washington.edu), 13 pp. (2004). (English, unpublished).

A pilot research program was carried out in collaboration with industry to identify techniques for future testing that are likely to reduce seabird interactions with catcher processor trawl vessels operating the Bering Sea fishery for pollock (*Theragra chalcogramma*) and that are practical and safe. Emphasis was placed on reducing seabird interactions with trawl cables: nets warps, as well as the netsounde cable (3rd wire). Third-wire mitigation techniques included pulling the third wire as close as possible to the

water at the stern with a snatch block, paired streamer lines and various deterrents attached directly to the third wire (third-wire scarers).  Warp deterrents included a boom array or a buoy placed in the offal stream forward of the warps.  Results showed that both the snatch block and paired streamer lines have great potential to reduce seabird interactions with the third wire, but both require refinement for practical and safe application.  Deterrents applied directly on the third wire were less effective and impractical.  The boom array effectively excluded birds from the area around the trawl warps.  Buoys were less effective and were difficult to position effectively.  Formal testing of streamer lines, the snatch block, and the warp boom on two factory trawlers retrofitted to allow for the safe and practical deployment of the seabird interaction deterrents was proposed for 2005.  Limited tests suggested fish oil has great potential as a seabird deterrent.

**WG-FSA-05/39**
**Preliminary assessment of mackerel icefish (*Champsocephalus gunnari*) for the Heard Island Plateau region (Division 58.5.2) based on a survey in June 2005.** A.J. Constable, T.D. Lamb and R. Williams (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@aad.gov.au), 16 pp.  (English, unpublished).

A survey of mackerel icefish (*Champsocephalus gunnari*) was undertaken in Division 58.5.2 in the vicinity of Heard Island in June 2005 to provide information for an assessment of short-term annual yield in the 2005/06 CCAMLR season.  This paper provides a preliminary assessment of yield using the assessment methods of CCAMLR.  It is proposed that a one-year projection be used in the implementation of the CCAMLR assessment method because the fish are likely to disappear after they become 4 years old during the coming season.  This would result in an estimated yield of 1 210 tonnes, which is less than that predicted for the coming season in the 2004 assessment by WG-FSA.

**WG-FSA-05/40**
**Warp strike observations.**  E. Abraham (Datamine, PO Box 11 452, Wellington, New Zealand, edward@datamine.co.nz), Draft Final Research report to the New Zealand Ministry of Fisheries, Project IPA2004-014,  44 pp.  (English, unpublished).

This report contains an analysis of data on seabird trawl-warp strike collected by fisheries observers.  The survey was carried out in the southern squid trawl fishery (SQU6T/1T) over the summer of 2004/05.  The aim of the work was to test a new protocol for quantifying warp strikes and to assess the factors (fishery, environmental, behavioural and temporal) that appeared to influence the probability of warp strikes occurring for small and large birds.  The protocol was designed for use by non-specialist observers, to provide a robust and objective assessment of warp strike occurrence.  The key results are listed below:

- 904 good observations were made from 526 separate tows, on 19 different vessels;
- 789 large-bird heavy contacts were observed, at an average rate of 3.5 heavy contacts per hour (CV 9%);
- the number of small-bird heavy contacts was lower, with 306 contacts over the entire survey.  This corresponds to an average rate of 1.4 per hour (CV 12%);
- offal discharge was the most significant factor associated with large-bird strikes;
- discharging offal increased the large-bird strike rate by an estimated factor of 6, compared with no offal discharge;
- the strike rate for large birds decreased by an estimated factor of 2 when bird bafflers were used;
- higher small-bird strikes were observed at higher discharge rates, and the small-bird strike rates were not strongly dependent on discharge type;

- 106 dead or injured birds were recovered from the tows, a rate of 0.2 birds per tow (CV 13%);
- the discharge of offal was the factor most significantly associated with the recovery of dead and injured birds from the warps and the recovery of dead or injured birds from the warp was significantly associated with the warp strike rate.

**WG-FSA-05/41**

**Seabird warp-strike research design.**  A. Kennedy (Datamine, PO Box 11 452, Wellington, New Zealand, antony.kennedy@datamine.co.nz), Draft Final Research Report to the New Zealand Ministry of Fisheries, 18 pp.  (English, unpublished).

The paper documents a protocol for assessing warp strike occurrence for seabirds in trawl fisheries, and sets out the sampling plan, forms and protocols used to sample warp strikes in the southern squid fishery in 2005 in New Zealand.  Results of this sampling are set out in WG-FSA-05/40.

**WG-FSA-05/42**

**Review of research into seabird–fishery interactions.**  R. Alderman (Department of Primary Industries, Wildlife and the Environment, Nature Conservation Branch, Box 44, Hobart 7001, Tasmania, Australia), Draft Final Report to the New Zealand Ministry of Fisheries, Project IPA2004-09ALD, 64 pp.  (English, unpublished).

Research into seabird interactions with fisheries was reviewed.  Only recent research (post 1990), and in relation to direct effects of fishing through fisheries mortalities, was considered. The research was divided into five main groupings: (i) estimation of by-catch; (ii) population estimation and modelling; (iii) foraging studies; (iv) molecular research; and (v) management efficacy.  Research on mitigation efficacy had been covered under a separate review (Bull, unpublished).  The review was conducted to allow an assessment of the utility, current methodologies, and constraints of research into seabird biology and fishery interactions. Following from the findings of the review, recommendations were formulated by the review editorial panel (submitted separately to WG-FSA), to assist in the development of research plans for managing seabird mortalities and the effect of these on seabird population viability in New Zealand fisheries.

**WG-FSA-05/43**

**Recommendations for the toothfish tagging protocol in Subareas 88.1 and 88.2.** N.W. Bagley and A. Dunn (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, a.dunn@niwa.co.nz), 18 pp. (English, unpublished).

Revisions to the current tagging protocols for tag–release and recapture of toothfish in the Ross Sea are described, including revised instructions, layout, and revisions to the data capture forms.

**WG-FSA-05/44**

**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), 21 pp.  (English, unpublished).

**WG-FSA-05/45**

**Development of best practices for the collection of longline data to facilitate research and analysis to reduce by-catch: report of a workshop held at the International Fisheries Observer Conference, 8 November 2004, Sydney, Australia – Draft Executive Summary.** K.S. Dietrich, K.S. Rivera, V. Cornish and T. Conant (National Marine Fisheries Service, Alaska Regional Office, PO Box 21668, Juneau, AK 99802, USA), 5 pp. (English, unpublished).

