CCAMLR SCIENTIFIC ABSTRACTS 2007

CONTENTS

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 2007 meetings of the CCAMLR Scientific Committee and its working groups. It is published only in English.

Publication of an abstract does not imply in any way that the paper was reviewed by the Scientific Committee or its working groups, or was used in the work of CCAMLR.

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(iii) scientific papers not intended for publication, which are listed as 'unpublished'; and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Unpublished papers must not be cited without written permission of the author(s).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

Commission

CCAMLR-XXVI/30
The orderly development of the krill fishery. Delegation of Australia, 4 pp. (English, unpublished).

During deliberations at CCAMLR-XXV on revising the precautionary catch limit for krill in Division 58.4.2, Australia noted that while the scientific data supported an increase, such a large increase required the inclusion of other elements in the conservation measure to facilitate the orderly and precautionary development of the fishery.

Australia has this year submitted papers to WG-EMM and SCIC which outline the scientific and compliance requirements that Australia considers critical to the orderly and precautionary development of the krill fishery.

In summary Australia recommends that:

- krill stock surveys be undertaken in areas with no precautionary catch limits in order to establish a catch limit before fishing is prosecuted in these areas;
- small-scale management units be established to minimise localised impacts on krill predators prior to a threshold being reached;
- a threshold capacity be established for the fishery relative to the catch limits (small- or large-scale spatial limits);
- a program to monitor and observe krill catch and by-catch be developed;
- vessels carrying krill be subject to port inspections by amending Conservation Measure 10-03 so that it applies to the krill fishery;
- transhipment operations be overseen by the Flag State, similar to the unloading of catches at port in Conservation Measure 10-03;
- krill fishing vessels be required to carry a VMS device on board and automatically report their positions by amending Conservation Measure 10-04 to apply to the krill fishery;
- components of Conservation Measure 21-02 be applied to Conservation Measure 21-03 so that more rigorous assessment of notifications of intent to fish for krill can be achieved.

Australia considers that CCAMLR cannot meet its objective, nor can the orderly development of the krill fishery be achieved, unless the scientific and compliance requirements listed above are adopted as integral components of managing the krill fishery.

CCAMLR-XXVI/BG/21
The Nature Reserve of the French Southern and Antarctic Territories: an example of marine protected areas. Delegation of France, 5 pp. (French, unpublished).

Scientific Committee

SC-CAMLR-XXVI/7
Biomass of krill in Division 58.4.2 and an estimation of precautionary yield, including a subdivision of the precautionary catch limit along the 55°E longitude. Delegation of Australia, 3 pp. (English, unpublished).

This paper presents a revised analysis of krill biomass for Division 58.4.2 using data from the 2006 Australian survey and based on the most recent advice from WG-EMM.

SC-CAMLR-XXVI/BG/9 Rev. 1

A review of national observer training and education programs (Scheme of International Scientific Observation). CCAMLR Secretariat, 20 pp. (English, unpublished).

At CCAMLR-XXV, the Scientific Committee noted that the implementation of the observer program and the application of observer requirements could be improved by adopting a standard approach to education and training for observers in these fisheries (SC-CAMLR-XXV, paragraph 2.11). A review of current levels of education and training for observers was undertaken by the Secretariat. Information provided by participating Members was reviewed and common elements, differences and gaps in existing national programs were identified.

Nine main aspects of training and education considered important for scientific observers were identified: role of the scientific observer; vessel and fishing operations; catch estimation; gear configuration; species identification; sampling techniques and requirements; data handling and reporting procedures; sea survival and safety; and the CAMLR Convention and CCAMLR conservation measures in force.

The Secretariat believes that in order to achieve a consistent approach to education and training for scientific observers, Members would need to: further develop and agree on a set of training and education standards; consider ways to meet and maintain these standards; and develop a method of providing recognition to national programs that meet these standards.

Adopting a consistent approach to education and training for observers would improve the CCAMLR Scheme of International Scientific Observation. Also to improve observer data quality, Members could convene training workshops for national technical coordinators, as has been discussed previously (SC-CAMLR-XVII, Annex 5, paragraph 3.79; SC-CAMLR-XX, Annex 5, paragraph 3.50), and/or increase their attendance at the meetings of WG-FSA and ad hoc WG-IMAF.

SC-CAMLR-XXVI/BG/10

Review of CCAMLR activities on monitoring marine debris in the Convention Area. CCAMLR Secretariat, 24 pp. (English, unpublished).

The current status of national programs 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 13 sites, most within Area 48. There are four active sites that have data for more than three consecutive years, these are: Bird Island (South Georgia), Signy Island (South Orkney Islands), King George Island (South Shetland Islands) and Marion Island.

The number of beached marine debris items reached a peak in the period 1994–1996 at Bird Island and Signy Island, but declined after that. The number of debris items has increased at Bird Island in 2006 and Signy Island in 2007, but decreased at King George Island in 2007. The majority of items reported were packaging materials, fishing gear and wood.

Packaging items make up the majority of debris items reported from all three seasons at Marion Island. The most common packaging item is plastic soft drink bottles.

Conservation Measure 26-01 (2006) clearly prohibits vessels from using packaging bands to secure bait boxes and restricts their use for other purposes to vessels with on-board incinerators (closed systems) into which they should be placed once removed from packages. It is a concern therefore that packaging bands are being found during beach surveys at Bird Island and Signy Island, and that Antarctic fur seals are being reported as entangled by packaging bands at Bird Island. The conservation measure also instructs vessels to cut the bands before incinerating them, yet closed packaging bands are still being reported as debris from Bird Island.

The level of marine debris found in grey-headed albatross and wandering albatross colonies at Bird Island in 2007 has increased. Debris from black-browed albatross colonies at Bird Island in 2007 has remained low. Fishing gear, such as lines and hooks, and miscellaneous broken plastics continue to form the major part of the debris associated with seabird colonies. Data were received from Palmer Station, Anvers Island, for the 2007 season for two species of seabirds. This was the first submission from this site.

Marine mammal entanglement at Bird Island increased dramatically in 2007 with 58 reports of Antarctic fur seal entanglements. The most common marine entanglement materials were synthetic string or longline, packaging bands and fishing net. The number of seabirds contaminated with hydrocarbons remains low.

SC-CAMLR-XXVI/BG/16

Beach debris survey – Main Bay, Bird Island, South Georgia, 2005/06. F. Le Bouard and H.F. Taylor (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 20 pp. (English, unpublished).

During the 16th year of standardised beach surveys of man-made debris at Bird Island, South Georgia, a total of 544 items was collected, the highest amount of debris collected since 1995/96. Compared to the previous recording period, 170% more items were collected during winter and 101% more during summer, a mass increase of 1.19 kg overall (29%).

For the third consecutive year, nylon line was absent from Bird Island; an encouraging result after the peak of 546 pieces in 1995/96. However, plastic packaging bands are still regularly recovered. In the reporting period 16 pieces were found, more than in any of the previous nine years, suggesting that the ban on their use on board fishing vessels brought into force by CCAMLR in 1995/96 has yet to prove entirely effective.

Sixty-nine pieces of multifilament (multi-strand) gillnet were found on the survey beach this year (mainly in winter) compared to 11 in 2004/05. Miscellaneous debris comprised the greatest proportion of items (84% of the total).

SC-CAMLR-XXVI/BG/17

Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Bird Island, South Georgia, during the 2006 winter and 2006/07 breeding season. D.L.D. Malone (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 23 pp. (English, unpublished).

Results of the survey of entanglements of Antarctic fur seals at Bird Island, South Georgia, for the 17th consecutive winter (2006) and 19th consecutive summer (2006/07) are reported here. A total of 41 winter entanglements was observed in the reporting period compared to two observed in the previous winter. This is the second-highest winter total since records began in 1990 (the highest was in 1992 when 97 entanglements were reported). The number of entanglements seen during the summer period was 17, an increase of 112.5% over the previous summer, and the highest since 2001/02. During winter, 49% of entanglements were classed as severe (cutting through the skin) or very severe (breaking through both the skin and underlying fat layer). Over the summer period, 18% of entanglements were classed as severe or very severe.

Synthetic string/rope was the most commonly found item forming neck collars (37% and 35% during winter and summer respectively). On 16 occasions the material was found to be a loop of rope similar to that shown in Figure 3. Plastic packaging bands were the second-most abundant material overall (28%), closely followed by fishing nets (26%). Juveniles (including sub-adults) were involved in 56% of all entanglements in winter and 53% in summer. Overall females made up the majority of the sexed individuals in all age classes (43%) compared to males (33%) and the remainder unknown.

The increase in the number of winter entanglements (41) and animals with severe wounding (20) was the highest recorded in 14 years, whilst the recent escalation in summer entanglements since 2004/05 is also a cause for concern.

SC-CAMLR-XXVI/BG/18

Fishing equipment, marine debris and hydrocarbon soiling associated with seabirds at Bird Island, South Georgia, 2006/07. R.T.E. Snape (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 18 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 2006 to 31 March 2007. It is the 14th such annual report. As in previous years, more items of marine debris and fishing gear (mostly longline fishing gear) were found in association with wandering albatrosses than with any other species. The total number of items encountered (n = 170) increased after a recent short-term decline with large numbers of fishing hooks and line (n = 70) recovered from wandering albatross chick regurgitations, reflecting discard of used baited hooks at sea. Entanglements continue to be observed with hooks being typical of those used in the Patagonian toothfish industry.

SC-CAMLR-XXVI/BG/19

Beach debris survey, Signy Island, South Orkney Islands, 2006/07. M. Dunn (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 11 pp. (English, unpublished).

During the 2006/07 austral summer the 17th 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 50 items weighing 7.6 kg was collected. The number of items found was greater than the total found during the previous season, although the total mass of the waste recovered had decreased (an increase of 85.2% and decrease of 68.8% since 2005/06 respectively). There was a rise in the number of plastic packaging bands (18) from the total recorded the previous season (9), this increase representing a continuation of the rise in packaging bands experienced over recent seasons. The likely source of these bands is fishing vessels, so these findings highlight the fact that 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. Plastic waste was predominant, as in previous seasons, making up 80% of all items recorded, followed jointly by metal and wood, both at 10%. The results of this season's debris 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-XXVI/BG/20

Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Signy Island, South Orkney Islands, 2006/07. M. Dunn (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 9 pp. (English, unpublished).

The results of the 11th annual survey of entanglement of Antarctic fur seals at Signy Island, South Orkney Islands, are reported for the 2006/07 summer season. There was one sighting of a seal wearing a neck collar of man-made debris. Data are compared with results from a parallel study undertaken at Bird Island, South Georgia, in 2006/07.

SC-CAMLR-XXVI/BG/21

Notes on a study of environmental, spatial, temporal and operational effects on the incidental mortality of birds in the longline fishery in the Crozet and Kerguelen areas from 2003 to 2006. Delegation of France, 18 pp. (French, English abstract, figure captions and table legends, unpublished).

Incidental mortality has diminished considerably in comparison with the period from 2001 to 2003 (Delord et al., 2004).

During the 2003/04, 2004/05 and 2005/06 fishing seasons the incidental mortality of seabirds was reduced by approximately half each year.

A multivariate analysis has revealed that the incidental catch of white-chinned petrels and grey petrels is caused by a complex set of variables relating to the environment and fishing techniques. Results suggest that a significant proportion of the mortality of white-chinned petrels and grey petrels can be explained by the effects of season and geographical area, as was the case for the period 2001–2003.

Incidental mortality varies according to geographical area, being higher at Kerguelen (where there are some geographical disparities, with higher mortality in the northern and central areas in the east, and northern and southern areas in the west) than at Crozet.

Analyses show that a proportion of the incidental mortality can be explained by other factors, such as, for example, the type of lines used (integrated-weight lines or otherwise, or a mixture of both). The number of streamer lines is also a factor which influences incidental mortality, the rate of which is lower when the number of streamer lines deployed behind the vessel is increased.

This study highlights the phenomenon of incidental capture of live birds during hauling, and of the larger number of species involved than is the case during setting.

SC-CAMLR-XXVI/BG/22

Notes on a survey of the impact of fisheries on populations of white-chinned petrels (*Procellaria aequinoctialis*) and grey petrels (*Procellaria cinerea*) in the Crozet and Kerguelen Islands. Delegation of France, 15 pp. (French, English abstract and figure captions, unpublished).

This study reviews the impact of longline fishing on populations of white-chinned petrels and grey petrels from 2004 to 2006 at Crozet and Kerguelen (Subarea 58.6 and Division 58.5.1 respectively).

It shows that the population of white-chinned petrels at Possession Island (Crozet) decreased sharply between 1983 and 2004, with the main cause being changes in environmental variables. Nevertheless, the decrease in the population was more marked as a result of previous levels of incidental mortality. At present, the level of mortality of white-chinned petrels in Subarea 58.6 has not reached the critical point beyond which the population would be at risk of declining.

Past levels (up to 2003) of incidental mortality of white-chinned petrels in Division 58.5.1 have probably had a negative effect on the population. At present, incidental mortality of this petrel has a limited effect on the population.

The population of grey petrels in the Kerguelen archipelago (Division 58.5.1) is also very sensitive to changes in environmental variables and particularly to positive values of the Southern Oscillation Index (SOI). The legal toothfish fishery had a significant negative impact on adult survival and population growth rate between 2001 and 2004. Since 2005, incidental mortality of this species is no longer at the levels above which the number of birds killed could cause a decline in the population. In order to limit the decrease, new conservation measures were established for the 2006/07 fishing season.

SC-CAMLR-XXVI/BG/24

Criteria for the selection of Marine Protected Areas (MPAs). S. Grant (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, susie.grant@dsl.pipex.com), 9 pp. (English, unpublished).

Selection criteria have been widely advocated as a tool to assist in the identification of Marine Protected Areas (MPAs) worldwide (e.g. Kelleher, 1999; Roberts et al., 2003; CBD, 2006). The application of selection criteria can assist in evaluating candidate sites, prioritising areas that merit protection, and determining the appropriate design and boundaries for selected areas. While they do not provide definitive answers to questions relating to the location and design of protected areas, criteria can be used alongside other tools to support decision-making. For example, selection criteria might be applied in conjunction with bioregionalisation analysis to support the systematic development of a representative system of MPAs.

The effective application of selection criteria depends on the definition of clear objectives to be achieved by a system of MPAs. Different criteria may apply to the selection of different types of Marine Protected Areas (e.g. Antarctic Specially Protected Areas, Antarctic Specially Managed Areas, and other area-based measures including those relating to sustainable fisheries management), designed for the achievement of a range of objectives.

This paper considers how existing selection criteria for protected areas, both in the context of the Antarctic Treaty System and in other international systems, might be applied in the identification of candidate marine sites for special protection and management in the Southern Ocean.

SC-CAMLR-XXVI/BG/25 Rev. 1

Data on feeding and food objects of southern minke whales. S.G. Bushuev (Odessa Branch of the Southern Scientific Research Institute, of Marine Fishery and Oceanography, Mechnikova Street 132, Odessa 65028, Ukraine, bush@homei.net.ua), 10 pp. (English, unpublished).

SC-CAMLR-XXVI/BG/26

New page in the Antarctic krill fishing. V. Bibik, A. Vinnov and D. Sclabos (presented as a translation from *The Fishing Industry of Ukraine*, 1–2/2007: 11–14).

Antarctic krill (*Euphausia superba*) is one of the largest marine resources of animal origin protein on the planet. Krill is the key element of the Antarctic region ecosystem. Construction of modern vessels for krill fisheries and processing is foreseen; introduction of new technologies on krill catch and resulting products, such as krill oil, hidrolizates, astaxanthine-related antioxidants and other preparations, became possible due to the construction of specialised large-capacity fish–krill super trawlers.

SC-CAMLR-XXVI/BG/27

Antarctic seafloor geomorphology as a guide to benthic bioregionalisation. P.E. O'Brien (Geoscience Australia, GPO Box 378, Canberra 2601, Australia, phil.obrien@ga.gov.au), 17 pp. (English, unpublished).

Publicly available bathymetry and geophysical data can be used to map geomorphic features of the Antarctic continental margin and adjoining ocean basins at scales of 1:1–5 million. The geomorphic features identified and their properties can be related to major habitat characteristics such as sea floor type (hard versus soft), ice keel scouring, sediment deposition or erosion and current regimes. Where more detailed data are available, shelf geomorphology provides a guide to the distribution of the shelf benthic communities recognised by a number of authors. For areas off the shelf, the relationships between physical environmental parameters and the benthic biota are more poorly known, however,

geomorphic mapping provides insights into major processes that are likely to influence benthic habitats. The geomorphic mapping method presented here rapidly provides a layer to add to benthic bioregionalisation using readily available data and provides useful insights into seabed and oceanographic conditions that influence benthic communities, even in the absence of direct measurements. The conclusion from this preliminary study of sea-floor geomorphology from the Antarctic is that there is enough data available already to produce a meaningful benthic bioregionalisation for an area as poorly known as the Antarctic continental margin and surrounding oceans. Studies of shelf biota that have tried to link the physical environment with benthic communities have found links strong enough to suggest that geomorphology is a useful first-pass tool for mapping the distribution of communities. The link between biology and geomorphology is the degree to which sea-floor geometry influences oceanographic, biogeochemical and substrate processes to shape the conditions for benthic communities. Additional layers of bed-shear stress and sediment characteristics will further refine benthic bioregionalisation when data become available, however, the results produced by mapping from bathymetry alone are sufficient to justify its use in the first stage of benthic bioregionalisation for CCAMLR waters.

SC-CAMLR-XXVI/BG/30

Demersal fishing interactions with marine benthos in the Southern Ocean: an assessment of the vulnerability of benthic habitats to impact by demersal gears. A. Constable, D. Welsford, S. Doust and R. Kilpatrick (Department of Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@aad.gov.au), 13 pp. (English, unpublished).

A collaborative project between Australian industry, the Australian Antarctic Division (AAD), Australian Fisheries Management Authority (AFMA), and the Fisheries Research and Development Corporation has been established to investigate the interactions between demersal fishing gears targeting *Dissostichus* spp. with marine benthos in the Australian EEZ of the Southern Ocean.

Key outcomes of this project will include:

- compact camera systems which will be able to be deployed by scientific observers in the Convention Area to quantify habitat types where fishing occurs;
- identification of types and likely extent of interactions between different demersal fishing gears (trawl, longline, trap) with benthic communities around Heard and McDonald Islands (Division 58.5.2), and longlines on the Antarctic continental shelf;
- an assessment of the vulnerability of benthic habitats to impact by demersal gears in the sub-Antarctic and high latitudes of the Southern Ocean;
- recommendations for practical mitigation strategies to minimise fishing impacts on benthic communities.

Compact cameras have already been built and trialled on trawl and longline gear, and the footage captured indicates there is great potential for such systems to capture data to quantify interactions between demersal gears and the benthos in CCAMLR fisheries.

SC-CAMLR-XXVI/BG/31

IMAF risk assessment of fisheries by statistical area. Ad Hoc Working Group on Incidental Mortality Associated with Fishing (WG-IMAF), 29 pp. (English, unpublished).

SC-CAMLR-XXVI/BG/32

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).

Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM)

SG-ASAM-07/4
CCAMLR acoustic database: 2007 update. CCAMLR Secretariat, 16 pp. (English, unpublished).

SG-ASAM-07/5
Improving target identification of mackerel icefish using commercial and scientific observations. S. Fielding, M. Collins, I. Everson and A. Reid (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, sof@bas.ac.uk), 18 pp. (English, unpublished PowerPoint presentation).

SG-ASAM-07/6
Collaborative optical-acoustic survey technique (COAST) applied to rockfish in the SCB. D. Demer, J. Butler, D. Pinkard and K. Franke (Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, david.demer@noaa.gov), 18 pp. (English, unpublished PowerPoint presentation).

SG-ASAM-07/7
Descriptive analysis of mesopelagic backscatter from acoustic data collected in the Ross Sea. R. O'Driscoll (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Kilbirnie, Wellington, New Zealand, r.odriscoll@niwa.co.nz), 26 pp. (English, unpublished PowerPoint presentation).

SG-ASAM-07/8
South Georgia myctophid survey, March 2004 (Powerpoint presentation). M. Collins (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, macol@bas.ac.uk). (English, unpublished PowerPoint presentation).

SG-ASAM-07/9
The 2006 BROKE-West acoustic survey of krill distribution and abundance in CCAMLR Division 58.4.2. T. Jarvis, N. Kelly, E. van Wijk, S. Kawaguchi and S. Nicol (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, toby.jarvis@aad.gov.au), 29 pp. (English, unpublished PowerPoint presentation).

Working Group on Statistics, Assessments and Modelling (WG-SAM)

WG-SAM-07/4
Preliminary investigations of an assessment model for skates and rays in the Ross Sea. A. Dunn, S.M. Hanchet, S.L. Ballara and M.P. Francis (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Kilbirnie, Wellington, New Zealand, a.dunn@niwa.co.nz), 35 pp. (English, unpublished).

This report presents the data and preliminary results from a developmental model for Antarctic skates in SSRUs 881H, I, J and K of the Ross Sea. The developmental model

attempted to create a catch history of all skates and rays in the Ross Sea, and integrate these data with the available observational data (including tag–recapture data) into a single integrated stock assessment model.

We conclude that aspects of the catch history were very uncertain, including the species composition, the weight and number of skates caught, the proportion discarded, and the survival of those tagged or discarded. The size composition of the commercial catch was also very uncertain because of the low numbers sampled each year. Most aspects of the tagging data were also uncertain, including the actual numbers of skates released, the initial mortality of tagged skates, the tag loss rate and the numbers of skates scanned for tags. While updated summaries of the numbers of skate tag releases and recaptures have been reported, these data are still preliminary, and further work is required. Lastly, there is great uncertainty over the biological parameters, including age and growth, natural mortality, steepness, and size- and age-at-maturity.

The applicability of a general model, such as presented here, to a multi-species catch has not been investigated. While it is plausible that a general model may be adequate if the productivity parameters of the different species of skates and rays are similar, we conclude that additional research is required to investigate the usefulness of such models. We also make a number of suggestions for areas where better data are required. These include recommending work that would improve species identification, increasing the detection rate of tagged skates, increasing the number of skates measured and sexed, validating estimates of age and growth, revising the skate tagging protocols, and undertaking more extensive skate survivorship experiments.

WG-SAM-07/5

An updated descriptive analysis of the toothfish (*Dissostichus* spp.) tagging program in Subareas 88.1 and 88.2 for 2006/07. A. Dunn, S.M. Hanchet and S.L. Ballara (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Wellington, New Zealand, a.dunn@niwa.co.nz), 21 pp. (English, unpublished).

Descriptive analyses of the toothfish tagging program carried out in Subareas 88.1 and 88.2 since 2001 are updated. The paper provides a preliminary update of the tag–release and tag–recapture data that were presented at the October 2006 meeting of WG-FSA by including data from New Zealand vessels and preliminary data for other vessels that fished in 2007.

Release and recapture data that previously were unavailable for about half of the non-New Zealand vessels for 2004 are now available and described in this paper for the first time. Overall, a reported total of 12 177 Antarctic toothfish have been released and 333 recaptured, and 859 Patagonian toothfish have been released and 29 recaptured since 2001.

The number of tags recaptured in the Ross Sea in 2007 by New Zealand vessels was the highest annual recapture to date and double the number caught in 2006, although the nature of these recaptures suggests that assumptions of homogeneous mixing may need to be investigated. For the first time, long distance movements of Antarctic toothfish were observed from fish tagged by fishing vessels. A total of four fish moved significant distances from the slope fisheries in SSRUs 881H, I and K to Terra Nova Bay in SSRU 881J. There was also some evidence that more fish are recaptured after a longer time at liberty on the slope than in the north.

However, it was noted that data from the 2007 season for the non-New Zealand vessels were incomplete at the time of this analysis and will need to be updated in future analyses.

WG-SAM-07/6

Revised input parameters and implications for the Antarctic toothfish (*Dissostichus mawsoni*) stock assessment in Subareas 88.1 and 88.2. A. Dunn and S.M. Hanchet (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Wellington, New Zealand, a.dunn@niwa.co.nz), 32 pp. (English, unpublished).

This paper addresses a number of aspects of the model inputs and parameters of the Antarctic toothfish stock assessment for the Ross Sea fishery. In particular, catch history, length–weight relationships, catch-at-length and catch-at age are reviewed. In addition, some preliminary model runs that investigate the sensitivity of the 2006 stock assessment to changes in these model inputs and parameters are reported.

Tree-regression methods were used to investigate the areal structure of the length distribution of Antarctic toothfish. While tree-regressions suggested strong evidence of a high degree of small-scale areal complexity, the authors were unable to provide a stratification that resulted in improved or consistent patterns in length frequencies over the duration of the fishery. Including terms for nation, vessel, or vessel type did not provide any additional information as these tended to be highly correlated with the location variables.

The catch and CPUE indices for the Ross Sea Antarctic toothfish fishery were updated, as were some modelling parameters, and methods for calculating age and length frequencies. Most of these changes did not have a significant impact on the assessment results.

An update of the numbers of fish scanned at length by New Zealand vessels, and the numbers of tagged fish recaptured is provided. Inclusion of observations of the 2006 fish recaptured in 2007 had the greatest impact on the assessment model results. Dunn et al. (2007) noted that the locations of the 2007 recaptures were highly aggregated and were mostly located on four key locations in the Ross Sea, and most had moved only short distances. This confirms the concern that the key uncertainty underlying the current model is the impact of movements and spatial structure in the Antarctic toothfish population, in particular, the level and nature of the bias from non-homogeneous mixing assumptions of tagged fish.

WG-SAM-07/7

Comparison of estimators of effective sample size for catch-at-age and catch-at-length data using simulated data from the Dirichlet-multinomial Distribution. S.G. Candy (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, steve.candy@aad.gov.au), 38 pp. *CCAMLR Science*, submitted (English).

The incorporation of 'effective sample size' (ESS) in integrated assessments is an approximate but simple way of modelling the distribution of catch-at-age or catch-at-length frequencies using a multinomial likelihood when there is extra-multinomial heterogeneity in age-class or length-class frequencies. The ESS applied within the definition of the negative log-likelihood contribution to the objective function in CASAL determines the implicit weight given to the commercial catch-at-age or catch-at-length frequency data relative to the other types of data used in integrated assessments of toothfish stocks. An appropriate and accurate estimate of the ESS for catch-frequency data for each fishery and fishing year is therefore important for such assessments and this issue is studied using simulation. Between-haul heterogeneity within fishing year was simulated using samples from the Dirichlet-multinomial (D-M) distribution with marginal class probabilities generated using a simple age-structured model incorporating fishing selectivity. Either between-year 'process' or 'systematic' error in these probabilities was also generated by varying one of the selectivity function parameters across years randomly or linearly respectively. Five alternative methods of estimation of effective sample size were compared using this simulation model. Two existing methods are based on the lack-of-fit of predictions of class probabilities using

aggregate year-level frequencies. The other three estimators use the haul-level frequencies, including a method based on a conditional profile maximum likelihood estimate of the D-M dispersion parameter. This last method generally gave the best estimator of an ESS that is appropriate for haul-level heterogeneity with another of the haul-level methods giving similar estimates. The year-level methods gave very inaccurate estimates of this ESS when process error variance was set to zero with relative mean square error an order of magnitude worse than the best two haul-level methods. When process error was incorporated one of the year-level methods gave reduced estimates of ESS. An appropriate distributional model that incorporates process error in addition to haul-level heterogeneity while giving a marginal variance relationship which allows an ESS to be defined, does not appear to be available, so heuristic arguments and simulation results are used to discuss the issue of estimating ESS in the presence of process error. It is shown that care should be taken to avoid year-to-year model lack-of-fit due to systematic deviations in observed versus predicted class frequencies being mistaken for process error and used to reduce the ESS inappropriately.

WG-SAM-07/8

Proposed methodology for the assessment of the exploratory fishery for *Dissostichus* spp. on BANZARE Bank (Division 58.4.3b). D.C. Welsford, A.J. Constable and G.B. Nowara (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, dirk.welsford@aad.gov.au), 11 p. (English, unpublished).

In 2006 the CCAMLR Scientific Committee noted several features of exploratory *Dissostichus* fisheries in the southern Indian Ocean (Subarea 58.4) which gave cause for concern as to the status of the resource in this area, and the lack of a scientific basis for setting catch limits in this area (SC-CAMLR-XXV, paragraphs 4.184 to 4.192).

In its management advice for this and other exploratory fisheries, the Scientific Committee requested urgent consideration by Members of methods for collecting data and assessing these stocks.

A methodology to assess the BANZARE fishery is outlined, including:

- identification of grounds through analysis of spatial patterns in catch and effort;
- construction of standardised CPUE series for each ground;
- de Lury/Leslie analysis of standardised CPUE of *Dissostichus* and major by-catch groups to provide initial estimates of biomass and rates of depletion in each ground until such time as they can be improved;
- estimation of the proportion of the stock which can be harvested (γ) to satisfy the CCAMLR decision rules.
- analysis of relative catch rates of by-catch groups and target species.

The input data for this assessment are the C2 catch and effort data held by CCAMLR for the fishery in this division since it began in 2003/04.

The results presented in this paper indicate that this methodology will produce an improved understanding of the trends in this fishery and greatly assist in developing management advice for the stocks of *Dissostichus* and major by-catch species on BANZARE Bank.

The authors welcome recommendations from WG-SAM as to the most productive way forward to an assessment for this division to be considered at CCAMLR-XXVI.

WG-SAM-07/9

Update of the Antarctic toothfish stock assessment for the Ross Sea by means of the TSVPA separable cohort model. D. Vasilyev, K. Shust, V. Babayan and T. Bulgakova (VNIRO, 17a V. Krasnoselskaya, Moscow 107 140, Russia, antarctica@vniro.ru), 10 pp. (English, unpublished).

An updated Antarctic toothfish (in the Ross Sea) stock assessment was carried out by means of the TISVPA model (2006 data on catch-at-age and CPUE, and the data on tag recaptures were included). All three sources of information taken separately (and together) indicate historical increases in stock biomass, possibly due to development (broadening) of the fishery. The results show that, according to the Constable and de la Mare (1996) decision rules, annual catches of 23 000 tonnes are appropriate.

WG-SAM-07/10

Extension of the development of a management procedure for the toothfish (*Dissostichus eleginoides*) resource in the Prince Edward Islands vicinity. A. Brandão and D.S. Butterworth (Marine Resource Assessment and Management Group (MARAM), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa, doug.butterworth@uct.ac.za), 26 pp. (English, unpublished).

Three Operating Models (OMs) reflecting an 'Optimistic', an 'Intermediate' and a 'Pessimistic' current status for the toothfish resource in the Prince Edward Islands region are developed which take account of the different selectivities of past longline and pot fisheries. These models are used for trials of a candidate Management Procedure (MP) which could provide future catch limit recommendations for this resource. The MP uses two data sources: the recent trend in longline CPUE and the mean length of the catches made. This MP provides encouraging performance over the wide range of scenarios considered, increasing catches substantially if the resource is above MSYL, while increasing more slowly if the resource is heavily depleted while nevertheless securing stock increase with high probability.

WG-SAM-07/11

Preliminary assessment of the South Georgia ray populations. D.J. Agnew, R. Mitchell, T. Carruthers, J. Roberts, R. Hillary and J. Pearce (Department of Biology, Faculty of Life Sciences, Imperial College, Prince Consort Road, London SW7 2BP, United Kingdom, d.agnew@imperial.ac.uk), 19 pp. (English, unpublished).

The ray population at South Georgia was modelled using a surplus production model implemented in a Bayesian framework. Catch and CPUE data were reconstructed for the time series 1985–2006 from a variety of sources, and included the consideration that since 2004 the practice of cutting rays off lines at the water surface should have increased survivorship of discarded rays, although this survivorship has been found to decrease as depth of fishing increases. This analysis was concentrated on catches deeper than 800 m, and it was assumed that the majority of catches were of the *Amblyraja* variant species previously described.

The assessment indicated that the data were informative with respect to carrying capacity but not with respect to *r*, the intrinsic rate of growth of the ray population. The authors chose a conservative, low value of *r* thought to be representative of long-lived rajids, but conducted sensitivity tests with higher and lower values. The assessment suggests that the level of mortality currently experienced by the population is sustainable, and that currently the population is well above Bmsy. Whilst current catches appear not to be significantly impacting the ray population, trends to deeper-water fishing and increasing numbers of autoliners (whose catch rates of rays is greater than Spanish gear longliners) should continue to be observed closely. Future analyses should make use of the increasing accuracy and duration of CPUE data and the results of an ongoing mark–recapture experiment for rays at South Georgia.

WG-SAM-07/12

A spatial multi-species operating model of the Antarctic Peninsula krill fishery and its impacts on land-breeding predators. É.E. Plagányi and D.S. Butterworth (Marine Resource Assessment and Management Group (MARAM), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa, eva.plaganyi-lloyd@uct.ac.za), 34 pp. (English, unpublished).

An updated version of the Spatial Multi-species Operating Model (SMOM) of krill–predator–fishery dynamics is described. This has been developed in response to requests for scientific advice regarding the subdivision of the precautionary catch limit for krill among 15 small-scale management units (SSMUs) in the Scotia Sea, to reduce the potential impact of fishing on land-based predators. SMOM has been revised from the original version presented in Plagányi and Butterworth (2006a) in three main ways: (i) accounting for seasonality; (ii) explicitly modelling fish and whales in addition to penguin and seal predators; and (iii) addition of an alternative movement model based on the results from the OCCAM model.

This modelling framework provides an example of a method for bounding some of the uncertainty associated with multi-species models used for management. Results are presented as probability envelopes rather than in point estimate form, giving a truer reflection of the uncertainty inherent in outcomes predicted on the basis of multi-species models, as well as highlighting how such probability envelopes could be narrowed given improved data on key parameters such as survival. Results are useful for evaluating different spatial allocations of krill catches. An example is given of how such a framework can be used to develop a management scheme which includes feedback through management control rules.

WG-SAM-07/13

An assessment strategy evaluation framework for testing the application of a CASAL-based management system to the HIMI fishery. I.R. Ball and S.G. Candy (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, ian.ball@aad.gov.au), 100 pp. (English, unpublished).

A useful way of testing assessment methodology and related decisions is through the framework of management strategy evaluation and the simpler form of assessment strategy evaluation. Such a framework uses an operating model of the system, to generate data against which the assessment system, or the entire management system can be evaluated against a number of suitably chosen performance measures. This paper defines the term 'Assessment Strategy Evaluation (ASE)' and provides a practical framework for carrying out such an evaluation. The framework is implemented in the R programming language and the technical details and decisions made in the formulation of this framework are included in this paper. Initial testing of this framework with respect to the Patagonian toothfish (*Dissostichus eleginoides*) fishery in Division 58.5.2 is described.

WG-SAM-07/14

Rationale, structure and current templates of the Ecosystem, Productivity, Ocean, Climate (EPOC) modelling framework to support evaluation of strategies to subdivide the Area 48 krill catch limit amongst small-scale management units. A. Constable (Antarctic Climate and Ecosystems Cooperative Research Centre and the Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@aad.gov.au), 33 pp. (English, unpublished).

Since 2002, the Working Group on Ecosystem Monitoring and Management (WG-EMM) has been undertaking a work program to develop a management procedure for krill fisheries. To date, this has primarily focussed on subdividing the region-wide krill catch limit in the southwest Atlantic into small-scale management units through a number of workshops. Computer simulations are being used by WG-EMM to evaluate the costs and benefits to

achieving conservation and fishery objectives of the six different strategies for undertaking the subdivision. This paper further elaborates the Ecosystem Productivity, Ocean, Climate (EPOC) modelling framework. In particular, it outlines the general considerations for designing a simulation environment for evaluating the strategies for subdividing the krill catch limit and, on the basis of these considerations, provides an update of the conceptual structure of EPOC and outlines the templates developed for EPOC to facilitate this work.

WG-SAM-07/15
Lenfest Ocean Program Workshop 'Identifying and Resolving Key Uncertainties in Management Models for Krill Fisheries'. Letter from the organisers, 7 pp. (English, unpublished).

Working Group on Ecosystem Monitoring and Management

WG-EMM-07/4
CEMP indices: 2007 update. CCAMLR Secretariat, 113 pp. (English, unpublished).

The CCAMLR Ecosystem Monitoring Program (CEMP) uses indices derived from data on indicator species collected by standard methods in the three Integrated Study Regions of the Convention Area. Each year the Secretariat updates the standardised index values and provides a summary of trends and anomalies in these data. This report covers predator indices only.

Data were submitted by eight Members for 10 sites and 13 different CEMP parameters for the 2006/07 season. No data were submitted from Ross Island, however, counts from aerial photographs are being undertaken. Data were collected from Esperanza Station, but were lost in a fire on board the icebreaker *Irizar*.

The development of an ordination method, with guidance from WG-EMM and consultation with experts, remains a main priority for future work.

WG-EMM-07/5
Krill fishery report: 2007 update. CCAMLR Secretariat, 26 pp. (English, unpublished).