To facilitate research and analysis of factors influencing by-catch of marine mammals, sea turtles, and seabirds in longline fisheries, a workshop was organised to develop 'best practices' in observer data collections. The workshop was held in conjunction with the International Fisheries Observer Conference, 8–11 November 2004, in Sydney, Australia.

The objectives of the workshop were to:

- Share information on current data collection practices and methodologies (i.e. which variables are collected by observer programs worldwide and how are they collected).
- Solicit information from data users on variables that are critical, preferred, optimal, or not important to facilitate research and analysis to reduce by-catch of protected species.
- Identify data not currently being gathered systematically that might facilitate research and analysis to reduce by-catch of protected species.
- Coordinate with observer program staff to understand data collection limitations.
- Recommend best practices for observer data collection in longline fisheries that would facilitate research and analysis to reduce by-catch of protected species, in the form of a prioritised list of variables and consistent procedures.
- Establish a network to continue to develop, refine and implement best practices.

Workshop participants recommended variables to be collected systematically in all longline observer programs to aid in by-catch reduction research and analysis. An additional set of variables was identified to optimise data collections specific to by-catch species.

**WG-FSA-05/47**

**Fisher training exchanges in seabird mitigation.** S.M. Waugh (Ministry of Fisheries, PO Box 1020, Wellington, New Zealand, susan.waugh@fish.govt.nz), Unpublished Report to the New England Aquarium's Marine Conservation Action Fund, 29 pp. (English, unpublished).

An initiative to provide training exchanges in seabird mitigation was trialled in 2004. The aim was to provide a placement for a fisher from a Latin American county on board a vessel operating in the New Zealand fishery, which had a proven record of seabird-friendly fishing techniques. The report documents the process and outcomes of the first exchange to occur, which was for the placement of a Chilean skipper, Luis Uribe – a swordfish fisher working in the Southern Chilean artisanal fleet – on board the Sanford vessel *San Aotea II*, using demersal longline methods to fish for ling and other species.

**WG-FSA-05/48**

**The use of sea lion exclusion devices in the New Zealand Auckland Islands shelf trawl squid fishery.** R. Mattlin (Ministry of Fisheries, PO Box 1020, Wellington, New Zealand, mattlinr@fish.govt.nz), 7 pp. (English, unpublished).

The New Zealand sea lion is taken incidental to trawl fisheries within New Zealand's fisheries waters. About 99% of the incidental sea lion take occurs within the Auckland Islands region in association with a seasonal trawl fishery for squid. From 1995 to 2004, an estimated 79 (SD ±35) sea lions were taken annually, incidental to trawl squid fisheries. The threatened classification of sea lions necessitates that measures are taken to mitigate the fisheries-related incidental mortality. The Squid Fishery Management Company has

undertaken the development of a Sea Lion Exclusion Device (SLED) that they believe is a viable practical way to allow sea lions to escape a net when trawling for squid while not adversely affecting squid catch or quality. While it has been demonstrated that the SLED does allow sea lions to escape, there are questions surrounding their short and long-term survival.

**WG-FSA-05/49**

**Ross Sea fishery research and data collection plan.** J.M. Fenaughty (Silvifish Resources, PO Box 17058, Wellington, New Zealand, jmfenaughty@clear.net.nz), 15 pp. (English, unpublished).

A review of the use and effectiveness of research lines as a data collection and effort spreading tool within the Ross Sea exploratory toothfish fishery (CCAMLR Subareas 88.1 and 88.2) is presented. The increase in the number of vessels in the exploratory fishery in Subareas 88.1 and 88.2, combined with the greater number of small-scale research units (SSRUs) and the amount of data collected through fishing activities has effectively made the requirement to force a spread of research sets (5 n miles spatial separation) superfluous as other factors produce the same result. The paper also demonstrates that by-catch levels, particularly catches of Whitson's grenadier (*Macrourus whitsoni*), are demonstrably higher on research hauls.

The paper concludes with a proposal for a more effective research plan for the Ross Sea exploratory toothfish fishery that achieves the requirement to collect biological, environmental, and longline specific data on both the target species and on other by-catch species in a non-biased and statistically valid manner covering as wide a range as possible.

**WG-FSA-05/50**

**Observer coverage required for the prediction of incidental capture of seabirds in New Zealand commercial fisheries.** M.H. Smith and S.J. Baird (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand), Draft New Fisheries Assessment Report, New Zealand Ministry of Fisheries, 107 pp. (English, unpublished).

This report obtains estimates of observer coverage required to predict the total numbers of incidental seabird captures (albatross and petrel taxa combined) in a fishery with a specified coefficient of variation (CV). Fisheries analysed are determined by the quality and the availability of data and a known history of seabird captures: the trawl fisheries targeting hoki in the sub-Antarctic, on the Chatham Rise, and off the west coast of the South Island; the trawl fisheries targeting squid in the Auckland Islands part of SQU 6T and on the Stewart-Snares shelf; and the autoliner fisheries targeting ling on the Chatham Rise and in waters south of 46°S.

A random-effects model was developed to enable the contribution from the correlation between the numbers of captures per tow/set by the same vessel to be included in the calculation of the CV of the predicted total number of seabird captures. The model also permits the estimation of the contribution from the extra variation that arises from the tendency for seabird capture incidents to involve large numbers of birds on rare occasions. Estimates of the variance components were derived from models that were fitted using data from the 1999/2000 to the 2002/03 fishing years for the trawl fisheries and from the 2000/01 to the 2002/03 fishing years for the longline fisheries.

The observer coverage fraction is expressed in terms of tows for the trawl fisheries and hooks hauled for the autoliner fisheries. The estimated observer coverage fraction required to attain a coefficient of variation of 30% in the fishery depends on the total effort and on the capture rate through the predicted total number of captures. The approximate coverage fractions required, based on typical estimated numbers of captures, were between 8 and 54%,

depending on the fishery and numbers of birds captured for trawl fisheries. For the ling autoliner fisheries, the required fraction of observer coverage does not depend to the same extent on the predicted total number of seabird captures because most uncertainty arises from between-vessel variation. Through wide ranges of predicted captures, the approximate effort coverage fractions required were between 70 and 91% of days depending on the fishery area.