As reported to the CCAMLR Secretariat, five vessels from three Contracting Parties are fishing for krill in Area 48 in the 2006/07 season, and these vessels have taken 61 876 tonnes of krill to date. Two CCAMLR scientific observers have been deployed. The preliminary estimate of the total catch of krill for the season is approximately 111 746 tonnes. This compares with 106 589 tonnes of krill reported in the STATLANT data for 2005/06. With the exception of the Republic of Korea and Poland, all Contracting Parties have submitted complete sets of haul-by-haul data for 2005/06. Fine-scale data from the Republic of Korea for 2004/05 are still overdue. The Secretariat has contacted both Korea and Poland.

The report includes: availability of fishery and observer data; time series of catch by season, Contracting Party and small-scale management unit; species composition of by-catch; occurrence of incidental catches of seabirds and mammals; development of measures of overlap between the krill fishery and krill predators; consideration of conservation measures in force in the fishery. Reference information on stock and areas, and parameters used in stock assessments are also included.

WG-EMM-07/7

Interaction between oceanography, krill and baleen whales in the Ross Sea and adjacent waters, Antarctica, in 2004/05. M. Naganobu, S. Nishiwaki, H. Yasuma, R. Matsukura, Y. Takao, K. Taki, T. Hayashi, Y. Watanabe, T. Yabuki, Y. Yoda, Y. Noiri, M. Kuga, K. Yoshikawa, N. Kokubun, H. Murase, K. Matsuoka and K. Ito (National Research Institute of Far Sea Fisheries, 2-12-4 Fukuura, Kanazawa-ku, Yokohama, Kanagawa, 236-8648 Japan, naganobu@affrc.go.jp), 52 pp. *CCAMLR Science*, submitted (English).

A joint survey of the RV *Kaiyo Maru* and the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) was carried out to study the interactions between oceanographic conditions, and the distribution of krill as prey and baleen whales as predators in the Ross Sea and its adjacent waters, Antarctica, in the austral summer of 2004/05. Results indicated close interactions between the thermal conditions, krill and baleen whale distributions. The oceanography of the surface layer was summarised as an oceanographic environmental index that integrated the mean temperature from 0 to 200 m in depth (ITEM-200). Distribution of ITEM-200 was used as background information for comparing with distribution patterns of each species. Antarctic krill (*Euphausia superba*) mainly distributed in the Antarctic Surface Water (ASW) area (ITEM-200 = 0 to –1°C) and extended in the Shelf Water (SW) area (less than ITEM-200 = –1°C). Ice krill (*E. crystallorophias*) clearly distributed in SW but not ASW. Humpback whales (*Megaptera novaeangliae*) mainly distributed in the Antarctic Circumpolar Current (ACC) waters with high density around ITEM-200 = 0°C near the southern boundary of ACC and their distribution slightly extended in ASW. Antarctic minke whales (*Balaenoptera bonaerensis*) mainly distributed in ASW and SW with a high density around ITEM-200 = –1°C in the continental shelf slope frontal zone. The interaction between distributions of krill and baleen whales with ITEM-200 could yield quantitative information to identify the boundary of distributions of Antarctic krill and ice krill for biomass estimations using acoustic data in the surveys. Finally, a conceptual model of interaction between oceanography relating water mass and circulation pattern of the oceanic surface layer with ITEM-200 was summarised, as well as the distribution and abundance of krill and baleen whales.

WG-EMM-07/8

Demography of Antarctic krill and other Euphausiacea in the Lazarev Sea in winter 2006. V. Siegel, M. Haraldsson, M. Vortkamp, L. Würzberg and S. Schöling (Institute of Sea Fisheries, Johann Heinrich von Thunen-Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries, Palmaille 9, 22767 Hamburg, Germany, volker.siegel@ish.bfa-fisch.de), 13 pp. (English, unpublished).

A standardised krill net sampling survey was conducted in the Lazarev Sea (CCAMLR Subarea 48.6) in mid-austral winter during July/August 2006. During the survey period the entire survey area was completely covered with seasonal pack-ice. Fifty-four RMT samples were taken along three transects south of 60°S. Krill and other Antarctic Euphausiacea species densities were estimated from RMT net samples. Size and maturity stage composition and spatial distribution were analysed. Distribution and density of krill calyptopis and furcilia larvae are provided for the Lazarev Sea.

WG-EMM-07/9

The state of Antarctic krill (*Euphausia superba*) fisheries in Statistical Area 48 (Subareas 48.1 and 48.2) in 2006. V.A. Bibik and N.N. Zhuk (YugNIRO, 2 Sverdlov Street, Kerch 98300, Ukraine, krill@kerch.net, island@crimea.com), 12 pp. (English, unpublished).

Based on data collected by YugNIRO scientific research assistants on the fisheries cruise of the FV *Konstruktor Koshkin* in Subareas 48.2 and 48.1 from February to May 2006, the

authors analyse the state of fishable krill biomass in areas where fishing and exploratory operations are conducted, and provide descriptions of hydrometeorological and ice conditions in addition to biological data on krill.

WG-EMM-07/10

Time and energy budgets during winter for gentoo penguins (*Pygoscelis papua*) in the South Shetland Islands. J.T. Hinke (Marine Biology Research Division, Scripps Institution of Oceanography, UC San Diego, La Jolla, CA 92093, USA and Antarctic Ecosystem Research Division, Southwest Fisheries Science Center, La Jolla, CA 92037, USA, jhinke@ucsd.edu), 22 pp. (English, unpublished).

Time and energy budgets during winter of gentoo penguins (*Pygoscelis papua*) from two breeding colonies in the South Shetland Islands were studied with data from archival temperature tags. Foraging trip durations tracked light availability throughout the winter and exhibited mainly diel and diurnal patterns. Lower variation in trip duration among individuals in early winter suggests that gentoo penguins use all available daylight to maximise time spent foraging prior to the mid-winter period. Increased variability in late winter trips may be related to differences in local resource availability. Air temperature and wind regime helped predict the seasonal cycle in trip duration but not trip frequency. Daily energetic requirements exhibited a seasonal cycle with a mid-winter minimum. Using a daily time budget to estimate energy budgets may improve estimates of consumption requirements of gentoo penguins. Future work during winter will benefit from increased sample sizes, geolocation of sample birds, continued use of tagging technologies to determine activity budgets, and complementary data collection on diets and metabolic rates to refine estimates of consumption.

WG-EMM-07/11

Chinstrap penguins alter foraging and diving behaviour in response to krill size. A.K. Miller and W.Z. Trivelpiece (Antarctic Ecosystem Research Division, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, aileen.miller@noaa.gov), 27 pp. (English, unpublished).

Penguins may exhibit plasticity in their diving and foraging behaviours in response to changes in prey availability. Chinstrap penguins are dependent predators of Antarctic krill in the Scotia Sea region. Both the sizes of krill found in penguin diets and acoustic estimates of krill biomass have fluctuated in recent years. The diet of chinstrap penguins at Livingston Island, South Shetland Islands was therefore examined in relation to their diving and foraging behaviour using time-depth recorders (TDRs) over five seasons: 2002–2006. When krill were smaller, chinstrap penguins often exhibited a shift to deep dives after sundown, and then resumed their shallower pattern at sunrise. These night-time dives were unexpectedly deep (up to 110 m) and mean night-time depths sometimes exceeded those from the daytime. The average annual size of krill was negatively correlated to the number of penguins foraging on fish, mean night-time dive depths, and the proportion of foraging trips occurring overnight. Based on these patterns, it is suggested that when krill were small, penguins foraged more on myctophid fish. The average krill size was negatively correlated to the time chinstrap penguins spent foraging which suggests that penguins made this switch to fish with a cost: more time was spent at sea foraging.

WG-EMM-07/12

Trends and relationships between atmospheric tele-connections and Upper Circumpolar Deep Water (UCDW) influence on phytoplankton biomass around Elephant Island, Antarctica. C. Reiss, O. Holm-Hansen and C.D. Hewes (Antarctic Ecosystem Research Division, Southwest Fisheries Science Center, La Jolla, CA 92037, USA, christian.reiss@noaa.gov), 20 pp. (English, unpublished).

Using 18 years of hydrographic data collected during austral summers from 1990–2007, the influence of atmospheric tele-connections on water column properties and phytoplankton biomass around Elephant Island (EI), Antarctica were examined. The influence of Upper Circumpolar Deepwater (UCDW) was indexed by calculating the mean temperature of the water at the 27.6 kg m^{-3} isopycnal across all stations sampled around EI. There was a strong negative correlation ($r = –0.61$, $p < 0.001$) between the index of UCDW and the strength of the El Niño 3.4 (EN34) index. No linear secular trend was observed, however, a significant unimodal pattern was found suggesting long-term decadal scale variability was also captured in our study. In contrast to other areas along the West Antarctic Peninsula, local phytoplankton biomass was not correlated to the influence of the UCDW, although a high EN34 index was related to low phytoplankton biomass. Instead, phytoplankton biomass was positively correlated with both upper mixed layer (UML) temperature, and the UML depth. Stepwise regression showed that UML temperature not UML depth was correlated with the variability in mean phytoplankton biomass over the 18 year time series. Macro-nutrient (NO_3^- and SiOH) concentrations were positively correlated to the EN34 index. The results here indicate that both ENSO event scale forcing and long-term trends in atmospheric forcing influence UCDW in the vicinity of the Elephant Island region of the South Shetland Islands. Further, it is shown that the collapse of phytoplankton productivity during El Niño is likely the result of a deepening UML and lower temperatures, not a decline in nutrients.

WG-EMM-07/13

Protocol for aerial censusing of Weddell seals as an EMM protocol. D. Ainley, D. Siniff, R. Garrott and P. Wilson (HT Harvey and Associates, San Jose, CA 95118, USA, dainley@penguinscience.com), 5 pp. (English, unpublished).

Weddell seals (*Leptonychotes weddellii*) have proved to be an important predator of Antarctic toothfish (*Dissostichus mawsoni*). As there is no ecosystem monitoring program currently in place with respect to the Ross Sea toothfish fishery, a means to begin such a program is offered here. Described are procedures, based on a 40-year dataset from McMurdo Sound, to begin to monitor the population trajectories of Weddell seals along the Victoria Land coast, all of which likely forage in CCAMLR SSRUs 881H and J.

WG-EMM-07/14

Short note on time series of Drake Passage Oscillation Index (DPOI) and its influence on environmental variability. M. Naganobu and K. Kutsuwada (National Research Institute of Far Sea Fisheries, 2-12-4 Fukuura, Kanazawa-ku, Yokohama, Kanagawa, 236-8648 Japan, naganobu@affrc.go.jp), 6 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, Argentina, and Base Esperanza, 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). Significant correlations between krill recruitment and DPOI were found.

Additionally, a time series of DPOI from January 1952 to March 2006 was calculated. In addition, a comparison between DPOI and oceanographic condition using CTD data from 1990 to 2004 was attempted. As a result, DPOI had a strong correlation with the averaged temperature of the surface layer (ITEM-200). DPOI suggests an influence on the variability of oceanic condition and thus on the Antarctic krill ecosystem.

WG-EMM-07/15

Long-term forecast of the conditions of krill (*Euphausia superba* Dana) fisheries in the Antarctic part of the Atlantic Ocean. V.A. Bibik and V.A. Bryantsev (YugNIRO, 2 Sverdlov Street, Kerch, 98300, Ukraine, krill@kerch.net, island@crimea.com), 7 pp. (English, unpublished).

It is shown that it would be possible to make long-term forecasts of CPUE (tonnes per hour) for Antarctic krill, the principal indicator of krill abundance and density of krill concentrations in the areas around the South Shetland and South Orkney Islands and South Georgia, applying the following factors: average annual level of solar activity, speed of the Earth's rotation and its derivatives.

The relationships between these elements can be explained as follows. It has been asserted that anomalies in the solar activity index are inversely related to the recurrence of zonal atmospheric transfer. The latter is directly related to the index of krill abundance in the first of the abovementioned areas and inversely related to this index in the second and third of the abovementioned areas. Therefore, based on the above, zonal transfer leads to the formation of concentrations of crustaceans in gyres on the South Orkney and South Georgia shelves, whereas longitudinal transfer is predominant in the South Shetland Island area.

WG-EMM-07/16

Analysis of scientific observer data from the *Saga Sea*, 2006–2007. P. Orr, J. Hooper, D. Agnew, J. Roe, G. Doherty and A. Pryor (Department of Biology, Faculty of Life Sciences, Imperial College, Prince Consort Road, London SW7 2BP, United Kingdom, d.agnew@imperial.ac.uk), 18 pp. (English, unpublished).

UK observers were present during all fishing operations of the Norwegian flagged *Saga Sea* from June 2006 to June 2007. This paper presents an initial analysis of the krill and fish by-catch sampled. Although a reasonably large number of continuous and conventional trawls were undertaken, the distribution of these trawls in time and space was not random. The vessel tended to fish with one trawl type for a number of weeks or months before changing, for operational reasons to the other type. This did not create an ideal sampling environment for comparing the performance of the two types of trawls. There did not appear to be a consistent difference between the size of krill caught by conventional and continuous trawls deployed by the *Saga Sea*. Sampling of larval fish was unfortunately not sufficiently comprehensive to allow a robust analysis of larval fish by-catch data. However, the results to date suggest that catch rates of larval fish on the *Saga Sea* are similar to those reported for conventional trawls.

WG-EMM-07/17

Investigations of krill transport factors in localised areas in the Scotia Sea: variability of krill distribution on the fishing grounds due to the effect of krill transport. S.M. Kasatkina and V.N. Shnar (Atlantic Research Institute of Marine Fisheries and Oceanography (AtlantNIRO), 5 Dmitry Donskoy Street, Kaliningrad 236022, Russia; ks@atlant.baltnet.ru), 17 pp. (English, unpublished).

The authors examine certain SSMUs by the example of SOW (South Orkney West) and SGW (South Georgia West), analysing variability of krill transport and distribution

characteristics in particular areas within these SSMUs. Data from regular Russian acoustic surveys accompanied by trawl and CTD samples form the basis of this work.

It is shown that repeated replacements of the water masses in each of the study areas were associated with a 'pulse' pattern of krill transport, i.e. krill transport across polygon boundaries occurs in an irregular manner. Here it is important to note not only the pulse pattern of changes in biomass (in our case, $CV_{biomass}$ = 57%), but also the observed changes in krill aggregation patterns resulting in the irregular transport of krill biomass (in our case, $CV_{swarms/mile^2}$ = 63%). Thus, the irregular transport of krill biomass resulted in aggregations of differing commercial importance being transported into the fishing grounds. This has been confirmed by the correspondent dynamic of the actual operational statistics of fishing fleet.

The authors come to the conclusion that the temporal and spatial changes of krill transport factors in relation to the dynamics of krill distribution indices and trawler operational indices in various areas of the Scotia Sea should be taken into consideration for the development of krill stock management procedures. Simulation of such complex processes in ecosystem models (KPFM2, SMOM, EPOC), developed for testing options of krill precautionary catch allocation among SSMUs, is possible only on the basis of the actual data describing annual and seasonal variability of krill biomass and aggregation characteristic distribution patterns in SSMUs due to transport processes. If this were not the case, the preliminary results of the analyses would be insufficiently substantiated to form the basis for management decisions.

WG-EMM-07/18

A balanced trophic model of the ecosystem of the Ross Sea, Antarctica, for investigating effects of the Antarctic toothfish fishery. M.H. Pinkerton, S.M. Hanchet and J. Bradford-Grieve (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Wellington, New Zealand, m.pinkerton@niwa.co.nz), 23 pp. (English, unpublished).

This paper reports on the development of a mass balanced carbon-budget trophic model of the Ross Sea with which to investigate effects of the fishery for Antarctic toothfish (*Dissostichus mawsoni*). A survey of the available literature provided an initial set of parameters describing the abundance (seasonal and spatial where possible), energetics (growth, reproduction, consumption), and trophic linkages (diets, predators) for major groups of biota. The level of uncertainty on these parameters was also estimated. The Ross Sea is a low primary production system, with high seasonal, spatial and interannual variability in primary production. In the relative absence of krill, Antarctic silverfish (*Pleuragramma antarctica*) and mesozooplankton (mainly copepods) are probably the major middle-trophic level link between primary production and the larger predators, though the role of cepahlopods in the system is poorly known. A number of demersal fish species (including *Macrourus whitsoni*, *Bathyraja eatonii*, *Chionobathyscus dewitti*, *Antimora rostrata* and *Chionodraco hamatus*) are present, but their abundances and feeding characteristics are not well known. Toothed and baleen whales visit the Ross Sea in summer in relatively large numbers. Adélie and emperor penguins have breeding colonies along the Victoria Land coast, and petrels, skuas and albatrosses are seasonal visitors. Weddell, crabeater, leopard and Ross seals are also present in summer, and some may stay in the region year-round.

The trophic model was balanced by adjusting the initial set of parameters obtained from the literature and available datasets. A novel objective method of adjustment that takes into account estimates of parameter uncertainty, and appropriately handles the huge range of magnitude (>5 orders of magnitude) in trophic flows between different groups of organisms is presented. Biomass, production rates, consumption rates and diet fractions are adjusted simultaneously. Ecotrophic efficiency was set to unity for all non-primary producers. Changes to the initial set of parameters needed to obtain balance were significant: up to 62% (biomass, production, consumption) and 40% (diet fractions). The balanced model presented here has not yet been validated and should be considered a work in progress. The current

version of the trophic model suggests that Antarctic toothfish have the potential to exert considerable predation pressure on some species of demersal fish. More information on demersal fish abundance is required to validate this result. Information on what the various species of demersal fish consume is needed to estimate the potential for trophic cascades due to the toothfish fishery. The significance of toothfish in the diets of predators (especially Weddell seal, type-C killer whale, sperm whale) are low in the model, but the model does not consider sub-populations of predators, or localised dependencies on toothfish as prey. More complete information on the abundances, diets, and population structures of top predators in the Ross Sea are needed to investigate these potential effects.

WG-EMM-07/19

Stable isotope analysis of Southern Ocean fish tissue samples to investigate trophic linkages of Antarctic toothfish (*Dissostichus mawsoni*). M.H. Pinkerton, S. Bury, S.M. Hanchet and D. Thompson (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Wellington, New Zealand, m.pinkerton@niwa.co.nz), 27 pp. *CCAMLR Science*, submitted (English).