Estimates of observer coverage required for both the trawl and ling autoliner fisheries can only be regarded as approximate since they are always based on variance estimates, which are notoriously uncertain. The ling autoliner fishery estimates however have an additional source of uncertainty that arises because there are few vessels involved in these fisheries and the distribution of the effort between the vessels can vary markedly between seasons. Thus, for the ling autoliner fisheries, the large values for the coverage required by days in the fishery combined with the large uncertainties in these estimates suggests that 100% coverage is desirable.

**WG-FSA-05/51**
**Review of the population status and national research conducted by New Zealand on Southern Ocean seabirds vulnerable to fisheries interactions.** E.C. Garland and S.M. Waugh (Ministry of Fisheries, PO Box 1020, Wellington, New Zealand), 23 pp. (English, unpublished).

Research undertaken in New Zealand on seabird interactions with fisheries, and research into the population status and distribution at sea of New Zealand seabirds is documented.

**WG-FSA-05/52**
**Geographical differences in the condition, reproductive development, sex ratio and length distribution of 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), 21 pp. *CCAMLR Science*, submitted (English).

A number of morphological and reproductive measurements made seasonally on Antarctic toothfish (*Dissostichus mawsoni*) from mid-December to early April during the 2000/01 to 2004/05 fishing seasons on board the autoliner *San Aotea II* have been analysed. 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 are length modal distribution, sex ratio, fish body condition factor and reproductive development. *D. mawsoni* samples from the northern part of the Ross Sea showed that this component of the population had a unimodal length distribution at a consistent peak over all sampling seasons in comparison with the southern group in which the distribution was multimodal, showed a consistent and significant higher ratio of males to females, was in poorer condition and was more advanced in reproductive development.

**WG-FSA-05/53**
**Results of the scientific research survey in CCAMLR Subarea 88.3 in the 2004/05 season.** G.J. Patchell (Sealord Group Limited, PO Box 11, Nelson, New Zealand, gjp@sealord.co.nz), 12 pp. (English, unpublished).

Results from the New Zealand research survey in CCAMLR Subarea 88.3 in February 2005 are presented. While ice conditions prevented the successful completion of the full research plan as approved at CCAMLR-XXIII, research activities were completed with 10 research hauls, temperature profiling, icthyoplankton sampling, toothfish tagging and biological sampling of toothfish and other species completed.

Pre-recruit *D. mawsoni* were caught at much greater depths than in the other subareas of Area 88. This result has significant implications for future trawl surveys in this area. The

catch rate obtained on one line on the Antarctic shelf is similar to catch rates taken in other subareas and divisions where substantial exploratory fisheries are currently under way. The limited results indicated a surprising lack of biodiversity in the De Gerlache Seamount study area.

While the results of this research survey are limited, they do suggest that further research activity is required in Subarea 88.3 before any fishing activity be permitted.

**WG-FSA-05/54**

**Longlining operations on New Zealand autoline vessels fishing for toothfish in CCAMLR waters.** J.M. Fenaughty and J. Bennet (Silvifish Resources Ltd, PO Box 17-058, Karori, Wellington, New Zealand, jmfenaughty@clear.net.nz), 7 pp. (English, unpublished).

A description of the autoline fishing method, including standard terminology for the fishing operation and gear used, is provided.

**WG-FSA-05/55**

**Australian albatross and petrel research programs.** B. Baker and R. Gales (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia), 5 pp. (English, unpublished).

Information on Australia's national albatross and petrel research programs is provided to CCAMLR as requested in the Intersessional Work Plan for ad hoc WG-IMAF (Item 2.1) for 2004/05.

**WG-FSA-05/56**

**Seabird mortality associated with Patagonian toothfish longliners in Falkland Island waters during 2002/03 and 2003/04.** H. Otley and T. Reid (C/- Foreign and Commonwealth Office, King Charles Street, London SW1A 2AH, United Kingdom, hotley@fisheries.gov.fk), 3 pp. (English, unpublished).

The Patagonian toothfish longline fishery set approximately 7.5 million hooks and 9.6 million hooks in 2002/03 and 2003/04 respectively. Observers were present during the setting of 59% of all lines during 2002–2004 to record adherence to the above provisions and record seabird mortality. Only black-browed albatross (*Thalassarche melanophris*) mortalities were recorded. The estimated total mortality was 80 and 45 black-browed albatrosses for 2002/03 and for 2003/04 respectively. The rates for 2002/03 and 2003/04 were 0.011 and 0.005 birds/thousand hooks respectively, indicating that the toothfish longline vessels are meeting the requirements of the relevant National Plan of Action.

**WG-FSA-05/57**

**Proposal for a mark–recapture experiment to estimate toothfish population size in Subarea 48.4.** D.J. Agnew and A. Payne (MRAG, 18 Queen Street, London W1J 5PN, United Kingdom, d.agnew@imperial.ac.uk), 8 pp. (English, unpublished).

One UK vessel fished around the South Sandwich Islands (Subarea 48.4) in July 2005 in accordance with Conservation Measure 41-03. During this time, fish were tagged in order to start a mark–recapture program to assess the toothfish population. Catch rates were similar to those experienced in Subarea 48.3. The UK proposes to undertake a more extensive mark–recapture experiment in Subarea 48.4 over the 2006–2007 fishing seasons. The objective of the experiment will be to assess toothfish population structure and size. The research will be undertaken during April in each year by up to two vessels: details are yet to be confirmed. The proposal is to tag 500+ fish taking 100 tonnes of catch each year. The target species will be *Dissostichus eleginoides*, but any *D. mawsoni* caught will also be tagged or retained for analysis as appropriate.

**WG-FSA-05/58**

**A two-fleet 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), 27 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 has become available for the years 2004 and 2005. The assessment is also generalised to allow for a second fleet to accommodate data from a pot fishery that has been in operation since November 2004. Results obtained show a much greater selectivity for larger toothfish for the pot than for the longline fishery – a feature which has important implications for the status of the population. The possible extent of cetacean predation and its consequences are also investigated. Twenty-year biomass projections under the assumption of various constant annual catches for the two-fleet model are computed. Although higher sustainable yields may be possible, it is suggested that a prudent management approach at this stage would be for the annual legal catch not to exceed 500 tonnes for the time being, together with encouragement that this be taken more by pots than by longline to reduce the impact of cetacean predation. Industry observations of the extent of cetacean predation for the longline fishery have proved helpful, and should be extended to a more formal data recording basis in the future.

**WG-FSA-05/59**

**Mitigation trials and recommendations to reduce seabird mortality in the pelagic icefish (*Champsocephalus gunnari*) fishery (Subarea 48.3).** J.O. Roe (Albatross and Petrel Programme, Falklands Conservation, 1 Princes Avenue, Finchley, London N3 2DA, United Kingdom), 18 pp. (English, unpublished).

Trials were conducted during the 2004/05 mackerel icefish (*Champsocephalus gunnari*) season in Subarea 48.3, to quantify seabird interactions with fishing operations, to trial different mitigation methods in an attempt to reduce seabird mortality caused by entanglement with the net and to collect baseline data on general seabird abundance while fishing.

Priority was placed on developing a new idea of binding the net with sisal string on shooting, in order to prevent it opening until it had sunk beneath the sea surface, and thereby reduce the chance of seabirds becoming entangled while attempting to feed from the net. Observations suggest this technique to be highly efficient and adoption of this technique across the fleet is recommended.

The use of streamer lines during shooting and hauling of the net was also tested, however, due to low vessel speed this proved to be impractical and their use was discontinued.

In addition, other ideas were considered and reviewed. These included reducing the size of the 'dangerous' 200 mm net meshes to a safer 140 mm, the use of additional weighting on the net body during hauling to reduce the amount of time that the net is on the surface, and the placing of a small-mesh 'jacket' on top of the dangerous meshes. Established techniques, such as cleaning the net and reducing offal discharge prior to shooting and hauling, were also monitored.

Unfortunately only 39 trawls were completed and due to the small number of replications it was not possible to show significant differences between the treatments.

**WG-FSA-05/60**

**Age validation of Patagonian toothfish (*Dissostichus eleginoides*) from Heard and Macquarie Islands.**  K. Krusic-Golub and R. Williams (Primary Industries Research Victoria, 2A Bellarine Highway, Queenscliff 3225, Victoria, Australia, kyne.krusicgolub@dpi.vic.gov.au), 12 pp.  (English, unpublished).

Patagonian toothfish (*Dissostichus eleginoides*) have traditionally been aged by counting presumed growth increments on the sectioned face of sagittal otoliths.  While there is a general consensus that the observed increments represent annual events, no direct validation has been provided for this species.  This study attempts to validate the annual increments using strontium (Sr) marked otoliths from tagged–recaptured samples.  Since 1996, a large scale tag-and-release program on *D. eleginoides* in the Heard Island and Macquarie Islands fisheries has included injection of most fish with strontium chloride ($SrCl_2$) on release.  Of these strontium marked fish, 142 were selected for analysis.  Strontium marks were detected in 139 of the 142 otoliths examined.  Using the number of observed increments after the mark in relation to the time-at-liberty between tagging and recapture, it was determined that for age classes 5 to 18, one increment is laid down per year.  The expected number of increments was the same as the observed increments for 88% of cases (when the time-at-liberty was known at the time of reading, and 52% when the time-at-liberty was not known.  These results indicate that while interpretation difficulties of increment structure in sectioned otoliths of *D. eleginoides* may result in variability from the absolute age, reliable estimates can still be produced.

**WG-FSA-05/61**

**First increment validation of Patagonian toothfish (*Dissostichus eleginoides*) from Heard Island.**  K. Krusic-Golub, C. Green and R. Williams (Primary Industries Research Victoria, 2A Bellarine Highway, Queenscliff 3225, Victoria, Australia, kyne.krusicgolub@dpi.vic.gov.au), 10 pp.  (English, unpublished).

Patagonian toothfish (*Dissostichus eleginoides*) have traditionally been aged assuming one opaque and one translucent increment is formed each year on the sectioned face of sagittal otoliths.  It has been recorded that differences in otolith interpretation exist between institutes routinely ageing *D. eleginoides,* resulting in differences of ageing data presented.  One area that was assumed to cause interpretation differences was the position of the first increment that corresponded with the end of the first year of growth.  While there is general consensus that the observed increments represent annual events, no direct validation has been provided for the early growth of this species.  In an attempt to determine the position of first increment formation, daily increments in seven sagittal otoliths were counted.  An average daily increment count between the hatch mark and the outer edge of the opaque nucleus of 229 days was recorded.  Due to the resolution of light microscopy, increments could not be confidently counted in the first translucent zone immediately succeeding the opaque nucleus.  It was assumed that the outer edge of the first translucent zone would correspond with the end of the first year's growth.  The average measurement from the primordium to the outer edge of the first translucent zone on the ventral side of the otolith section was 0.630 mm.  This is consistent with the measurements in previously aged samples from the Heard and Macquarie Islands fisheries.  These data suggest that the protocol currently used for the determination of the first annual increment is valid.

**WG-FSA-05/62**

**Results from the New Zealand exploratory fishery for *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2 in the 2004/05 season.**  G.J. Patchell (Sealord Group Ltd, PO Box 11, Nelson, New Zealand, gjp@sealord.co.nz), 7 pp.  (English, unpublished).

The New Zealand longliners *Janas* and *San Aspiring* were authorised to operate in the exploratory fishery in Divisions 58.4.1 and 58.4.2 during the 2004/05 season.  The results from their first season in this fishery are presented. The *Janas* undertook 44 sets in Division 58.4.2 for a catch of 37.9 tonnes of *D. mawsoni* and 0.395 tonnes of *D. eleginoides*. Two sets were undertaken in Division 58.4.1 SSRU C for a catch of 0.372 tonnes of *D. mawsoni*.  The *San Aspiring* undertook 20 research sets in Division 58.4.1 SSRU G for a catch of 20.9 tonnes of *D. mawsoni* and 0.4 tonnes of *D. eleginoides*.

The first sign of the onset of spawning activity for *D. mawsoni* was noted this season for this part of the Indian Ocean with one ripe female and 10 males sampled in Division 58.4.2 during March.

**WG-FSA-05/63**

**Size-at-maturity and histological procedures explored to determine spawning activity of female *Dissostichus mawsoni* from samples collected from the Ross Sea in January 2004, December 2004 and January 2005.**  M.E. Livingston and P. Grimes (Ministry of Fisheries, PO Box 1020, Wellington, New Zealand), 20 pp.  (English, unpublished).