Flesh tissue samples were collected by scientific observers on board New Zealand fishing vessels during the 2005/06 season in the Ross Sea (CCAMLR Subarea 88.1) in order to investigate trophic links between toothfish and demersal fish. Muscle samples were collected from: Antarctic toothfish (TOA – *Dissostichus mawsoni*) n = 142; Patagonian toothfish (TOP – *D. eleginoides*) n = 2; Whitson's grenadier (WGR – *Macrourus whitsoni*) n = 107; icefish (CHW – *Chionobathyscus dewitti*) n = 48; blue antimora (ANT – *Antimora rostrata*) n = 103; moray cod (MRL – Muraenolepididae) n = 1. Samples were lipid extracted, and analysed to determine C and N stable isotope composition. Values of $\delta^{15}N$ and $\delta^{13}C$ suggested that a minimum of three trophic levels exists between icefish occupying the lowest trophic level, and Antarctic toothfish occupying the highest level. Some Antarctic toothfish sampled in this study occupied a similar trophic level according to their $\delta^{15}N$ signatures to killer whales and Weddell seals in McMurdo Sound, bluefin tuna in the Atlantic, and sperm whales from the Gulf of Mexico. There was high variance in $\delta^{15}N$ and $\delta^{13}C$ values for each of the species sampled, on the order of 3–4‰ for $\delta^{15}N$ (which equates to one trophic level) and 4‰ for $\delta^{13}C$ (suggesting multiple primary sources of organic matter). For each species where sufficient data exist (TOA, ANT, CHW, WGR), a stepwise generalised linear model was used to identify significant relationships between the two dependent variables, $\delta^{15}N$ and $\delta^{13}C$, and four variables: location (SSRU), fish length, sex and depth. Location and a positive relationship with fish length were usually the only variables identified as significant. The isotope data agrees with previous work that the diet of the Antarctic toothfish varies with location, but the spatial patterns are not clear. Positive relationships between length and $\delta^{15}N$ indicates that larger fish consume prey of a higher trophic level than smaller fish, which may be due to ontogentic changes in diet, and/or progressive consumption of larger individuals of the same species with age. There was significant residual variance in $\delta^{15}N$ and $\delta^{13}C$ values for each of the species sampled. Applying typical isotope fractionation factors for one trophic level (+0.4 for $\delta^{15}N$, and +3.4 for $\delta^{13}C$) allowed plotting of 'prey polygons' for SSRUs 881C, H and I. Antarctic toothfish generally lay outside the prey polygons implying that the isotopic composition of tissue of the predator was not explained by the isotopic composition of prey sampled in that area. This may be due to: (i) variability in isotopic ratios within species and SSRU; (ii) uncertainty in trophic fractionation (in both C and N) between trophic levels; (iii) missing prey items (probably Antarctic silverfish, smaller fish species, crustaceans and squid); (iv) movement since formation of the muscle (number of years). The work

reported here is very much a preliminary analysis of the data. Further analysis of the data and further sampling (including more prey species, simultaneous stomach and stable isotope analysis, and multiple tissue sampling) to investigate these factors is planned.

WG-EMM-07/20

Developments, considerations and recommendations by the land-based predator survey correspondence group: a second summary and update. C. Southwell, P. Trathan, W. Trivelpiece, M. Goebel and P. Wilson (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, colin.southwell@aad.gov.au), 3 pp. (English, unpublished).

This paper briefly summarises deliberations of the predator survey correspondence group since 2006. In particular, some general principles for estimating predator demand are outlined, and draft terms of reference for a workshop in 2008 are presented.

WG-EMM-07/21

The relationship between sea-ice cover and Adélie penguin reproductive performance at Béchervaise Island. L. Emmerson and C. Southwell (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, louise.emmerson@aad.gov.au), 18 pp. (English, unpublished).

The relationship between Adélie penguins and ice is undeniable, with ice influencing penguin populations through a variety of processes operating at different spatial and temporal scales. The Smith et al. (1999) conceptual model of Adélie penguin population growth incorporates the relationship between sea-ice and penguin populations based on data from multiple sites to predict the likely outcome of population growth in response to a reduction in the frequency of heavy sea-ice years. However, it is difficult to generalise the predictions from the model because penguin–ice interactions vary according to the form of sea-ice present, the season in which it is present and the processes that such sea-ice influences, such as primary productivity or foraging trip duration. To further explain the relationship between sea-ice and Adélie penguin reproductive performance, the relative importance of various attributes of sea-ice on breeding success at Béchervaise Island is investigated.

WG-EMM-07/22

Information on krill in reports from the CCAMLR Scheme of International Scientific Observation and its utility for management. J. Foster, S. Nicol and S. Kawaguchi (Institute of Antarctic and Southern Ocean Studies, University of Tasmania, Private Bag 77, Hobart 7001, Tasmania, Australia), 19 pp. (English, unpublished).

A preliminary analysis of the 32 reports submitted under the CCAMLR Scheme of International Scientific Observation revealed that there are a number of inconsistencies in the information being reported. Few reports have been submitted each year with a maximum of eight submitted in 2005. Very little information is reported from seasons other than winter. The areas being observed are heavily biased to Subarea 48.3. Information on fishing gear suggests great differences between vessels. Aspects of operational procedures are reported sporadically and inconsistently. Similarly, because of the differences in the information reported in individual observer reports it is difficult to assess the level of by-catch of larval fish or of vertebrates. Suggestions for changes to the observer reports are made to reduce ambiguities. Consistent reporting of observer information, and comprehensive observer coverage in the krill fishery, appear to be the only way to achieve the aims of the scheme.

WG-EMM-07/23

Scientific requirements for an orderly development of the krill fishery. A. Constable, G. Slocum and S. Nicol (Department of Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@aad.gov.au), 10 pp. (English, unpublished).

At CCAMLR-XXV Australia presented the results of the BROKE-West acoustic krill biomass survey. These were used by the Scientific Committee to recommend to the Commission a revised precautionary catch limit for krill in Division 58.4.2 of 1.49 million tonnes (up from 450 000 tonnes). During the Commission's deliberations on this issue, Australia noted that, while the scientific data supported the large increase in the precautionary catch limit, such a large increase required the inclusion of other elements in the conservation measure to facilitate the orderly and precautionary development of the fishery. The aim of this paper, which Australia committed to present to this year's WG-EMM, is to outline the scientific requirements related to the orderly development of the krill fishery, and to provide justification for why they are important. Not all of the requirements outlined below are required to be established immediately, however, at a minimum there needs to be mechanisms developed to ensure that they are in place prior to any problems arising in the fishery. The rationale for the timing of these requirements is also provided.

The paper recommends that in keeping with the precautionary approach, steps need to be taken to establish when, relative to the scale of the fishery, different arrangements need to be set in place. The following is recommended for ensuring the orderly development of the krill fishery:

(i) Undertake krill stock surveys in areas with no precautionary catch limits in order to establish a catch limit before fishing is prosecuted in these areas.

(ii) Establish small-scale management units to minimise localised impacts on krill predators prior to a threshold being reached, where the threshold is determined as the magnitude of catch that, if it were taken from one location, would avoid impacting on the predators dependent on that location for food, and allow for the reasonable development of the fishery.

(iii) Establish a threshold capacity for the fishery relative to the catch limits (small- or large-scale spatial limits) such that the capacity (effort) of a fishery should not expand beyond what might be just enough to take the catch limit for a given area until the system for managing the catch limits is in place.

(iv) Develop a program to monitor and observe krill catch and by-catch, with methods for minimising by-catch in krill fisheries developed early (if they are needed) so that satisfactory low-levels of by-catch are achieved from the outset.

WG-EMM-07/24

Ecological risk management and the fishery for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea, Antarctica. M.H. Pinkerton, A. Dunn and S.M. Hanchet (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Wellington, New Zealand, m.pinkerton@niwa.co.nz), 22 pp. (English, unpublished).

Ecological risk management is increasingly being applied to marine fisheries worldwide as an aid to developing management strategies to avoid, mitigate, or manage adverse outcomes. Risk management encompasses four major steps: recognition of risk; assessment of risk; development of strategies to avoid, mitigate, manage or tolerate risk; and monitoring of risk. In this paper, the development of an ecological risk assessment for the Antarctic toothfish (*Dissostichus mawsoni*) longline fishery in the Ross Sea, Antarctica, is begun. It is proposed that, by defining risks and quantifying potential impacts, the limited research and management resources can be prioritised so as to meet the objectives of Article II of CCAMLR. Risks are considered in four categories:

1. Target species harvest: risks of depletion of Antarctic toothfish to below a level that ensures stable recruitment.
2. By-catch species harvest: risks of depletion of other harvested species to below a level that ensures stable recruitment.
3. Ecosystem impacts: risks of changes to the marine ecosystem relationships due to the removal of harvested and by-catch species.
4. Exogenous effects: risks of change in the marine ecosystem due to, or exacerbated by, exogenous effects (e.g. the introduction of alien species, effects of associated activates on the ecosystem, and effects of environmental change).

The assessment of risk is based on combining the likelihood of an adverse outcome occurring and the consequence should it occur. Numerical models, such as stock or ecosystem mass-balance models can provide insights into these factors for some risks. In addition, semi-quantitative and qualitative estimates are needed because of a lack of knowledge and inability to predict the future dynamics of some parts of the system. It is also recognised that some risks (e.g. impacts of climate change) may not be able to be well predicted. The uncertainty arising from the complexity of the system and external factors acting on it means that risk management and ongoing monitoring will be required to ensure that the fishery is managed according to the conservation principles of Article II of CCAMLR.

WG-EMM-07/25

Interim protocol for fish/fish larvae by-catch observation in krill fishery. S. Kawaguchi (Department of Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, so.kawaguchi@aad.gov.au), 11 pp. (English, unpublished).

This interim protocol has been developed in cooperation with UK and Japanese colleagues/operators/observer coordinators in response to these recent requests by the CCAMLR Scientific Committee (SC-CAMLR, 2006). The purpose of developing this protocol is to standardise the larval fish by-catch observation among observers and vessels so that it can be used later for quantitative analysis. The fish identification can also be verified by CCAMLR fish experts by using systematically archived images. It is also designed so that the data can be validated later by using randomly kept samples by the Flag States. This protocol will be used only for fish and larval fish by-catch observation, and therefore the rest of the observation must be undertaken using the usual CCAMLR *Scientific Observers Manual*. This manual was distributed to all krill fishing nations for use in the 2006/07 fishing season.

WG-EMM-07/26

CCAMLR scientific observation: tasks, priorities and time budget. S. Kawaguchi (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, so.kawaguchi@aad.gov.au), 10 pp. (English, unpublished).

The workload of the tasks required in the CCAMLR *Scientific Observers Manual* is assessed. The total time needed for the minimum amount of daily routine tasks was well above the capacity that an observer can undertake. The manual must be structured in its entirety so that the observer, only by following instructions in the manual, can produce the report and logbook data which are collected systematically and allow CCAMLR to achieve its objectives.

WG-EMM-07/27

Analysis of krill fishery behaviour in the southwest Atlantic: potential signals for moving fishing activities amongst SSMUs. S. Kawaguchi, A. Constable and S. Nicol (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, so.kawaguchi@aad.gov.au), 20 pp. *CCAMLR Science*, submitted (English).

This paper outlines the difference in fishing patterns between regions (subareas) and seasons by analysing CPUE (catch per hour) patterns towards the end of vessels' sets of operations before leaving an SSMU, as well as its timing of the day, diurnal pattern of CPUE and fishing depth. Vessels tend to move between SSMUs frequently in summer, especially in SSMUs in Subarea 48.1, mostly spending less than a day to explore the fishing grounds from multiple options for the start of the fishing season. Vessels move around less frequently in Subarea 48.2 during the summer season because of only one viable SSMU, but in autumn, there appears to be some opportunistic fishing on the way from Subarea 48.1 to 48.3. Continuous operations in a single SSMU are longer later in the fishing season, especially for the winter operation in Subarea 48.3, but are forced to be relatively short in Subarea 48.1 due to changing ice conditions etc. Skippers tend to allow a day to decide before leaving an SSMU after days of continuous operations. This behaviour suggests there are two types of tactics employed within an SSMU. The first set of tactics is to optimise factory supply. When factory supply diminishes, the skipper may initiate a second set of pre-departure tactics over one day to determine if factory supply can be regained. CPUE and towing depth generally showed clear diurnal patterns. It was not possible to outline vessel patterns of pumping methods due to the small amount of data accumulated so far. More detailed data is needed to improve these analyses and models in the future.

WG-EMM-07/28

Size selectivity of the RMT8 plankton net and a commercial trawl for Antarctic krill. V. Siegel (Institute of Sea Fisheries, Johann Heinrich von Thunen-Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries, Palmaille 9, 22767 Hamburg, Germany, volker.siegel@ish.bfa-fisch.de), 9 pp. *CCAMLR Science*, submitted (English).

Net selection of the scientific RMT8 plankton net and a commercial-sized pelagic trawl has been studied. Selection curves indicate that krill length classes smaller than 20 mm are underrepresented in the RMT8. For the commercial trawl with a liner mesh size of 12 mm, length classes smaller than 35 and 45 mm are undersampled, probably depending on the size composition of the catch. A preliminary study on krill damaged during trawling operations indicates an effect on trawling duration and total catch per haul.

WG-EMM-07/29

Histopathology of Antarctic krill (*Euphausia superba*) bearing black spots. S. Miwa, T. Kamaishi, T. Matsuyama, T. Hayashi and M. Naganobu (Inland Station, National Research Institute of Aquaculture, 224-1 Hiruta, Tamaki, Mie, 519-0423 Japan, miwasat@affrc.go.jp), 18 pp. (English, unpublished).

In Antarctic krill (*Euphausia superba*) sampled by a Japanese scientific observer on board a krill fishing vessel in the winters of 2003 and 2006 in the South Georgia region, approximately 2–5% of sub-samples of 100 krill bore small black spots. The black spots were most often found on the cephalothorax of the body. Three bacteria were isolated from these black spots, and classified into either Psychrobacter or Pseudoalteromonas by the sequences of 16S rRNA genes. Histological observations revealed that the black spots were melanised nodules. A single melanised nodule often contained more than one type of morphologically distinct bacterial cell. More than three bacterial species or strains were also confirmed by *in situ* hybridisation for 16S rRNA. The melanised nodules were almost always

accompanied by a tumour-like mass of unknown large heteromorphic cells, which seemed to be derived from a gonadal tissue. These results suggest that krill were affected by bacterial infections, whereas the presence of multiple bacterial species suggests that the infections were likely to be secondary. The development of the tumour-like cell mass in the gonad may be the primary condition, although this requires further detailed study.

WG-EMM-07/30 Rev. 1

CCAMLR-2000 revisited. D.A. Demer, A.M. Cossio and C.S. Reiss (Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, david.demer@noaa.gov), 17 pp. *CCAMLR Science*, submitted (English).

The total abundance of krill in the Scotia Sea was estimated from an international echosounder and net survey (CCAMLR-2000) to be 44.3 million tonnes (CV = 11.4%), prompting the Antarctic Treaty's Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) to revise the precautionary catch level for krill in the area from 1.5 to 4 million tonnes (SC-CAMLR, 2000). By incorporating recent improvements in the remote identification and target strength (TS) of krill, a range of krill biomass was estimated, 108.0 million tonnes (CV = 10.4%) to 192.4 million tonnes (CV = 11.7%), depending solely on the expected distribution of krill orientations. The new methods were then reviewed by CCAMLR, and revised protocols based on the Stochastic Distorted Wave Born Approximation (SDWBA) model were adopted. Here, the protocols are applied to again reanalyse the CCAMLR-2000 data. Using the 120 kHz echosounder data, the resulting estimates of krill biomass in the Scotia Sea are 197.78 million tonnes (CV = 11.06%) and 37.29 million tonnes (CV = 21.20%), depending on whether two or three frequencies are used for krill identification respectively. At 38 kHz, estimates of krill biomass range from 65.64 million tonnes (CV = 11.50%) to 10.39 million tonnes (CV = 15.25%); and at 200 kHz from 343.09 Mt (CV = 12.91%) to 38.73 Mt (CV = 14.86%). CCAMLR uses the estimates derived from the 120 kHz data. Results of the three-frequency method are likely less biased owing to better rejection of non-krill species; also the patchiness of krill is better elucidated, resulting in higher CVs. Thus, the revised estimates of krill biomass in the Scotia Sea during the CCAMLR-2000 Survey are 37.29 million tonnes (CV = 21.20%), or 15.8% lower than the original estimate, but with a larger CV.

WG-EMM-07/31

2007 krill biomass update of the South Shetland and Elephant Island regions of Area 48. C.S. Reiss and A.M. Cossio (US AMLR Program, Southwest Fisheries Science Center, La Jolla, CA 92037, USA, christian.reiss@noaa.gov), 13 pp. (English, unpublished).

Antarctic krill biomass trends in the South Shetland Island region of Area 48 are presented. Updated time series using the Stochastic Distorted Wave Born Approximation, and a dynamic ΔS_v krill delineation model are used to derive krill biomass. This paper provides updated (through summer 2007) acoustic biomass estimates previously presented at the 2006 WG-EMM meeting in Namibia (WG-EMM-06/32). In 2007, biomass in the South Shetland Islands region exceeded 19 million tonnes. This increase from <500 000 tonnes in 2006 represents the largest biomass recorded in nearly 20 years and a 50% increase over the peak observed in 2003. Biomass comprised 1, 2 and 3+ year-old krill, suggesting either a large recruitment event was not captured in surveys conducted in 2005 or 2006, or that advection from elsewhere is responsible for the recent increase.

WG-EMM-07/32

A guide to identification of fish caught along with the Antarctic krill. T. Iwami and M. Naganobu (Laboratory of Biology, Tokyo Kasei Gakuin University, Japan, iwami@kasei-gakuin.ac.jp), 29 pp. (English, unpublished).

A field key to early life stages of Antarctic fish caught along with the Antarctic krill is produced. The key includes eight families and 28 species mainly from the Atlantic sector of the Southern Ocean and uses distinguished characters which permit rapid field identification. In some cases, however, it is impossible to discriminate among species of the same family by distinguished characters. A species key is not shown for such a look-alike species and a brief summary of the main morphological features of species and genera is provided.

WG-EMM-07/33

Distribution and abundance of Antarctic krill (*Euphausia superba*) off East Antarctic (30–80°E) in January–March 2006. T. Jarvis, N. Kelly, E. van Wijk, S. Kawaguchi and S. Nicol (Southern Ocean Ecosystems Program, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, toby.jarvis@aad.gov.au), 32 pp. (English, unpublished).