Gonad samples from female Antarctic toothfish (*Dissostichus mawsoni),* collected during the 2003/04 and 2004/05 commercial fishing seasons in the Ross Sea to improve estimates of size-at-maturity, were analysed macroscopically and histologically.  Progress was, however, limited because few samples of toothfish less than 80 cm and over 120 cm total length were obtained.  The first part of the study used classic histological techniques to classify ovary stages by the most advanced state of oocyte development visible in histological sections of the 2003/04 samples.  Using this methodology, it is theoretically possible to determine the proportion of fish maturing to spawn, and from that, determine the mean size-at-maturity.  The calculated $L_{m50}$ of 113.0 cm was very close to the value of 115.2 cm estimated in 2000/01.  GSI data collected from across the fleet, however, still raise doubt about the true $L_{m50}$.

The second part of the study examined histological sections from the 2004/05 season for indicators of spawning activity that may also be useful in ascertaining the maturity ogive of *D. mawsoni* in the previous season.  A range of staining techniques was used to determine variations in the presence of PAS bodies (macrophage aggregates), encapsulated residual eggs, ovary wall thickness, atretic oocytes, the configuration of lamellae tips and oocyte packing. The latter three attributes showed the greatest potential in identifying post-spawners, but require calibration over a much wider range of size samples than obtained for this study. Recommendations for further sampling and character measurements are given.

**WG-FSA-05/64 Rev. 1**

**Growth models for *D. eleginoides* for the Heard Island plateau region (Division 58.5.2) calibrated from otolith-based length-at-age data and validated using mark–recapture data.**  S.G. Candy, T.D. Lamb, A.J. Constable and R. Williams (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, steve.candy@aad.gov.au), 23 pp.  *CCAMLR Science*, submitted (English).

Length-at-age data for Patagonian toothfish (*Dissostichus eleginoides*) caught by trawl in Division 58.5.2 were fitted using von Bertalanffy (VB) and segmented-linear models using likelihoods that either did or did not incorporate fishing selectivity and the length-bin sampling frequencies for ageing relative to those for random length-frequency (LF) samples to give the variable probability (VP) of sampling lengths.  A segmented linear trawl fishing

selectivity function was used where the upper arm was estimated, as described elsewhere, from comparisons of longline LF samples to that for trawls for seasons where both fishing methods were used. Due to the small number of fish in the aged sample that were older than 20 years, the general trend in the data of length with age did not exhibit obvious asymptotic behaviour so the fit of the VB model to a segmented linear model was compared. Also the VB model was adjusted by incorporating a multiplicative term that reduces the VB length-age trajectory below an estimated young age to give a more realistic predicted length at age zero than that for the unadjusted model. Fixing the $t_0$ and $L_\infty$ parameters of the VB model was also tried to give age-zero length of 30 mm and asymptotic length of 2 000 mm but the fit to the data was very poor. The Akaike Information Criterion indicated that the 2-segment linear model gave the best fit to the length–age data. Predictions from these models were compared with growth increments obtained from mark–recapture data for a large sample of recaptured fish. Mean annual growth increment from mark–recapture data for days at liberty greater than 175 days was 36.6 mm yr$^{-1}$ while that predicted from the 2-segment linear model for lengths above 557 mm was 37.6 mm yr$^{-1}$. Mean annual relative growth rates for mark–recapture data corresponded most closely to predictions from the VB model fitted by maximising the VP likelihood. For the 5–25 year age range predicted lengths from this VB curve and the 2-segment linear model were almost identical.

**WG-FSA-05/65**

**Estimating fishing gear selectivity for Patagonian toothfish (*Dissostichus eleginoides*) caught by trawlers on the Heard Island plateau region (Division 58.5.2) using trawl and longline length-frequency data and forward-calculated continuation ratios.** S.G. Candy (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, steve.candy@aad.gov.au), 14 pp. (English, unpublished).

Length-dependent fishing selectivity for trawlers fishing for Patagonian toothfish (*Dissostichus eleginoides*) on the Heard Island Plateau (Division 58.5.2) was modelled as a 3-segment linear model, which has ascending lower and descending upper arms corresponding to lower and upper fishing selectivity and a plateau section in between for the length range where fish are assumed fully selected. Using random length-frequency (LF) data collected from each trawler and longliner for the fishing seasons 2003–2005, the upper arm of the gear selectivity function for trawlers is estimated using a two-stage process. In the first stage a parameter was estimated for each 40 mm wide length bin from the fit of a binomial generalised linear mixed model (GLMM) to the number of fish in the bin using a logit link function and binomial sample size defined as the number of fish in that bin or greater. The data were combined for length bins and the GLMM was fitted to this combined dataset since the binomial counts are conditionally independent. A forward-calculated continuation ratio is the probability of a fish being in a length bin compared to that of being in a greater length bin and the logit link function allows the predicted log of these ratios or odds to be obtained directly from the GLMM. The ratio of the odds for trawl to that of longliners when this odds ratio is less than one gives the trawl gear selectivity for that length bin assuming fish in this bin are fully selected by longlines. To account for different availabilities of length classes with fishing depth, length bin was simultaneously fitted by depth interaction terms in the GLMM. In the second stage, the upper arm of the selectivity function was obtained as a linear fit through these ratios for the subset of bins where this ratio is less than one. The fitted linear decline in selectivity begins from near 800 mm and declines from a selectivity of 1 to 0 at 1 731 mm length. Adjusting for gear type, the GLMM predicts that the availability of large fish increases with increasing fishing depth.

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**WG-FSA-05/66**

**A method for inferring movement rates of fish from mark–recapture data.** C. Wilcox (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania and CSIRO Marine and Atmospheric Research, Castray Esplanade, Hobart 7001, Tasmania, Australia, chris.wilcox@csiro.au), 11 pp. (English, unpublished).

This paper presents methods to infer the rate of movement of fish that are marked, released and subsequently captured. The information that is available is the location and date of the release and the recapture. In addition, the intensity of fishing effort (i.e. sampling) by location and time is known. The simplest approach is to make a frequency plot of the distance between each release and recapture. This is somewhat problematic, as recaptures (i) are biased by variable sampling between locations, and (ii) do not consider the possibility of moving further than the maximum distance between any release and recapture point. An alternative approach presented here is to build an underlying model of movement, and then consider spatially variable sampling of marked fish moving according to this model. While this model-based approach requires assuming some description of movement, it has the advantage of being able to allow a much richer description of movement than is available with the frequency-of-distances approach. In addition, it also provides a way to generate a movement model that is parameterised, which includes uncertainty that can readily be integrated into a population simulation. If the goal of estimating movement distances and rates is to estimate mixing times for mark–recapture studies, there are simpler approaches that might be useful. For instance, one alternative would be to ask how much time is required for the probability of recapture in a location to match the relative probability of catching an unmarked fish in that location. Clearly this may be related to the distance from the release point, but considering this distance and the time required, one could estimate the time required for mixing from any initial deployment scheme. Other issues surrounding the use of mark–recapture data for estimating movement patterns are considered.

**WG-FSA-05/67**

**Seabird abundance and by-catch on the Brazilian longline fishing fleet.** T.S. Neves, L. Bugoni, D.S. Monteiro, L. Nascimento and F. Peppes (Projeto Albatroz, Av. Rei Alberto I, 450, sala 05, Ponta da Praia, Santos-SP, Brazil, tatiana.neves@iron.com.br), 15 pp. (English, unpublished).

Southern Brazil is an important foraging ground for several albatross and petrel species during breeding and non-breeding seasons. Information is presented on seabirds attending longline fishing vessels in the Brazilian Exclusive Economic Zone and international waters of the southwestern Atlantic Ocean (SW), based on 262 censuses. Spectacled petrel (*Procellaria conspicillata*) was the most frequent and abundant species through the year. Other species with significant numbers found in both warm and cold months were yellow-nosed albatross (*Thalassarche chlororhynchos*) and great shearwater (*Puffinus gravis*). Abundant species in winter were black-browed albatross (*T. melanophris*), white-chinned petrel (*P. aequinoctialis*), cape petrel (*Daption capense*) and southern fulmar (*Fulmarus glacialoides*). Seabird by-catch per unit effort obtained during 32 cruises (351 sets and 371 368 hooks) was 0.09 birds/thousand hooks, and affected black-browed albatross (70.6% of birds caught), white-chinned petrel, yellow-nosed albatross and spectacled petrel. Strong overlap between longline fishery and seabirds in southern Brazil during winter is a major cause for concern.

**WG-FSA-05/68**

**By-catch in the Australian fisheries in Division 58.5.2.** E.M. van Wijk (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, esmee.vanwijk@aad.gov.au), 11 pp. (English, unpublished).

This paper presents by-catch information for the Australian fisheries in Division 58.5.2 for the 2003/04 and 2004/05 seasons. By-catch in the trawl fisheries was low, generally less than 1% of the total catch (target plus by-catch). Higher percentage by-catch rates occurred in trawling grounds where the fishing effort, and therefore target catch, was low. By-catch in the longline fisheries was higher, ranging from 6 to 13% of the total catch when only landed by-catch was considered and ranging between 11 and 26% when skate and grenadiers cut and lost from longlines were included. The main by-catch species were skates and grenadiers in the *D. eleginoides* fishery and skates and *C. rhinoceratus* in the *C. gunnari* fishery. The total skate catch in Division 58.5.2 (including those cut from longlines) was 126.6 tonnes in 2003/04 and 91.1 tonnes in 2004/05.

**WG-FSA-05/69**

**Evaluating methods to assess yield of Patagonian toothfish (*Dissostichus eleginoides*) in CCAMLR Division 58.5.2.** A.J. Constable, I. Ball, B. Raymond, S.G. Candy, R. Williams and A. Dunn (Australian Antarctic Division, Department of Environment and Heritage, Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@aad.gov.au), 42 pp. (English, unpublished).

This paper describes aspects of the Management Strategy Evaluation being developed to evaluate possible management strategies for the Patagonian toothfish fishery in Division 58.5.2. As requested by the Subgroup on Assessment Methods, this paper elaborates on the plausible operating models currently being used for Patagonian toothfish in Division 58.5.2, the types of data and observations of the stock and the fishery being obtained from the region, the parameters that need to be estimated and the types of methods being used to assess yield of toothfish according to the CCAMLR decision rules. Some preliminary results are summarised as well as the details of continuing work for assisting the special Subgroup on Assessment Methods workshop to be held prior to the meeting of WG-FSA in 2005. These results will be presented in an updated version of this paper provided to the workshop.

**WG-FSA-05/70**

**Biological and fishery information for skates in Division 58.5.2.** E.M. van Wijk and R. Williams (Australian Antarctic Division, Channel Highway, Kingston 7050, Tasmania, Australia, esmee.vanwijk@aad.gov.au), 21 pp. (English, unpublished).

This paper presents biological and fishery information available for skates from Division 58.5.2. Estimates of growth calculated from trawl-tagged recaptured *Bathyraja eatonii* were 15 mm per year in total length and wing span, and 0.15 kg per year in mass, indicating that this species is very slow growing. Composition of the skate by-catch by fishery and depth zone is described. Length–weight equations are provided relating total length and weight by species. The length at first maturity ($L_{50}$) was estimated for *B. irrasa* at 865 mm and the length at first spawning ($L_{m50}$) at 1 210 mm. Estimates of abundance of skates by species and stratum are presented from survey data. CPUEs of skates by species from both research surveys and the commercial trawl and longline fisheries are also presented.

**WG-FSA-05/71**

**Two species of toothfish in two basic longline fishery regions – Patagonian toothfish in Subarea 48.3 (South Atlantic) and Antarctic toothfish in Subareas 88.1 and 88.2 (South Pacific).** K.V. Shust, E.N. Kuznetsova, A.N. Kozlov, N.V. Kokorin and A.F. Petrov (VNIRO, 17 V. Krasnoselskaya, Moscow 107140, Russia, antarctica@vniro.ru), 14 pp. (English, unpublished).

Now after more than 30 years of research, it is clear that the most valuable commercial (target) species in the CCAMLR Area are the two species of genus *Dissostichus*. These species have a wide circumpolar distribution but the areas of distribution of Patagonian and Antarctic toothfish fall into different latitudes. A comparison of Patagonian toothfish from Subarea 48.3 (South Georgia) and Antarctic toothfish from Subareas 88.1 and 88.2 (Ross Sea) reveal several similar features in distribution and biology but some different characteristics of these species in the study areas.

**WG-FSA-05/72**

**On the necessity for reconsideration of geographic boundaries, TAC estimates and duration of research fishing of Antarctic toothfish in SSRUs of Subarea 88.1 in the Ross Sea.** K.V. Shust, N.V. Kokorin and A.F. Petrov (VNIRO, 17 V. Krasnoselskaya, Moscow 107140, Russia, antarctica@vniro.ru), 9 pp. (English, unpublished).