Multifrequency echosounder data were collected during the 2006 BROKE-West summer survey of Division 58.4.2 for the purposes of estimating the unexploited biomass (B_0) of Antarctic krill (*Euphausia superba*) and its associated coefficient of variance (CV). This paper updates the version submitted to WG-EMM in 2006 (WG-EMM-06/16) because a reanalysis of the data has resulted in amendments to the acoustic estimates of krill mean biomass density, biomass and variance. The mean acoustic biomass density of krill, integrated to 250 m depth across the entire survey stratum (1.31 million km^2), was 9.48 g m^{-2}. B_0 was estimated to be 12.46 million tonnes with a CV of 15.15%. Krill were widely distributed at relatively low densities throughout the survey area; only 13% of the 2-km-alongtrack echo-integration intervals were devoid of krill, 50% of intervals registered densities of 1 g m^{-2} of krill or less, and 80% of intervals registered densities of 10 g m^{-2} or less. Mean densities were highest in the waters to the south of the southern boundary of the Antarctic Circumpolar Current, particularly in waters to the west which were within the influence of the Weddell Gyre. Half of the cumulative density across the survey was found within 120 km of the 1 000 m isobath (the shelf break/slope), and 40% within 50 km. This was mostly due to very high densities (up to 1 400 g m^{-2}) around the shelf break on three of the 11 transects surveyed. The majority of acoustic krill detections were in the top 100 m of the water column, centred around 50 m depth. The krill distributions inferred from both the acoustic data and from net catches were considered in the context of the physical oceanography, from which a case is presented for the subdivision of Division 58.4.2 into smaller, more biologically homogeneous areas. A qualitative critical appraisal of the methods is included by way of contribution to ongoing discussions about acoustic survey and analysis methods for krill.

WG-EMM-07/34 Rev. 1

Community structure of epipelagic macrozooplankton in the Ross Sea. Y. Watanabe, S. Sawamoto, T. Ishimaru and M. Naganobu (Tokyo University of Marine Science and Technology, 4-5-7 Konan, Minato, Tokyo, 108-8477 Japan, naganobu@affrc.go.jp), 9 pp. (English, unpublished).

During the ninth research cruise of the RV *Kaiyo Maru*, macrozooplankton samples were collected from three layers between the surface and 200 m with RMT8 along the three longitudinal lines in the Ross Sea and neighbouring waters. Biomass and abundance (number of individuals) were 0 ~ 32.1 g 1 000 m^{-3} and 1.8 ~ 2 314.3 inds 1 000 m^{-3} along 175°E line, 1.6 ~ 23.7 g 1 000 m^{-3} and 226.4 ~ 3 224.0 inds 1 000 m^{-3} along 180°, and

0.1 ~ 8.5 g 1 000 m^{-3} and 46.8 ~ 619.7 inds 1 000 m^{-3} along 170°W. Biomass and abundance were extremely low at stations on the continental shelf along 175°E and 170°W except the southernmost station located at 78°S 175°E. A total of 13 taxa occurred at all stations and a mean of 7.4 taxa occurred in each sample. There was no marked difference in numbers of taxa occurring at each station and layer except at 0 ~ 50 m of 72°S 175°E, where euphausiids only occurred. Copepods and chaetognaths dominated north of 72°S, while pteropods and euphausiids occurred as well south of 72°S along 175°E. Pteropods comprised a high percentage of the total abundance at the southernmost stations along 175°E and 170°W. Stations and layers were categorised into four major groups by cluster analysis based on taxonomic composition. Group 1 comprised of stations with a bottom depth of deeper than 1 000 m (north of 72°S along 175°E) and group 2 to 4 on the continental shelf. The latter three groups are characterised by copepods + chaethognaths + euphausiids, pteropods + euphausiids and pteropods. These were overlapped geologically with different group(s) at different layer(s).

WG-EMM-07/P1

Seabird research at Cape Shirreff, Livingston Island, Antarctica, 2006/07. R. Orben, S. Chisholm, A. Miller and W.Z. Trivelpiece. *AMLR 2006/2007 Field Season Report*.

Our tenth season of seabird research at Cape Shirreff allowed us to assess trends in penguin population size, as well as interannual variation in reproductive success, diet and foraging behaviour. The gentoo breeding population has decreased marginally from the previous season and is the third lowest population size in the 10 years of census data. The number of diet samples containing fish was the highest ever and comparable to the first six years of the study. Unlike 2005/06, 18% of the gentoo penguin diet samples contained juvenile krill. Fledgling success and fledgling weights were slightly below the nine year means for these parameters at our study site.

The chinstrap penguin breeding population has been declining for the past seven years and is at its lowest size in the 10 years of study. Chinstrap penguins ate mainly Antarctic krill, with a strong component of juvenile krill in their diet samples. Juvenile krill were also plentiful in the chinstrap penguin's diets in the 1997/98 and 2002/03 seasons. The mean foraging trip duration during chick-rearing was approximately one hour longer than in 2005/06. The data collected, using the PTTs and TDRs, on foraging location and diving behavior should assist us in interpreting the foraging trip data. Fledgling success and chick fledging mass in 2006/07 were higher than both last season and the past 10-year mean.

WG-EMM-07/P2

Cycles of *Euphausia superba* recruitment evident in the diet of Pygoscelid penguins and net trawls in the South Shetland Islands, Antarctica. A. Miller and W. Trivelpiece. *Polar Biol*., (in press).

Size and sex of Antarctic krill taken from chinstrap and gentoo penguin diet were compared to those from scientific net surveys in the South Shetland Islands from 1998–2006 in order to evaluate penguin diet as a sampling mechanism and to look at trends in krill populations. Both penguin diet and net samples revealed a 4–5 year cycle in krill recruitment with one or two strong cohorts sustaining the population during each cycle. Penguin diet samples contained adult krill of similar lengths to those caught in nets; however, penguins rarely took juvenile krill. Penguin diet samples contained proportionately more females when the krill population was dominated by large adults at the end of the cycles; net samples showed greater proportions of males in these years. These patterns are comparable to those reported elsewhere in the region and are likely driven by the availability of different sizes and sexes of krill in relation to the colony.

WG-EMM-07/P3

Insights from the study of the last intact neritic marine ecosystem. D. Ainley. 2007. *Trends in Ecology & Evolution*, 22 (9): 444–445.

Frank, K.T. et al. (2007: *Trends Ecol. Evol*. 22, 236–242) provide interesting analysis, after compiling information from 19 subregions, on how the exploited shelf ecosystems of the North Atlantic are structured, either by predation (top down) or resource availability (bottom up), depending on their biodiversity and climate (cold vs warm). By the ecological 'rules' laid out, the Ross Sea should be structured by predation. Analysis has shown, however, that some portions of the Ross Sea follow the rules but others do not. This is apparent, though, only because the Ross Sea, unlike the remaining Southern Ocean and other portions of the World Ocean, remains at least for now, intact. If its whales, flightless seabirds, seals and large predatory fish had been severely reduced, as in the North Atlantic, bottom-up structuring likely would prevail.

WG-EMM-07/P4

The Antarctic toothfish: how common a prey for Weddell seals? P.J. Ponganis and T.K. Stockard. 2007. *Ant. Sci*., 19 (4): 441–442.

Reported herein are observations of Weddell seals (*Leptonychotes weddellii*) feeding on Antarctic toothfish (*Dissostichus mawsoni*) in McMurdo Sound, Antarctica, during 2001–2003 austral summers. In addition to past reports of isolated toothfish captures, the frequency of these observations and the quantity of toothfish captured lead us to suggest that this species is a significant prey item for Weddell seals, and that the recent development of a toothfish fishery in the Ross Sea may have broader impacts than expected. This is especially important in the McMurdo Sound region as toothfish are probably common (as evidenced by more than 30 years of sustained research projects on that toothfish population).

WG-EMM-07/P5

Learning about Antarctic krill from the fishery. S. Kawaguchi and S. Nicol. 2007. *Ant. Sci*., 19 (2): 219–230.

Antarctic krill has been studied for many decades, but we are still long way from understanding their biology to be able to make reliable predictions about the reaction of their populations to environmental change. This is partly due to certain difficulties in relation to logistics, operations and survey design associated with scientific surveys that have been obstacles for us to better understand krill biology. The krill fishery is the largest fishery in the Southern Ocean, continuously operating since early 1970s. Recent studies revealed its potential to be used as a unique source for scientific discussions to understand krill biology. In this paper, after a brief overview of krill fishery operation and krill biology, we examine how current data collection through the fishery operation could contribute to a greater understanding of krill biology, and then suggest future priorities for fisheries-related research in relation to recent changes in the Southern Ocean environment.

WG-EMM-07/P6

Male krill grow fast and die young. S. Kawaguchi, L.A. Finley, S. Jarman, S.G. Candy, R.M. Ross, L.B. Quetin, V. Siegel, W. Trivelpiece, M. Naganobu and S. Nicol. *Mar. Ecol. Prog. Ser*. (in press).

The size-differentiated sex ratio (proportion of males: POM) of Antarctic krill was examined with an extensive dataset derived from scientific surveys in the Indian Ocean sector and the southwest Atlantic sector, and from the krill fishery in the Southern Ocean. The percentage of males in size classes of adult krill was generally high in krill of 30–35 mm total length, always low in 38–42 mm krill, sometimes showed higher values in 45–50 mm krill, but always decreased in the largest krill (>50 mm). This pattern was reproduced by a model

simulation that assumed faster growth and a shorter lifespan for males when compared to females. These results suggest that the numbers of males should decline with time unless new recruits enter the population. Indeed, interannual variations in the proportion of males from the field (net collected data and penguin diet data) showed a decline in proportion of males when several years of low recruitment followed a recruitment pulse. These results lead us to conclude that male krill grow faster and have a shorter lifespan than females in the natural environment.

WG-EMM-07/P7

Setting management goals using information from predators. A.J. Constable. 2006. In: Boyd, I., S. Wanless, C.J. Camphuysen (Eds). *Top Predators in Marine Ecosystems: their Role in Monitoring and Management*. Cambridge University Press, Cambridge: 324–346.

This paper is a published book chapter examining how goals and reference points might be set for higher trophic levels – such as marine mammals, birds and fish. It briefly explores the general characteristics of objectives for higher trophic levels within the context of ecosystem-based management, noting that the emphasis for managing the effects of human activities on higher trophic levels is biased towards fisheries-based approaches rather than approaches that take into account the maintenance of ecosystem structure and function. Following this, the precautionary approach developed in the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) for taking account of higher trophic levels in setting catch limits for target prey species is described. The last section considers indicators of the status of predators with respect to establishing target and limit/threshold reference points that can be used directly for making decisions. These indicators include univariate indices summarising many multivariate parameters from predators, known as composite standardized indices, as well as an index of predator productivity directly related to lower trophic species affected by human activities.

WG-EMM-07/P8

Spatial and temporal operation of the Scotia Sea ecosystem: a review of large-scale links in a krill centred food web. E. J. Murphy, J.L. Watkins, P.N. Trathan, K. Reid, M.P. Meredith, S.E. Thorpe, N.M. Johnston, A. Clarke, G.A. Tarling, M.A. Collins, J. Forcada, R.S. Shreeve, A. Atkinson, R. Korb, M.J. Whitehouse, P. Ward, P.G. Rodhouse, P. Enderlein, A.G. Hirst, A.R. Martin, S.L. Hill, I.J. Staniland, D.W. Pond, D.R. Briggs, N.J. Cunningham and A.H. Fleming. 2007. *Phil. Trans. R. Soc. B*, 362: 113–148.

The Scotia Sea ecosystem is a major component of the circumpolar Southern Ocean system, where productivity and predator demand for prey are high. The eastward-flowing Antarctic Circumpolar Current (ACC) and waters from the Weddell–Scotia Confluence dominate the physics of the Scotia Sea, leading to a strong advective flow, intense eddy activity and mixing. There is also strong seasonality, manifest by the changing irradiance and sea ice cover, which leads to shorter summers in the south. Summer phytoplankton blooms, which at times can cover an area of more than 0.5 million km^2, probably result from the mixing of micronutrients into surface waters through the flow of the ACC over the Scotia Arc. This production is consumed by a range of species including Antarctic krill, which are the major prey item of large seabird and marine mammal populations. The flow of the ACC is steered north by the Scotia Arc, pushing polar water to lower latitudes, carrying with it krill during spring and summer, which subsidize food webs around South Georgia and the northern Scotia Arc. There is also marked interannual variability in winter sea ice distribution and sea surface temperatures that is linked to southern hemisphere-scale climate processes such as the El Niño–Southern Oscillation. This variation affects regional primary and secondary production and influences biogeochemical cycles. It also affects krill population dynamics and dispersal, which in turn impacts higher trophic level predator foraging, breeding

performance and population dynamics. The ecosystem has also been highly perturbed as a result of harvesting over the last two centuries and significant ecological changes have also occurred in response to rapid regional warming during the second half of the twentieth century. This combination of historical perturbation and rapid regional change highlights that the Scotia Sea ecosystem is likely to show significant change over the next two to three decades, which may result in major ecological shifts.

WG-EMM-07/P9

Monitoring and management in the Antarctic – making the link between science and policy. K. Reid. 2007. *Ant. Sci*., 19 (2): 267–270.

Management of human impacts in the Antarctic requires an effective system of monitoring to provide information about the process being managed and the effectiveness of management actions. Human impacts arise as a result of processes that originate in the region (endogenous) and those that originate outside the region (exogenous). A number of monitoring programmes have been established in both terrestrial and marine systems to measure impacts that arise as a result of endogenous process such as fishing, tourism and research. However, most of this monitoring is surveillance monitoring, which is not linked to a specific management objective, and does not produce quantitative metrics that can be assessed and compared to agreed targets. However, defining such target levels for the Antarctic, where the aim is to minimise human impacts, is a complex process. Although potential analogues for target setting exist in other parts of the world these are generally insufficiently precautionary to be applied in the Antarctic. The challenge for scientists and policymakers working in the Antarctic is to provide quantitative measures, with agreed trigger levels, and to develop appropriate monitoring schemes to manage human impacts in the future.

WG-EMM-07/P10

Circumpolar connections between Antarctic krill (*Euphausia superba* Dana) populations: Investigating the roles of ocean and sea ice transport. S.E. Thorpe, E.J. Murphy and J.L. Watkins. 2007. *Deep-Sea Res*., I, 54: 792–810.

Antarctic krill, *Euphausia superba* Dana, has a heterogeneous circumpolar distribution in the Southern Ocean. Krill have a close association with sea ice which provides access to a critical food source and shelter, particularly in the early life stages. Advective modelling of transport pathways of krill have until now been on regional scales and have not taken explicit account of sea ice. Here we present Lagrangian modelling studies at the circumpolar scale that include interaction with sea ice. The advection scheme uses ocean velocity output from the Ocean Circulation and Climate Advanced Modelling (OCCAM) project model together with satellite-derived sea ice motion vectors to examine the potential roles of the ocean and sea ice in maintaining the observed circumpolar krill distribution. We show that the Antarctic Coastal Current is likely to be important in generating the large-scale distribution and that sea ice motion can substantially modify the ocean transport pathways, enhancing retention or dispersal depending upon location. Within the major krill region of the Scotia Sea, the effect of temporal variability in both the ocean and sea ice velocity fields is examined. Variability in sea ice motion increases variability of influx to South Georgia, at times concentrating the influx into pulses of arrival. This variability has implications for the ecosystem around the island. The inclusion of sea ice motion leads to the identification of source regions for the South Georgia krill populations additional to those identified when only ocean motion is considered. This study indicates that the circumpolar oceanic circulation and interaction with sea ice is important in determining the large-scale distribution of krill and its associated variability.

WS-BSO-07/4

Southern Ocean continuous plankton recorder survey: spatial and temporal patterns of variation in zooplankton abundance, distribution and diversity. G.W. Hosie (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, graham.hosie@aad.gov.au), 2 pp. (English, unpublished).

The Southern Ocean Continuous Plankton (CPR) Survey started in 1991, with the purpose of mapping the biodiversity of zooplankton, variation in biodiversity patterns, and to monitor the health of the region by using the sensitivity of plankton to environmental change as early warning indicators. The survey involves Australia, Japan, Germany, New Zealand and Great Britain, and is a SCAR program supported by the Action Group on CPR Research. Spatial, seasonal, annual and long-term variability in plankton patterns are measured through much of the Southern Ocean, especially in relation to the various frontal zones and oceanographic features of the Antarctic Circumpolar Current (ACC). The survey has sampled much of the Southern Ocean from Drake Passage east to the Ross Sea. Most of the Pacific sector, notably the Amundsen and Bellingshausen seas, have not been sampled. The highest concentration of sample is between 60° and 160° E and south of 48°S. CPRs are towed on all voyages of the Australian research supply vessel *Aurora Australis*, from early spring to autumn and occasionally in winter. Tows are routinely towed from the *Shirase, Umitaka Maru, Tangaroa* and *Polarstern*. Tows have also been made from other Japanese research and chartered vessels operating in the Southern Ocean. New transects are being developed by the British Antarctic Survey in the South Atlantic. The CPR is towed behind the ships at a depth of about 10 m. The ships' propeller mixes the top 20 m. Each tow produces approximately 450 n miles (833 km) of continuous plankton data. The SO-CPR dataset comprises abundance data (counts) of zooplankton for 5 n mile sections. Zooplankton species are identified to species or the lowest possible taxon. Developmental stages of euphausiids are included. The dataset currently comprises approximately 20 000 records (sites), with 5 n mile resolution for 200+ species/taxa. All data coupled are time-stamped and geocoded and coupled with some environmental data such as sea-surface temperature and salinity. A number of papers have been published that describe the fine-scale distributions of species and assemblages in relation to the frontal and sub-branches, including season variation (Takahashi et al., 2002; Umeda et al., 2002; Hosie et al., 2003; Hunt and Hosie, 2003, 2005, 2006a, 2006b). This paper reviews the results of those studies and the results of the SO-CPR Survey in general that will be of relevance to the bioregionalisation of the Southern Ocean.

WS-BSO-07/5

Spatial patterns of temporal relationships in the Southern Ocean. M. Kahru and B.G. Mitchell (Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92093-0218, USA, mkahru@ucsd.edu), 9 pp. (English, unpublished).

Phytoplankton production during the austral summer in the Southern Ocean is known to be limited by iron and light. Distributions of satellite-detected chlorophyll-*a* (chl-*a*) show very complex and time-variable patterns that are hard to explain. The covariance between satellite-detected and modelled variables is analysed and it is shown that this covariance in time between the mixed layer depth (MLD), sea-surface temperature (SST) and chl-*a* can be used to map areas where different factors control phytoplankton production. Statistically significant spatial patterns in the covariance between MLD, SST and chl-*a* show that the physical factors controlling phytoplankton production in the Southern Ocean change in a

predictable manner. Well-defined areas exist where phytoplankton is light-limited in summer due to insufficient stratification and where phytoplankton is clearly limited by nutrients (probably iron). The boundary between light limitation and nutrient limitation can be sharp and may be associated with the main hydrographic fronts (e.g. the Sub-Antarctic Front).

WS-BSO-07/6

Marine classification: lessons from the New Zealand experience. B. Sharp, M. Pinkerton and J. Leathwick (New Zealand Ministry of Fisheries, PO Box 1020, Wellington, New Zealand, ben.sharp@vanuatu.com.vu), 22 pp. (English, unpublished).

New Zealand has a considerable body of experience creating spatial classifications of the marine environment, and applying them for management. We assert that recent innovations in multivariate statistical modelling have made possible the combined use of spatially comprehensive environmental data and discontinuous biological data to generate rigorous, objective, data-driven classifications of the Southern Ocean sensitive to ecologically important contrasts, consistent with CCAMLR's ecosystem management mandate. This paper considers a range of methodological options for data-driven marine classification, and reviews the results of three New Zealand classifications to draw methodological and practical lessons relevant to CCAMLR's bioregionalisation of the Southern Ocean.

The following explicit recommendations to the CCAMLR bioregionalisation process are offered: (i) use biological data; (ii) model species individually; (iii) generate a classification based on abundance, not presence–absence; (iv) use the most powerful statistical methods available, such as BRT and GDM; (v) use a hierarchical algorithm; (vi) focus on an environment or community of interest; (vii) include information representing uncertainty.

Some of the inherent limitations of all attempts to represent spatially and temporally dynamic ecosystems using static representations such as produced by marine classifications are highlighted. The authors identify important ecosystem processes that may not be captured by even the best classifications, and warn against uncritical or misinformed application of marine classifications in the management stage. Finally, some practical steps to make marine classifications more 'management-friendly' are highlighted.

WS-BSO-07/7

Use of biological data to inform bioregionalisation of the Southern Ocean. M. Pinkerton, B. Sharp and J. Leathwick (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Kilbirnie, Wellington, New Zealand, m.pinkerton@niwa.co.nz), 48 pp. (English, unpublished).

Innovative multivariate statistical modelling techniques allow modellers to generate spatially comprehensive species distribution layers from discontinuous biological data, by fitting complex and scale-dependent relationships between species abundance and available environmental data. These species-specific layers can then be used in bioregionalisation, for instance by classifying directly on biological data without the need for environmental proxies.

One method, called BRT (Boosted Regression Trees), by which we propose that CCAMLR may wish to generate species layers to inform the bioregionalisation of the Southern Ocean is described. The use of this method is demonstrated by generating 13 taxon-specific and aggregate data layers for pelagic zooplankton using a circumpolar dataset collected by Continuous Plankton Recorder (CPR) and 12 existing or newly derived continuous environmental data layers. The authors also describe other available data that is appropriate for this method and is likely to be important for the CCAMLR bioregionalisation process, e.g. a quantitative circumpolar krill and salp database and various top predator databases.

Biological distribution estimates, compiled from other sources, using other methods are also described. These include 115 marine mammal species layers generated using a semi-

objective Relative Environment Suitability (RES) model, and 33 avian taxa distributions collated from available literature. While perhaps not as rigorous as distributions generated using statistical methods, it is argued that these data constitute the best available information at present, and should not be ignored in the bioregionalisation process.

Finally the authors identify potentially valuable sources of biological data that are currently unavailable but likely to become available in the near future, and advocate the use of 'placeholder' data layers built into the bioregionalisation process, to be replaced as better data becomes available. In this way, CCAMLR can proceed using the best available information at present and still incorporate improved data layers without revisiting methodological or procedural decisions such as those that will be reached by this workshop.

WS-BSO-07/8

A scheme for mapping Antarctic sea-floor geomorphology to aid benthic bioregionalisation. P. O'Brien (Geoscience Australia, GPO Box 378, Canberra 2601, ACT, Australia, phil.obrien@ga.gov.au), 14 pp. (English, unpublished).

Publicly available bathymetry and geophysical data can be used to map geomorphic features of the Antarctic continental margin and adjoining ocean basins at scales of 1:1–5 million. The geomorphic features identified and their properties can be related to major habitat characteristics such as sea-floor type (hard versus soft), ice keel scouring, sediment deposition or erosion and current regimes. Where more detailed data are available, comparisons with the geomorphic features mapped in this study show that they can provide a guide to the distribution in the area of shelf benthic communities. The geomorphic mapping method presented here rapidly provides a layer to add to benthic bioregionalisation using readily available data.

WS-BSO-07/9

Summary fact sheets for bioregionalisation of the Southern Ocean – examples from the Indian Ocean sector (Area 58). K. Martin-Smith, P. O'Brien, B. Raymond and A. Constable (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@aad.gov.au), 23 pp. (English, unpublished).

Fact sheets outlining the physical and biological attributes of selected sectors of the CAMLR Convention Area are presented. An overview of CCAMLR Area 58 (Indian Ocean sector) illustrates bathymetry and major oceanographic features (fronts and sea-ice extent) and describes the findings of the major surveys BROKE and BROKE-West. Subsidiary fact sheets for the George V Land sector and Prydz Bay provide details of bathymetry, physical oceanography, cryosphere, geomorphology and benthic and pelagic biological communities. These fact sheets provide easily accessible summaries of information relevant to the process of bioregionalisation of the Southern Ocean.

WS-BSO-07/10

On biogeographic patterns of benthic invertebrate megafauna on shelf areas of the Southern Ocean Atlantic sector. S.J. Lockhart and C.D. Jones (US Antarctic Marine Living Resources Program, Southwest Fisheries Science Center, 8604 La Jolla Shore Drive, La Jolla, CA 92037, USA, chris.d.jones@noaa.gov), 25 pp. *CCAMLR Science*, submitted (English).

The ideal approach to bioregionalisation of Antarctic and Southern Ocean shelf communities incorporates a range of data on physical, environmental and biological properties, as well as the interaction of these properties. Here, benthic invertebrate megafaunal communities of shelf habitats within the Atlantic sector of the Southern Ocean were analysed quantitatively from scientific survey trawl catches in order to identify and characterise such communities for comparative purposes at a fine spatial scale, with an

ultimate aim of determining broad patterns of distribution. The region for which the greatest complexity of data was available, the northern Antarctic Peninsula and the South Shetland Islands, reveals a two-layered pattern based on the standardised total biomass data and the composition of phyla that contributes to that biomass. In terms of biomass, the shelf area adjacent to the northern part of the Antarctic Peninsula represents an extreme compared to the relatively sparse South Shetland Island shelf. The situation is reversed at each region's easternmost shelves. In terms of composition, the demarcation occurs where the sponge dominated communities most frequently encountered on both shelf systems rather abruptly decline westwards on the shelf north of the South Shetland Islands off western King George. By referencing physical oceanographic data for the region, a pattern of shelf faunal zonation emerges. Patterns of benthic invertebrate biomass are also described for the South Orkney Islands, as well as general patterns of composition at the level of phyla for South Georgia, the South Sandwich Islands and Bouvet Island. These latter regions are generally echinoderm dominated, relative to the hexactinellid sponge dominated northern Antarctic Peninsula region.

WS-BSO-07/11

Bioregionalisation: some key questions and considerations. S. Grant, A. Clarke, P.N. Trathan and H.J. Griffiths (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, susie.grant@dsl.pipex.com), 6 pp. (English, unpublished).

Bioregionalisation is a process to classify data on a range of environmental, biological and ecological attributes, resulting in a spatial framework that can be used as a planning tool for conservation and sustainable resource use. The success of this process will be dependent on establishing clear principles and objectives, focused at relevant spatial scales. Bioregionalisation analysis must address a range of technical questions relating to the development and use of appropriate methods and data, however it is important to establish in advance the framework within which this analysis will take place – why it is being undertaken, how and by whom it is intended to be used, and requirements of resolution and scale. This discussion paper outlines some key questions and considerations relating to the context, focus and products of a bioregionalisation analysis.

WS-BSO-07/12

Spatial disposition of euphausiid larvae in relation with the Weddell-Scotia Confluence. E. Marschoff, D. Gallotti, G. Donnini and N. Alescio (Instituto Antártico Argentino, Ministerio de Relaciones Exteriores, Commercio Internacional y Culto, Cerrito 1248, 1010 Buenos Aires, Argentina, marschoff@dna.gov.ar), 8 pp. (English, unpublished).

This paper reports on the work being conducted at the Insituto Antártico Argentino on the relationship between euphausiid larvae and oceanic features. The working hypothesis is that dispersion centres (Makarov et al., 1990; Marschoff, 1996) located at the Polar Front, East Wind Drift and coastal currents are responsible for the retention of euphausiid species, which differ in their temperature tolerances and hatching depths. These two characteristics seem to be enough to explain their varying ranges.

The hypothesis predicts that an upwelling of *Euphausia superba* should exist at the Weddell-Scotia Confluence, which in turn would imply that the youngest surface larvae should be found in relation to this front. A series of transects across the Confluence have been analysed using two measures of the age of larvae in a sample: median stage of Calyptopes present and size of Calyptopis I.

While a formal statistical analysis is under way, preliminary results seem to confirm the existence of an upwelling of early larvae of *E. superba* in relation to the Weddell-Scotia Confluence.

The upwelling of larvae means that a significant fraction of the offspring of adult populations in the Weddell Gyre contributes to the abundance of krill in the Scotia Sea. Probably, this contribution is much larger than the quantities that may flow with surface water after reaching the surface in the gyre. Thus, small variations in the upwelling at the Weddell-Scotia Confluence would result in large changes in the krill population in the Scotia Sea.

WS-BSO-07/P1

Conserving pattern and process in the Southern Ocean: designing a Marine Protected Area for the Prince Edward Islands. A.T. Lombard, B. Reyers, L.Y. Schonegevel, J. Cooper, L.B. Smith-Adao, D.C. Nel, P.W. Froneman, I.J. Ansorge, M.N. Bester, C.A. Tosh, T. Strauss, T. Akkers, O. Gon, R.W. Leslie and S.L. Chown. 2007. *Ant. Sci*., 19 (1): 39–54.

South Africa is currently proclaiming a Marine Protected Area (MPA) in the Exclusive Economic Zone (EEZ) of its sub-Antarctic Prince Edward Islands. The objectives of the MPA are to: 1) contribute to a national and global representative system of MPAs, 2) serve as a scientific reference point to inform future management, 3) contribute to the recovery of the Patagonian toothfish (*Dissostichus eleginoides*), and 4) reduce the bird bycatch of the toothfish fishery, particularly of albatrosses and petrels. This study employs systematic conservation planning methods to delineate a MPA within the EEZ that will conserve biodiversity patterns and processes within sensible management boundaries, while minimizing conflict with the legal toothfish fishery. After collating all available distributional data on species, benthic habitats and ecosystem processes, we used C-Plan software to delineate a MPA with three management zones: four IUCN Category Ia reserves (13% of EEZ); two Conservation Zones (21% of EEZ); and three Category IV reserves (remainder of EEZ). Compromises between conservation target achievement and the area required by the MPA are apparent in the final reserve design. The proposed MPA boundaries are expected to change over time as new data become available and as impacts of climate change become more evident.

WS-BSO-07/P3

A new approach to selecting Marine Protected Areas (MPAs) in the Southern Ocean. J. Harris, M. Haward, J. Jabour and E.J. Woehler. 2007. *Ant. Sci*., 19 (2): 189–194.

Conservation of the high seas marine environment poses a significant challenge to policy-makers and managers. Marine conservation efforts are often hindered by the lack of data and the difficulties in addressing multiple, and typically conflicting uses. The majority of extant Marine Protected Areas (MPAs) are in coastal or tropical regions within national jurisdiction. Conservation of high seas MPAs has emerged on the international agenda as a critical issue requiring the application of novel approaches, international cooperation and political will. Knowledge and understanding of the marine environment and data on marine biodiversity are all typically limited for the high seas, and the use of surrogates to assist in the identification of areas of high conservation value is one possible mechanism to address and potentially overcome these limitations. Drawing upon a database spanning more than 20 years and containing approximately 140 000 records of seabird sightings at sea, this study assesses the potential use of seabirds as surrogates for marine biodiversity in the Indian sector of the Southern Ocean. At-sea ranges, species diversity and the distributions of endangered species may be appropriate selectors or filters to identify areas with high conservation values. Integrating policy with science provides an appropriate mechanism to identify and prioritise MPAs in the Southern Ocean.

WS-BSO-07/P4

Development of the Southern Ocean Continuous Plankton Recorder survey. G.W. Hosie, M. Fukuchi and S. Kawaguchi. 2003. *Progress in Oceanography*, 58: 263–283.

The Continuous Plankton Recorder (CPR) Type I was first used in Antarctic waters during the 1925–1927 Discovery Expedition, and has been used successfully for 70 years to monitor plankton in the North Sea and North Atlantic Ocean. Sixty-five years later the CPR as a Type II version returned to Antarctic waters when the Australian Antarctic Division initiated a survey of the Southern Ocean on RSV *Aurora Australis* south of Australia and west to Mawson. The objectives are to study regional, seasonal, interannual and long-term variability in zooplankton abundance, species composition and community patterns, as well as the annual abundance and distribution of krill larvae. The survey covers a large area from 60°E to 160°E, and south from about 48°S to the Antarctic coast—an area of more than 14 million km^2. Tows are conducted throughout the shipping season, normally September to April, but occasionally as early as July (midwinter). The large areal and temporal scale means that it is difficult to separate temporal and geographical variation in the data. Hence, CPRs are now also towed on the Japanese icebreaker *Shirase* in collaboration with the Japanese Antarctic programme. *Shirase* has a fixed route and time schedule, travelling south on 110°E in early December and north on 150°E in mid-March each year, and will serve as an important temporal reference for measuring long-term interannual variability and to help interpret the Australian data. Since 1991, over 90 tows have been made, providing over 36 000 nautical miles of records. The most successful seasons to date have been the 1997/98, 1999/2000 and 2000/01 austral summers with 20, 31 and 26 tows respectively. The 1999/2000 season included a unique, nearly simultaneous three-ship crossing of the Southern Ocean along 25° 30'E, 110°E and 157°E. Typical CPR tows show very high abundance of zooplankton in the uppermost 20 m of the permanently open ocean zone between the sea-ice zone and the Sub-Antarctic Front; this is an area thought to be oligotrophic. Appendicularians and small calanoid and cyclopoid copepods dominate the plankton. By comparison the surface waters of the sea-ice zone have low species diversity and abundances. Zooplankton data, and hence distribution patterns, can be time- and geo-coded to GPS data and environmental data collected by the ships' underway monitoring system (e.g. fluorescence, water temperature, salinity, and meteorological data).

WS-BSO-07/P5

The Continuous Plankton Recorder in the Southern Ocean: a comparative analysis of zooplankton communities sampled by the CPR and vertical net hauls along 140°E. B.P.V. Hunt and G.W. Hosie. 2003. *J. Plankton Res.*, 25 (12): 1561–1579.

A repeat transect was run south of Tasmania, along ~140°E, during November and December 2001. NORPAC nets were deployed during a CTD transect on the southern leg, sampling four depth zones at each of 19 stations: 0–20, 20–50, 50–100 and 100–150 m. A Continuous Plankton Recorder (CPR) was deployed on the northern leg (average sampling depth = 10.5 m). Both net systems were harnessed with 270 μm mesh and all sampling was conducted between 47°S and the Southern Polar Front (S-PF) at ~61°S. Zooplankton in the top 150 m of the water column demonstrated strong, small-scale, vertical distribution patterns. Species richness and diversity increased with depth, and were lowest for CPR samples. Conversely, dominance decreased with depth and was highest for CPR samples. Evenness was similar for all sample groups, indicating that all communities had a similar distribution of abundance amongst species. There was little variation in abundance between NORPAC depth zones (average = 82 ± 47 individuals m^{-3}), while abundance was substantially higher in the CPR samples (average = 144 ± 103 individuals m^{-3}), despite it under-sampling fast-moving and delicate components of the plankton community. The higher CPR abundance was due to

significantly higher abundance levels of Appendicularia, *Oithona similis* and *Rhincalanus gigas* nauplii. The NORPAC samples showed that these three taxa were most abundant in the surface waters. The significant increase in abundance in the CPR samples was attributed to the growth in size during the period between the NORPAC and CPR surveys (minimum 15 days) increasing their catchability. Both the NORPAC nets and CPR surveys identified distinct communities to the north and south of the Southern Sub-Antarctic Front. Owing to its shallow towing depth, the CPR focuses on species with surface distributions. Despite under-sampling some components of the zooplankton, the CPR provided sufficient taxonomic resolution to identify biogeographic zones in the Southern Ocean. The utility of the CPR as a long-term monitoring tool in the Southern Ocean is discussed.

WS-BSO-07/P6

Zonal structure of zooplankton communities in the Southern Ocean south of Australia: results from a 2 150 km continuous plankton recorder transect. B.P.V. Hunt and G.W. Hosie. 2005. *Deep-Sea Res*., I, 52 (7): 1241–1271.

The Southern Ocean south of Australia is oceanographically complex, being characterized by double branches of the Sub-Antarctic Front (SAF), Polar Front (PF) and Southern Antarctic Circumpolar Current (SACCF), in addition to the Southern Boundary (SB) of the ACC. From 25 February to 3 March 2002 a 2150-km Continuous Plankton Recorder (CPR) transect was conducted along 140°E, between 47.02°S and 66.36°S, crossing each of these frontal zones. Surface temperature, salinity, and fluorescence were measured at 1-min intervals in conjunction with CPR samples. Additional physical data for the region south of 61°S was provided by nine CTD stations. Multivariate and Indicator Species analysis of the high resolution (~9.2 km) zooplankton samples identified six distinct assemblages which were strongly correlated with frontal/oceanographic zones. These assemblages appeared to be structured by a combination of zonal differences in water mass structure, phytoplankton regimes, and small scale intra-zonal features (e.g. eddies). The northern branch of the SAF was the strongest biogeographic boundary, separating a high proportion of sub-tropical and temperate species from the waters to its south. The study area differed from other sectors of the Southern Ocean in that the northern PF, equivalent to the PF in other sectors, was not a zone of distinct ecological transition. Two of the identified assemblages were located with the seasonal ice zone, south of the northern SACCF. Although *Euphausia superba* larvae were a component of both of these assemblages, this species, together with appendicularia, was most abundant south of the SB. The seasonal ice zone north of the SB was dominated by small copepods (*Oithona similis* and *Ctenocalanus citer*), appendicularia and foraminifera. Although the physical characteristics of the frontal zones can be subtle, the demarcation between zooplankton assemblages was clear. Cross-frontal changes in zooplankton assemblages highlight their role in long-term monitoring programs as indicators of environmental change.

Working Group on
Fish Stock Assessment

WG-FSA-07/6 Rev. 1
A summary of observations on board longline vessels operating within the CCAMLR Convention Area during the 2006/07 season. CCAMLR Secretariat, 24 pp. (English, unpublished).