The comparative analysis of fishing and investigations on Antarctic toothfish distribution in the Ross Sea (Pacific sector of Antarctic) show the complete failure of the division of Subarea 88.1 into 12 SSRUs adopted in 2003 and allocation of TACs (quotas) based on the seabed surface area and CPUEs (kg/thousand hooks) obtained for the other toothfish species (Patagonian toothfish) in Subarea 48.3 (Atlantic sector of Antarctic).

**WG-FSA-05/73**

**Reviewing the age-structured production model (ASPM) as an alternative method to estimate the Patagonian toothfish biomass in CCAMLR Subarea 48.3.** O.C. Wöhler, P.A. Martínez and A. Aubone (INIDEP, Paseo Victoria Ocampo No. 1, 7600 Mar del Plata, Argentina, owohler@inidep.edu.ar), 18 pp. (English, unpublished).

An age-structured production model (ASPM) has been proposed and applied for the Patagonian toothfish stock assessment in CCAMLR Subarea 48.3. Results obtained from this model, presented at the 2005 meeting of WG-FSA-SAM held in Yokohama, Japan, show acceptable fit with standardised CPUE series, annual catches and observed catch-length proportions (Wöhler et al., 2005 – WG-FSA-SAM-05/5).

In this paper, the same model is applied, but a function modified from Brandão and Butterworth (2003) is introduced to estimate vulnerability patterns. The results were similar to those obtained in WG-FSA-SAM-05/5.

**WG-FSA-05/74**

**Video monitoring trial on the *Avro Chieftain* in 2005 – an interim report.** B. Stanley (Australian Fisheries Management Authority (AFMA), PO Box 7051, Canberra Business Centre, ACT 2610, Australia, bob.stanley@afma.gov.au), 4 pp. (English, unpublished).

In May and June 2005 a trial of an Archipelago Marine Research video monitoring system within Division 58.5.2 was undertaken. The initial results from the monitoring of the hauling are optimistic but need to be fully analysed against the observer data that were generated for the same period. There is confidence that the trial achieved the objectives required of monitoring the hauling, but the results of monitoring the setting operation were unsatisfactory due to operational and technical limitations of the system that was deployed.

**WG-FSA-05/75**

**Analysis of albatross and petrel distribution within the CCAMLR Convention Area: results from the global procellariiform tracking database.** BirdLife International (Prepared by Dr Cleo Small, BirdLife Global Seabird Programme, RSPB, The Lodge, Sandy, Beds SG192DL, United Kingdom, cleo.small@rspb.org.uk, and Frances Taylor), 23 pp. *CCAMLR Science*, submitted (English).

This paper presents an analysis of the distribution of albatrosses and petrels in the CCAMLR Convention Area (areas, subareas, divisions and subdivisions), based on data from the Global *Procellariiform* Tracking Database. The results highlight the importance of the CCAMLR Convention Area, particularly for breeding distributions of populations of wandering, grey-headed, light-mantled, black-browed and sooty albatrosses, and populations of both northern and southern giant petrel and white-chinned petrel. The distribution data also emphasise the importance for breeding albatrosses and petrels of regions north of the CCAMLR boundaries. Overall, the CCAMLR subareas with the highest proportion of albatross and petrel distribution were Subareas 48.3 and 58.6, but the breeding ranges extend across the majority of the CCAMLR Convention Aarea, with the lowest proportion of distribution being in Subareas 88.2 and 88.3. Current and future tracking studies will enable analysis of non-breeding albatross and petrel distribution, for which many data gaps currently remain.


**WG-FSA-05/76**

**Oceanological factors affecting formation of mackerel icefish aggregations in the South Georgia area during different seasons of the year.** Zh.A. Frolkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, west@atlant.baltnet.ru), 26 pp. (English, unpublished).

Over winter, icefish do not form aggregations, but feed sluggishly and are scattered at depths of more than 250 m within a rather narrow temperature range (1.6–1.7°C). In this period the water temperature is a limiting factor restricting fish distribution.

In spring–summer, icefish feed at water temperatures of 0.0°C to 1.9°C in the South Georgia area and to 2.0°C near Shag Rocks. A high level of energy exchange and an abundant supply of food allow fish to disperse over wider depth and temperature ranges. Taking into account the fact that in other habitats icefish are found at water temperatures below zero and never at temperatures above 2°C, it is possible to assume that low water temperatures restrict fish distribution into the warmer waters.

Autumn encompasses feeding and pre-spawning periods. Pre-spawning fish do not depend on the distribution of their prey species, but migrate to the spawning grounds. These migrations occurred in the near-bottom layer. The trigger for the spawning migration to begin is the warming of the near-bottom water on the spawning ground to 1.6°C. The amount of accumulated fat determines the readiness of an individual fish to spawn. Icefish which spawn in a particular year continue feeding, but feeding activity decreases considerably and fish gradually shift to the wintering grounds.

Therefore, during the feeding period the abiotic conditions generally affect the formation of icefish aggregations indirectly through the availability of food items, the distribution of which depends on hydrodynamic conditions, temperature, illumination, sea roughness, availability of phytoplankton aggregations, etc. During pre-spawning and spawning periods, the distribution of icefish and the onset of spawning depend directly on abiotic conditions, primarily linked to temperature. The same is true for the wintering period.

**WG-FSA-05/77**

**Reasons for differences between the distribution and density of mackerel icefish (*Champsocephalus gunnari*) aggregations in the South Georgia area during summer and autumn in different years from bottom trawl survey data.** Zh.A. Frolkina (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, west@atlant.baltnet.ru), 28 pp. (English, unpublished).

During the feeding period icefish aggregations are confined to a frontal zone between opposite flows (coastal circumfluent current and ACC) or form inside quasi-stationary circulations, where the largest aggregations of food organisms are concentrated at the beginning of spring. Icefish concentrations were detected at the periphery of a cyclonic meander or in the centre of the anticyclonic circulation formed by the Weddell waters. It was also noted that the fish were confined to the boundary of water masses between the shelf waters and ACC. Favourable conditions for the formation of dense aggregations resulted from the availability of clear-cut frontal zones caused by the interaction of warm deep waters and the coastal waters. This confinement of fish aggregations to dynamically active zones arises from the concentration of food organisms in these areas rather than from favourable conditions for the fish.