WG-FSA-07/7 Rev. 1
Summary of observations on board trawlers operating in the Convention Area during the 2006/07 season. CCAMLR Secretariat, 13 pp. (English, unpublished).

WG-FSA-07/8 Rev. 1
A summary of scientific observations related to Conservation Measures 25-02 (2005), 25-03 (2003) and 26-01 (2006). CCAMLR Secretariat, 15 pp. (English, unpublished).

WG-FSA-07/9
Summary of an observation on board a pot vessel operating in the Convention Area during the 2006/07 season. CCAMLR Secretariat, 5 pp. (English, unpublished).

WG-FSA-07/10 Rev. 5
Estimation of IUU catches of toothfish inside the Convention Area during the 2006/07 fishing season. CCAMLR Secretariat, 8 pp. (English, unpublished).

The paper presents an estimate of IUU catches of toothfish during the 2006/07 fishing season, using the standard methodology.

WG-FSA-07/11
Brief report on scientific observation on the fishing vessel *Simeiz* (FAO Statistical Area 41, November 2006 to March 2007). A.K. Zaytsev (YugNIRO, 2 Sverdlov Street, Kerch 98300, Ukraine, zak2006@yandex.ru), 16 pp. (English, unpublished).

Scientific observation was conducted during the commercial trip on the longliner *Simeiz*, operating under the Ukrainian flag, in the southwestern Atlantic Ocean outside the exclusive (marine) economic zones of foreign States (FAO Statistical Area 41) in the period from 7 November 2006 to 2 April 2007. Fisheries for Patagonian toothfish were carried out on two fishing grounds: Scotia Bank (Division 41.3.2) and Patagonian shelf (Division 41.3.1) between 47° and 42°S. Most catches did not exceed 500 kg per longline set. Substantial differences were noted neither in size composition nor in the biological state of fish both in different operating periods and on different fishing grounds.

WG-FSA-07/12
Species profile of mackerel icefish (*Champsocephalus gunnari*). K.-H. Kock and I. Everson (Institute of Sea Fisheries, Johann Heinrich von Thunen-Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries, Palmaille 9, D-22767 Hamburg, Germany, karl-hermann.kock@vti.bund.de), 83 pp. (English, unpublished).

Mackerel icefish (*Champsocephalus gunnari*) has been exploited since the early 1970s and became the target species of fisheries in many parts of the low-Antarctic from 1975 to 1990. Exploitation has been limited to South Georgia and Heard and McDonald Islands since the second half of the 1990s with annual catches of a few thousand tonnes in each of the two areas. Aspects of the biology and exploitation of the species have been summarised in Kock

and Everson (2003) and Kock (2005). Additional information is scattered over various CCAMLR working papers of the last 15 years. The species profile collates existing information on the taxonomy and biology of the species.

WG-FSA-07/13

Autoliners and seabird by-catch: do line setters increase the sink rate of integrated weight longlines? G. Robertson, J. Williamson, M. McNeill, S. Candy and N. Smith (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, graham.robertson@aad.gov.au), 10 pp. (English, unpublished).

Line setters are used with integrated weight (50 g m^{-1} lead core, IW) by some autoline vessels in the Kerguelen and Crozet Islands Patagonian toothfish fisheries to deter seabirds, ostensibly by expediting gear sink rates. A trial was conducted in the Ross Sea in 2007 to determine the effectiveness of line setters in increasing sink rates of IW longlines. Time-depth recorders were deployed along magazines of line set with and without a line setter using a paired treatment design. Sink rates of longlines set with and without a line setter were identical, including in the first few metres of the water column where seabird interactions are likely to be most intense. The results reveal that line setters confer no sink rate advantage to IW longlines. Longlines deployed with a line setter enter the water several metres closer to the stern of vessels, thereby increasing slightly (<0.5 m) the depth of longlines with distance behind vessels. It is doubtful that this small increase in depth will result in substantial reductions in interactions between longlines and seabirds in the Kerguelen and Crozet fisheries.

WG-FSA-07/14

A new fishing gear in the Chilean Patagonian toothfish fishery to minimise interactions with toothed whales with associated benefits to seabird conservation. C.A. Moreno, R. Castro, L.J. Mujica and P. Reyes (Instituto de Ecología y Evolución, Universidad Austral de Chile, Casilla 567, Valdivia, Chile, cmoreno@uach.cl), 25 pp. *CCAMLR Science*, submitted (English).

A new fishing technique, called the Chilean system, adapted from an artisan fishery for Patagonian toothfish is described. The artisan system was modified to include a net sleeve that is placed on secondary vertical lines, which has practically eliminated depredation by killer whales and sperm whales. In addition to this, each 15 m-long vertical line carries a weight at the end, which sinks baited hooks at up to 0.80 m sec^{-1}. This fast sink rate causes the line to sink immediately behind the vessel preventing seabirds from seeing the baited hooks at the surface. Additionally, this system does not reduce CPUE when compared to the traditional Spanish longline system. The performance of this fishing technique with regard to seabird mortality and depredation of sperm whales and killer whales on fish catch rate during the season September–December 2006 in the fishery of the Drake Passage in Chilean waters is evaluated.

WG-FSA-07/15

Line weights of constant mass (and sink rates) for Spanish-rig Patagonian toothfish longline vessels. G. Robertson, C.A. Moreno, E. Gutiérrez, S.G. Candy, E.F. Melvin and J.P. Seco Pon (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, graham.robertson@aad.gov.au), 17 pp. *CCAMLR Science*, submitted (English).

CCAMLR Conservation Measure 25-02 requires Spanish-system longline vessels to attach 8.5 kg weights at 40 m intervals on longlines to minimise interactions with seabirds. The weights are collections of rocks enclosed in netting bags. The netting bags abrade on the

seabed, rocks are lost and weights become progressively lighter, requiring ongoing weighing and repair. This problem can be solved by use of torpedo-shaped steel weights. Steel weights are smaller, lighter for equivalent mass, more hydrodynamic than their rock counterparts and require no maintenance. An experiment was conducted on a chartered Spanish-rig longline vessel to determine the statistical relationship in sink rates of longlines equipped with bags of rocks (4, 6 and 8 kg) and lines with steel weights of equivalent masses. The purpose of the experiment was to provide vessel operators with the option of substituting steel weights for rock weights while remaining in compliance to the sink rates associated with the line weighting requirements of the conservation measure. Both the traditional Spanish method and the newly developed Chilean method (a modified version of the former method to avoid fish loss by toothed whales) were examined in the experiment. Traditional method longlines with 8 kg per 40 m rock weights averaged 0.24 m s^{-1} to 2 m depth, which would be equal to or exceeded by lines with 5 kg steel weights. Sink rates of Chilean method longlines greatly exceeded those of the traditional method, ranging from 0.68 m s^{-1} (4 kg rocks) to 1.41 m s^{-1} (8 kg steel) in the shallow depth ranges. For operational simplicity and to facilitate compliance to the conservation measure irrespective of fishing method, it is recommended that operators be given the option of using either 8.5 kg rock weights or 5 kg torpedo-shaped steel weights.

WG-FSA-07/16

Biomass abundance and distribution of fish in the Kerguelen Islands area (Division 58.5.1). G. Duhamel and M. Hautecoeur (Muséum national d'histoire naturelle, Département des milieux et peuplements aquatiques, UMR 5178, CP 26, 43 rue Cuvier, 75231 Paris Cedex 05, France, duhamel@mnhn.fr), 37 pp. *CCAMLR Science*, submitted (French and English).

A fish biomass survey cruise (POKER 2006) was conducted during spring 2006/07 (September–October 2006) off the Kerguelen Islands (Division 58.5.1), in the northern part of the Kerguelen Plateau. The swept-area method was used in the depth range 100 to 1 000 m with random stratified stations of bottom trawling. Estimates of biomass and abundance are provided for eight commercial species. The total biomass is 245 000 tonnes, half of which is Patagonian toothfish (*Dissostichus eleginoides*) (124 000 tonnes). This biomass is spread over the continental shelf and deep-sea areas. This assessment is as yet incomplete, as four of the species (*D. eleginoides*, *Macrourus carinatus*, *Bathyraja eatonii* and *B. irrasa*) are also found at depths greater than 1 000 m, i.e. the limit of the POKER 2006 survey. Some shelf and slope species (*Champsocephalus gunnari* and *Notothenia rossii*) show low levels of biomass as compared to the results of previous surveys (1987/88, SKALP survey). Other species (*Channichthys rhinoceratus* and *Lepidonotothen squamifrons*) seem to have increased considerably, or even doubled, their biomass during the period between the two surveys. Apart from the commercial species, two species were abundant: *Zanclorhynchus spinifer* on the shelf and *Alepocephalus* cf. *antipodianus* in deep-sea areas. The data on the latter species are new. Analysis of the geographical and bathymetrical distributions of the species leads to the conclusion that concentrations of the common fish species are locally very stable. Cohorts of some species (*D. eleginoides* and *C. gunnari*) were observed in some well-defined sectors. In addition, the survey enabled the distribution of species which are fished commercially or are of particular importance in the ecosystem to be defined or even discovered. This is of undeniable interest for the management and conservation of fish populations in the area.

WG-FSA-07/18

Effect of two natural repellents on the depredation of mackerel baits by white-chinned petrels (*Procellaria aequinoctialis*). N. Gasco and J.P. Pierre (Muséum national d'histoire naturelle, Département des milieux et peuplements aquatiques, UMR 5178, CP 26, 43 rue Cuvier, 75231 Paris Cedex 05, France, nicopec@hotmail.com), 14 pp. (English, unpublished).

Longline fisheries worldwide have impacts that can be harmful or fatal to seabirds. Preliminary testing of potential seabird deterrents in longline fisheries around the sub-Antarctic Kerguelen Islands is reported. A comparison is made of white-chinned petrel (*Procellaria aequinoctialis*) responses to mackerel (*Scomber scombrus*) baits treated with capsaicin and piperine mixtures, and untreated baits. Petrels readily consumed all untreated baits. However, there were significant differences among the six categorised responses to treated baits (capsaicin mixture: $\chi 5 = 161.71$, $P < 0.001$; capsaicin and piperine mixture: $\chi 4 = 114.40$, $P < 0.001$). Petrels rarely immediately swallowed treated baits (1.6% of treated baits), but vigorously 'washed' their bills in water after swallowing treated baits (21.9% of treated baits), manipulated the treated baits prior to swallowing and washing their bills in seawater (27.4%), manipulated then abandoned treated baits (21.9%), and sometimes ignored treated baits completely (27.1%). These results suggest that with further testing and development, treated baits could be effective in reducing seabird attacks on baited hooks, consequently reducing seabird by-catch.

WG-FSA-07/19

Experience with seabird by-catch limits in a trial of longline fishing in the Macquarie Island toothfish fishery. T. Hewitt and I. Hay (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, tara.hewitt@aad.gov.au), 5 pp. (English, unpublished).

The Australian Fisheries Management Authority (AFMA) recently granted a permit for a trial of longline fishing in the Macquarie Island toothfish (*Dissostichus* spp.) fishery, which lies just outside the CAMLR Convention Area. Several threatened seabird species, including albatrosses and petrels, have very small breeding populations on Macquarie Island and are potentially vulnerable to interactions with fishing vessels. The seabird by-catch mitigation measures adopted for the trial included a ban on offal discharge, night-time setting only, use of integrated weight longlines (CCAMLR standard), paired streamer lines and strict seabird by-catch limits.

The seabird by-catch limits categorised seabirds into three groups of species with a different limit for each group. The groupings reflected the varying conservation status of the seabird populations breeding on and foraging around Macquarie Island, and the vulnerability of each species to fisheries interactions. The group containing those species with the most critical conservation status and highest risk of interacting with fishing operations had a by-catch limit of one seabird; limits on the other categories were two and three individuals respectively. In addition, if three seabirds in total from categories 1–3 were killed as a result of interactions with fishing gear, then longline fishing was to cease for the remainder of the season.

WG-FSA-07/20

Educational poster on hook ingestion. G. Robertson (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, graham.robertson@aad.gov.au), 1 p. (English, unpublished).

Since the 2001/02 season CCAMLR has recognised the importance of the high level of hooks discarded in fish heads and ingested by seabirds, especially wandering albatrosses which are large enough to swallow fish heads whole (SC-CAMLR-XXI/BG/7). For example, in 2001/02 the scientific observer on board the FV *Argos Helena* estimated that >15 000 fish

heads were discarded with hooks still in them. The hooks found in albatross colonies at South Georgia in years prior to 2001/02 were of the type used in the regulated fishery in Subarea 48.3 (SC-CAMLR-XXI/BG/7). In 2007, overwintering scientists at Bird Island, South Georgia, have noted an increase in the occurrence of hook injuries to wandering albatrosses. The injuries appear to have two sources – injuries from the ingestion of discarded fish heads and offal, and injuries to birds that appear consistent with interactions during line hauling. This raises once again the importance of actions by CCAMLR to minimise or eliminate the discarding of fish heads containing hooks. CCAMLR-XXI noted the difficulty in getting the message to relevant fishers and indicated that alternative means should be considered. One alternative means would be the production and distribution by CCAMLR of a poster designed to educate fishers of the consequence to seabirds of discharging heads and offal containing hooks. The poster would be located in the processing areas of vessels, carry a simple and clear message, be inexpensive to produce and be produced in the languages spoken by crews. A draft poster will be submitted to ad hoc WG-IMAF for discussion.

WG-FSA-07/21

Biology and distribution of South Georgia icefish (*Pseudochaenichthys georgianus*) around South Georgia and Shag Rocks. S. Clarke, W.D.K. Reid, M.A. Collins and M. Belchier (British Antarctic Survey, Natural Environment Research Council, Biological Sciences Division, High Cross, Madingley Road, CB3 0ET Cambridge, United Kingdom, macol@bas.ac.uk), 37 pp. (English, unpublished).

Pseudochaenichthys georgianus is a member of the unique Channichthyidae family, which lack haemoglobin. The distribution, length-frequency and summer diet are described from 14 bottom trawl surveys undertaken in the austral summers between 1986 and 2006. *Pseudochaenichthys georgianus* (50–590 mm total length) were caught throughout the South Georgia shelf from depths of 76 to 370 m, but very few specimens (<1%) were caught on the Shag Rocks shelf. Multiple cohorts were present during each survey and length-frequency analysis of these cohorts suggests that growth is fast during the first 3–4 years. Stomach contents analysis (2005 and 2006) indicate that *P. georgianus* is a pelagic or semi-pelagic predator, with the summer diet dominated by Antarctic krill (*Euphausia superba*). Fish (channichthyids and notothenids) were also taken, but were a relatively minor part of the diet.

WG-FSA-07/22

Composition and standing stock estimates of finfish from the *Polarstern* bottom trawl survey around Elephant Island and the South Shetland Islands (Subarea 48.1, 19 December 2006 to 3 January 2007). K.-H. Kock, J. Appel, M. Busch, S. Klimpel, M. Holst, D. Pietschok, L.V. Pshenichnov, R. Riehl, S. Schöling (Institute of Sea Fisheries, Johann Heinrich von Thunen-Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries, Palmaille 9, D-22767 Hamburg, Germany, karl-hermann.kock@vti.bund.de), 33 pp. (English, unpublished).

Germany conducted a bottom trawl survey on board the RV *Polarstern* around Elephant Island and the South Shetland Islands from 19 December 2006 to 3 January 2007. Information on species composition, biomass and size composition of the abundant fish species was provided. Estimates of total biomass for Elephant Island and the South Shetland Islands separately as well as biomass overall were provided for *Notothenia rossii*, *N. coriiceps*, *Lepidonotothen larseni*, *L. squamifrons*, *Gobionotothen gibberifrons*, *Champsocephalus gunnari*, *Chaenocephalus aceratus* and *Chionodraco rastrospinosus*. Biomass was found to be much lower than in 2002 and 2003 for *C. gunnari*, *C. aceratus*, *C. rastrospinosus*, *G. gibberifrons*, *L. larseni* and *L. squamifrons* while biomass was found to be higher in *N. coriiceps* around the South Shetland Islands and *N. rossii* in both areas. The

proportion of juvenile *G. gibberifrons* decreased further due to the production of poor year classes since the late 1990s. A concentration of *N. rossii* was found in the same location where aggregations of the species have been detected in 1975/76 and 1977/78 before they were depleted by the commercial fishery. Two concentrations of *N. coriiceps* were encountered in the South Shetland Islands. Given the low stock size of most species, it is recommended that Elephant Island and the South Shetland Islands remain closed for commercial finfishing.

WG-FSA-07/23

Interaction of sperm whales with bottom longlines and the Mammal and Bird Excluding Device (MBED) operation in the Patagonian toothfish (*Dissostichus eleginoides*) fishery in the southwestern Atlantic. O. Pin and E. Rojas (Antarctic Resources Area, National Direction of Aquatic Resources (DINARA), Constituyente 1497, Montevideo, Uruguay CP 11200, opin@dinara.gub.uy), 17 pp. *CCAMLR Science*, submitted (Spanish, English abstract).

This paper describes the interaction between sperm whales (*Physeter macrocephalus*) and the toothfish (*Dissostichus eleginoides*) fishery carried out by longline fishing vessels operating in two different fishing zones at 40º and 50ºS latitudes in the southwestern Atlantic from March to May 2007. In the northern zone (latitude 40º00'S), 62 hauls were performed, while 41 hauls were performed in the southern zone (latitude 50º00'S) at an average depth of 1 282 m. Of the total number of hauls, 57.2% were observed. On board observers recorded: (i) quantity and quality of fish parts remaining in the recovered longline; (ii) presence and number of sperm whales; and (iii) comparative fishing yields with and without sperm whales effective predation. The observations were performed using both, the traditional Spanish longline and a longline with a Mammals and Birds Excluding Device (MBED). The sink rate of the longline with MBED was determined as 1.14 m s^{-1}. In both fishing zones, sperm whale presence was observed in 77.4% of the total observed sets and the effective predation was determined in 22.6% with MBED. Effective predation was determined in 44% of observed sets during the day from 1200 h to 1800 h GMT. Lips and buccal parts were observed in 71% of sets with traditional longline and in 27% with MBED. The estimated fishing yields of northern and southern zones were 11.05 kg $hour^{-1}$ and 15.53 kg $hour^{-1}$ respectively, using the MBED and taking into account effective predation by sperm whales. In the southern zone the fishing yield increased to 23.03 kg $hour^{-1}$, using MBED, but without evidence of effective sperm whale predation. No incidental mortality of birds was registered using both tori line and MBED simultaneously, in spite of the remarkable abundance of the southern black-browed albatross (*Thalassarche melanophrys*) and Cape petrel (*Daption capense*) in 40.76% and 23.13% of total observed sets respectively.