The presence of cold intermediate layers are considered to be a negative hydrological factor for the formation of icefish aggregations as it impedes the descent of food objects to the layers inhabited by icefish and inhibits the migration of fish to the upper 100 m layer. Very high water temperatures (above 1.8–2.0°C) for this area in locations in which food organisms aggregate is another obstacle to the vertical migration of foraging fish. All physiological processes of icefish begin to decline at such temperatures, and at a higher temperature the fish evidently fall into a condition close to anabiosis. In such locations the fish are distributed deeper than this temperature layer, most often near the bottom.

As a rule, transition of icefish to pre-spawning condition is determined by visceral fat content (over 2 points). Spawning begins when near-bottom temperature on the spawning ground increases to 1.6°C. Therefore, the beginning of the spawning period is determined primarily by oceanological factors.

**WG-FSA-05/78**

**An alternative method of age composition assessment on the basis of survey length data using mixture distributions.** P. Gasyukov (AtlantNIRO, 5 Dmitry Donskoy Street, Kaliningrad 236000, Russia, pg@atlant.baltnet.ru), 19 pp. *CCAMLR Science*, submitted (English).

On the basis of bottom trawl surveys carried out by Russia and Great Britain during 2000, 2002, 2004 in the South Georgia area, it is demonstrated that the method described by Aitchison and the bootstrap method result in different estimates of mean fish density in the length series. Verification of the hypothesis of non-zero observations lognormal distribution for a large number of length groups casts doubt on the correctness of the application of the first method and therefore also of the method by de la Mare commonly used by CCAMLR in determining icefish age composition from abundance indices. To solve this problem it may be proposed that the modern version of the method, described by MacDonald and Pitcher, be applied. A comparison of this method and the method by de la Mare for length series, estimated with Aitchison's method, were carried out. The results appeared very similar. The method used by MacDonald and Pitcher has been tested on the length series obtained with the bootstrap method on the basis of the abovementioned survey data. To estimate the standard error of the mixture distribution parameters, the 'jackknifing-after-bootstrap' method was proposed.

**WG-FSA-05/79**

**Experimental acoustic survey of icefish resources in Subarea 48.3 in 2005.** M. Belchier, M. Collins, R.L. O'Driscoll, S. Clarke and W. Reid (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, markb@bas.ac.uk), 19 pp. (English, unpublished).

This report describes the activities and preliminary results of the research carried out during January 2005 on board the FPRV *Dorada* by British Antarctic Survey scientists on behalf of UK authorities.

Survey Objectives

The primary objectives of the proposed survey were to:
- refine methods for estimating icefish biomass using acoustics;
- examine temporal changes in the vertical distribution of icefish;
- assess precision of AUDOS estimates of crab density.

Secondary survey objectives were to:
- 'ground-truth' AUDOS estimates of crab density using comparisons with bottom trawls;
- provide more information on the distribution of the benthos on the South Georgia shelf;
- monitor commercial fishing activity in the area.

**WG-FSA-05/80**

**Setting a minimum line length for line sink rate testing: a review of existing data and some preliminary proposals for CCAMLR consideration in revising Conservation Measure 24-02 (2004).** N. Smith (Ministry of Fisheries, PO Box 1020, Wellington, New Zealand, smithn@fish.govt.nz), 12 pp. (English, unpublished).

This paper provides a brief descriptive analysis of some of the available data on the length of longlines used in exploratory fisheries and some of the data describing longline sink rate trials. In Subarea 88.1 the maximum length of longlines used by auto longline system vessels is approximately 15 000 m. The maximum length of longlines used by Spanish longline system vessels is approximately 37 500 m. The mean length of research and exploratory sets is very similar for autoline system vessels. However, for Spanish longline system vessels research sets are generally just over half the length of exploratory sets. Based on this review and known longline sink rates, options for revising Conservation Measure 24-02 (2004) are proposed.

**WG-FSA-05/P1**

**Seal mitigation measures on trawl vessels fishing for krill in CCAMLR Subarea 48.3.** J. Hooper, J.M. Clark, C. Charman and D. Agnew. 2005. *CCAMLR Science*, 12: 195–205.

**WG-FSA-05/P2**

**Towards a review of the population status and trends of albatrosses and petrels listed within the agreement.** ACAP Interim Secretariat. 2005. *ACAP Global Review Status and Trends July 2005*: 17 pp.

**WG-FSA-05/P3**

**CASAL (C++ algorithmic stock assessment laboratory): CASAL User Manual v2.07-2005/08/21.** B. Bull, R.I.C.C. Francis, A. Dunn, A. McKenzie, D.J. Gilbert and M.H. Smith. 2005. *NIWA Technical Report*, 127: 272 pp.

**WG-FSA-05/P4**

**Foraging of royal albatrosses, *Diomedea epomophora*, from the Otago Peninsula and its relationship to fisheries.** S. Waugh, D. Filippi, A. Fukuda, M. Suzuki, H. Higuchi, A. Setiawan and L. Davis. 2005. *Can. J. Fish. Aquat. Sci*, 62: 1410–1421.

**WG-FSA-05/P5**

**Shags in Antarctica: their feeding behaviour and ecological role in the marine food web.** R. Casaux and E. Barrera-Oro. *Ant. Sci*., accepted.

**WG-FSA-05/P6**

**Dietary composition of juvenile *Dissostichus eleginoides* (Pisces, Nototheniidae) around Shag Rocks and South Georgia, Antarctica.** E.R. Barrera-Oro, R.J. Casaux and E.R. Marschoff. 2005. *Polar Biol*., 28: 637–641.

**WG-FSA-05/P7**

**An alternative method for estimating the level of illegal fishing using simulated scaling methods on detected effort.** I. Ball. 2005. *CCAMLR Science*, 12: 143–161.

**WG-FSA-05/P8**

**A review of methodologies aimed at avoiding and/or mitigating incidental catch of protected seabirds.** L.S. Bull. In press. DoC Research, *Development and Improvement Series*.

**WG-FSA-05/P9**

*Regional Fisheries Management Organisations: their duties and performance in reducing bycatch of albatrosses and other species.* C.J. Small. 2005. BirdLife International, Cambridge, United Kingdom.
(Executive summary and full paper)

**WG-FSA-05/P10**

**BirdLife International. 2004.** *Tracking ocean wanderers: the global distribution of albatrosses and petrels. Results from the Global Procellariiform Tracking Workshop, 1–5 September, 2003, Gordon's Bay, South Africa.* BirdLife International, Cambridge, United Kingdom.
(Executive summary and full paper)