WG-FSA-07/24

Mercury concentrations of five species of Antarctic fish collected from CCAMLR Subareas 88.1 and 88.2. S.M. Hanchet, D.M. Tracey, A. Dunn, P.L. Horn and N. Smith (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, s.hanchet@niwa.co.nz), 18 pp. (English, unpublished).

The mean mercury level for the *Dissostichus eleginoides* 1998 samples was 0.43 mg kg^{-1}, which is slightly lower than the permissible level of 0.5 mg kg^{-1} set by the New Zealand Food Safety Authority (NZFSA). In contrast, mean levels of mercury for *D. mawsoni* were 0.10 mg kg^{-1} in the 1998 samples and 0.16 mg kg^{-1} in the 2006 samples, both of which are well below the permissible level.

Mercury levels were highly variable both within and between the five species studied. Once the factors length and year had been accounted for, the mercury levels in *D. eleginoides* were over four times greater than in *D. mawsoni*. The three prey species had intermediate

mercury levels, with Whitson's grenadier (*Macrourus whitsoni*) being only slightly lower than *D. eleginoides*, whilst the levels of icefish (*Chionobathyscus dewitti*) and blue antimora (*Antimora rostrata*) were at low levels, similar to that of *D. mawsoni*. Mercury levels were positively correlated with fish length in four of the species. Mercury levels also showed positive trends with depth for *D. eleginoides* and *C. dewitti*, and with area for *A. rostrata*. Mercury levels showed no trends with any factors for *M. whitsoni*.

The low levels of mercury in *D. mawsoni* relative to its prey species and the four-fold difference in mercury concentrations between it and *D. eleginoides* were unexpected. Reasons for these different levels of bioaccumulation were explored including differences in diet, growth, longevity and location. It is concluded that these results can only be explained by a lower rate of mercury assimilation and/or a higher rate of mercury elimination by *D. mawsoni*.

WG-FSA-07/25

Biological parameters for icefish (*Chionobathyscus dewitti*) in the Ross Sea, Antarctica. C.P. Sutton, M.J. Manning, D.W. Stevens, P.M. Marriott (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, c.sutton@niwa.co.nz), 27 pp. *CCAMLR Science*, submitted (English).

Icefish (Channichthyidae) specimens were randomly collected by observers during the 2005/06 fishing season. These observers were placed on board three longline vessels targeting Antarctic toothfish in the Ross Sea (Subareas 88.1 and 88.2). Biological data from 303 returned specimens were collected. These data included species identification, fish length, weight, sex, meristics, reproductive biology, diet and age estimation. All of the icefish sampled were identified as *Chionobathyscus dewitti*, and showed no significant difference in sex ratio. Meristic, diet and age data were consistent with previous research.

Regression equations for converting standard length to total length and for defining length–weight relationships were calculated and presented for both male and female fish. Gonad maturity stage data showed that most fish were either immature or resting (mature). Gonado-Somatic Indices (GSIs) were calculated and plotted against sample month. There was a weak positive trend in GSI between December and February, but this was limited, probably due to the short temporal distribution of the data. Length-at-maturity and age-at-maturity ogives indicated that 50% of the fish sampled were mature at about 340–360 mm (TL) and about 3–4 years of age and that 95% were mature at about 370–400 mm (TL) and 6–8 years of age.

Counts of growth zones in sectioned otoliths were used to determine ages and von Bertalanffy growth parameters. Fish growth was rapid for both sexes, and females approached a significantly larger mean asymptotic maximum size than males. Maximum ages of 8 and 11 years were obtained for male and female fish respectively.

Diet analysis showed most icefish stomachs were empty and the few prey items recovered were generally in advanced stages of digestion. This may be due to regurgitation of prey during capture.

WG-FSA-07/27

Identification and speciation of Antarctic skates. P.J. Smith, C.D. Roberts, A.L. Stewart, M. McVeagh and C.D. Struthers (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Wellington, New Zealand), 45 pp. (English, unpublished).

Two regions of mitochondrial (mt) DNA: cytochrome *b* and cytochrome *c* oxidase subunit 1(COI) were sequenced in nine species of *Bathyraja* skates from the Southern Ocean and New Zealand. Based on significant sequence divergence, the species that has been referred to as *B. eatonii* from the Antarctic shelf and slope is a species distinct from *B. eatonii* from the Kerguelen Plateau (the type locality), and is a new and undescribed species, and should be

provisionally referred to as *Bathyraja* n. sp. cf *eatonii*. There was no sequence divergence among samples of *B.* n. sp. 'dwarf' from the Ross Sea and South Atlantic. However, for *B.* n. sp. cf. *eatonii* and *B. maccaini* in the Ross Sea and South Atlantic, the DNA sequence divergences are indicative of differentiation among ocean basins, and for *B.* n. sp. cf. *eatonii* are similar to divergences among recognised *Bathyraja* species in the North Pacific.

Despite investigating four colour characters, eight meristic characters and six morphometric characters, relatively few were diagnostic for the Antarctic *Bathyraja*. Ventral colouration appeared reliable for distinguishing *B. meridionalis* and *B.* n. sp. dwarf, but dorsal colouration was unreliable. Proportional disc width showed substantial changes in shape between the juvenile and adult stages of *B.* n. sp. cf *eatonii*, hence, the common name 'allometric skate' is proposed. Eight meristic characters were evaluated. Pectoral radials and monospondylous vertebrae were useful in diagnosing *B.* n. sp. dwarf, and midline thorns for *B. meridionalis*. The presence/absence of thorns around the eyes and on the scapular appeared to be a reliable character to distinguish species in the Ross Sea. A field key for identification of Ross Sea skates is provided.

WG-FSA-07/28

A characterisation of the toothfish fishery in Subareas 88.1 and 88.2 from 1997/98 to 2006/07. S.M. Hanchet, M.L. Stevenson and A. Dunn (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, s.hanchet@niwa.co.nz), 20 pp. (English, unpublished).

The exploratory fishery for Antarctic toothfish (*Dissostichus mawsoni*) has been operating for 10 years in Subarea 88.1 and for five years in Subarea 88.2. This report summarises the large amount of data collected on toothfish and the associated by-catch by all vessels participating in the fishery. All SSRUs in the two subareas except for 881D and 882C have now been fished. The 2007 *D. mawsoni* catch was the second highest on record with a total of 3 431 tonnes against a combined catch limit of 3 579 tonnes. The management of the SSRUs within the two subareas was changed for the 2006 season as part of a three-year experiment (SC-CAMLR-XXIV). One of the aims of the experiment was to simplify the administration of the fishery by having fewer catch limits. This appeared to be moderately successful, with only one catch limit being slightly exceeded in the 2006 season, and two catch limits exceeded in the 2007 season. Although there was a large overrun of the catch limit in the north region, the overall catch limit for Subarea 88.1 was only exceeded by 2%. The catch limit was under-caught in Subarea 88.2. The concentration of effort within smaller spatial areas in Subarea 88.1 has undoubtedly contributed to the large increase in tag recoveries over the past two seasons (Dunn et al., 2007).

The length-frequency data from the Ross Sea fishery have been very consistent over the past three to four seasons. There is no evidence of any truncation of the overall length-frequency distribution, and no evidence for a reduction in fish length in any SSRU over time. Although moderate numbers of small fish are caught in some years (e.g. on the Shelf in 1999 and 2001), these year classes are not seen in large numbers in later years in the fishery. So at this stage there is no evidence for strong variation in year-class strength in the fishery.

WG-FSA-07/29

Preliminary assessment of the South Georgia toothfish stock, 2007. D.J. Agnew, R. Hillary and J. Pearce (Department of Biology, Faculty of Life Sciences, Imperial College, Prince Consort Road, London SW7 2BP, United Kingdom, d.agnew@imperial.ac.uk), 19 pp. (English, unpublished).

1. The catch-at-length based CASAL model for toothfish at South Georgia is updated with data from the 2007 fishing season. The predicted spawning stock biomass and the yield is slightly higher than was estimated last year.

2. Improvements are made to the fit of tag data through: (i) estimating a length-based ogive for tag-induced mortality, based on the authors' 2005 survivorship experiment, in which smaller fish survive tagging better than large fish, and (ii) by re-estimating from the authors' tagging data that tag-induced growth retardation is also related to size, smaller fish suffering less growth retardation than larger fish, and that on average it is one year or more.
3. A new model is developed which uses estimates of catches-at-age from 1998 to 2006 (based on random sampling of the catch for age determination). Fits of all data (CPUE; catches-at-length for the early fishery; catches-at-age for the later fishery; tag–recapture data) are all improved from earlier models, although some poor fits remain. The model estimates year-class strength which corresponds, in some years, with estimates made from the South Georgia groundfish survey data.
4. Several of the requests of WG-FSA for developments of the South Georgia toothfish model have now been completed.
5. Note that the data used here are preliminary and lack some of the precaution previously included in assessments. It is recommended that only small changes to the current catch limit be considered, and that the toothfish assessment is undertaken at periods of greater than one year.

All CASAL code has been deposited with the Secretariat.

WG-FSA-07/30

Proposal for further trials aimed at reducing *Macrourus* spp. by-catch on autoliners targeting *D. eleginoides* with longlines around South Georgia. Delegation of the United Kingdom, 5 pp. (English, unpublished).

Integrated weight (IW) longlines are effective in reducing the by-catch of birds in toothfish fisheries, but by putting the line closer to the seabed they increase the by-catch of macrourids and rajids. Experiments reported elsewhere demonstrate that some of this effect can be mitigated by the use of fish rather than squid bait, but even then autolines continue to catch more macrourid by-catch than Spanish systems. The UK intends to trial two alternative configurations against IW systems in Subarea 48.3 in the 2007/08 fishing season: non-IW autolines with spaced weights, and IW systems with alternately spaced weights and floats. All systems will have sink rates of at least 0.3 m s^{-1}. Comments on the experimental protocol are invited. Although it is intended to change gear configurations as described, all other conservation measures will apply.

WG-FSA-07/31

Proposal for trials to test modified longline gear as a means to reduce cetacean depredation and mitigate incidental bird catch. Delegation of the United Kingdom, 4 pp. (English, unpublished).

The UK undertook preliminary trials of the previously described 'cone' or 'bottle' longline configuration for mitigating cetacean interactions in 2006. This paper should be read in conjunction with the observer's report of that cruise (Basson, 2006). Initial results were promising, and the UK intends to proceed with further, more extensive trials, in the 2007/08 fishing season in Subarea 48.3. Although seabird interactions are expected to be minimal, the trials will stop if three seabirds are caught, and sink tests will be undertaken. Although it is intended to change gear configurations as described, all other conservation measures will apply.

WG-FSA-07/32

Results of the tagging experiment for *Dissostichus eleginoides* in Subarea 48.4, 2007 update. J. Roberts and D.J. Agnew (Marine Resources Assessment Group Ltd, 18 Queen St, London W1J 5PN, United Kingdom), 7 pp. (English, unpublished).

1. During the 2006/07 fishing season one UK and one New Zealand vessel fished in Subarea 48.4, catching 54 tonnes of toothfish. A total of 291 *Dissostichus eleginoides* and 1 *D. mawsoni* were tagged and released during fishing operations. This represents a very high tagging rate of 5.4 fish per tonne of catch. Additionally, 100 rajids were tagged and released.
2. *Dissostichus eleginoides* and rajids appear to have different distributions of abundance around the fishing area. There were two tag recaptures in 2007, both of *D. eleginoides*. These were recaptured 84 and 14 km from their points of release respectively.
3. The UK proposes to continue the mark–recapture experiment in Subarea 48.4 in 2007/08. Initial estimates of population size will be made in 2008/09. However, given the currently low level of recaptures, and the difficulties experienced in catching and tagging the anticipated number of toothfish each year, the experiment and Conservation Measure 41-03 may need to be extended for a few more years.

WG-FSA-07/33

Preliminary trials to test mitigation measures aimed at reducing *Macrourus* spp. by-catch on autoliners targeting *D. eleginoides* with longlines in the CCAMLR Convention Area. R.E. Mitchell, D.J. Agnew, T. Carruthers, J. Clark, L. Ross and J. van Heerden (Marine Resources Assessment Group Ltd, 18 Queen St, London W1J 5PN, United Kingdom), 10 pp. (English, unpublished).

Pilot studies were carried out in Subarea 48.3 in 2006 and in Subareas 88.1 and 88.2 in 2007 by the *Argos Helena*, testing 14/0 circle hooks and mackerel bait against hooks and bait routinely used by the vessel (14/0 EZ J-type hooks and squid bait respectively). Catch-per-unit-effort (CPUE) of *Macrourus* spp. (kg 1 000 hooks^{-1}) was lowest with J-type hooks and mackerel bait for both regional trials. Variation in catch rates of *Macrourus* spp. due to bait was significant, but not for hook-type. Bait type had similar effects on the catch rates of *Dissostichus* spp. and of all other by-catch species combined. However, variation in CPUE for target and non-target species due to geographical location, depth and soak time were also significant and when by-catch to catch ratios were analysed, the variation due to bait was not significant. In order for the benefits of mackerel bait in reducing macrourid (and other species) by-catch to be endorsed by the industry, further mitigation research is required to determine a gear configuration for automated longlines which maintains toothfish catch rates when this bait type is being used.

WG-FSA-07/34 Rev. 1

2007 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 (MARAM), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa, anabela.brandao@uct.ac.za), 26 pp. (English, unpublished).

The ASPM assessment of the Prince Edward Islands toothfish resource by Brandão and Butterworth (2006) 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 2006 and 2007. The assessment allows for a second fleet to accommodate data from a pot fishery that operated in 2004 and 2005. Biological parameter values adopted for Subarea 48.3 are used. The resource is estimated to be at about 37% of its average pre-exploitation level in terms of spawning

biomass. It is suggested that it would be prudent to restrict annual legal catches to 500 tonnes or less, unless a large proportion of the catch is to be taken by pots (which avoid the cetacean predation associated with longlining).

WG-FSA-07/35

A hypothetical life cycle for Antarctic toothfish (*Dissostichus mawsoni*) in Antarctic waters of CCAMLR Statistical Area 88. S.M. Hanchet, G.J. Rickard, J.M. Fenaughty, A. Dunn and M.J. Williams (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, s.hanchet@niwa.co.nz), 22 pp. *CCAMLR Science*, submitted (English).

Aspects of the reproduction, size distribution and movements of Antarctic toothfish (*Dissostichus mawsoni*) in Subareas 88.1 and 88.2 were reviewed. Based on the presumed location and timing of spawning, and the probable early life-history characteristics of toothfish, we investigated models that mimic the drift of eggs and larvae over a 6–24 month period using an oceanic circulation model linked to the high resolution global environmental model (HiGEM). The location of toothfish larvae after an 18–24 month period suggested by the models agreed moderately well with the distribution of the smallest toothfish taken in the toothfish fishery.

The authors' present hypothesis is that *D. mawsoni* in Subareas 88.1 and 88.2 spawn to the north of the Antarctic continental slope, mainly on the ridges and banks of the Pacific-Antarctic Ridge. The spawning appears to take place during winter and spring, and may extend over a period of several months. Depending on the exact location of spawning, eggs and larvae become entrained by the Ross Sea gyres, and may either move west settling out around the Balleny Islands and adjacent Antarctic continental shelf, south onto the Ross Sea shelf, or eastwards with the eastern Ross Sea gyre settling out along the continental slope and shelf to the east of the Ross Sea in Subarea 88.2. As the juveniles grow in size they move west back towards the Ross Sea shelf and then move out into deeper water (greater than 600 m). The fish gradually move northwards as they mature, feeding in the slope region in depths of 1 000–1 500 m, where they gain condition before moving north onto the Pacific-Antarctic ridge to start the cycle again. Spawning fish may remain in the northern area for up to 2–3 years. They then move southwards back onto the shelf and slope where productivity is higher, food is more plentiful and where they regain condition before spawning.

It is recommended that research surveys be carefully planned to test some of these hypotheses.

WG-FSA-07/36

Tagging larger toothfish, methods and equipment. J.M. Fenaughty (Silvifish Resources Ltd, PO Box 17-058, Karori, Wellington, New Zealand, jmfenaughty@clear.net.nz), 12 pp. (English, unpublished).

The current stock assessment in the Ross Sea (Subareas 88.1 and 88.2) is underpinned by a tag and recapture program, based on Antarctic toothfish (*Dissostichus mawsoni*). The tagging of toothfish in this area is a mandatory requirement (Conservation Measure 41-01, Annex 41-01/C). The annex requires vessels to 'target toothfish of all sizes in order to meet the tagging requirement'. This document details a number of methods and presents plans of some equipment used by New Zealand vessels operated by Sanford Limited, a major New Zealand fishing company, in order to satisfy this requirement. These techniques and equipment may have relevance in other tagging programs for the closely related Patagonian toothfish (*D. eleginoides*).

WG-FSA-07/37

Assessment models for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea including data from the 2006/07 season. A. Dunn and S.M. Hanchet (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Wellington, New Zealand, a.dunn@niwa.co.nz), 26 pp. *CCAMLR Science*, submitted (English).

This paper provides an update of the 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), using revised catch, catch-at-age and tag–recapture data for the 2006/07 season. The updated reference model resulted in a slightly lower estimate of initial biomass than the 2006 base case. The inclusion of the recaptures in 2007 of tags released in 2006 had the most substantive impact on the model estimates.

Models using tag–recapture data from all vessels are also presented. Inclusion of all vessels' tagging data resulted in a more optimistic assessment. The more optimistic estimate was probably due to the lower recapture rate by non-New Zealand vessels, particularly in the early years. The reason for this is unclear, and may be related to different distributions of fishing effort by different vessels, to poorer survival of tagged fish, or to poorer detection rates. However, if data from all vessels were restricted to 2007 recaptures of 2006 releases, then model estimates were more similar to the 2007 reference model.

Overall, model fits to the data were adequate, and, as in previous assessments, the tag–release and recapture data provided the most information on stock size. Monte-Carlo Markov Chain (MCMC) diagnostics suggested little evidence of non-convergence in the key biomass parameters. MCMC estimates of initial (equilibrium) spawning stock abundance (B_0) for the 2007 reference model were estimated as 71 200 tonnes (95% CIs 59 570–87 900 tonnes), and current (B_{2007}) biomass was estimated as 81.9% (78.4–85.4%). The estimated yield for the reference case, using the CCAMLR decision rules, was 2 700 tonnes.

Similar estimates of initial biomass and yield were obtained for models where the north fishing selectivity was assumed to be logistic (median B_0 = 78 480 tonnes, yield = 2 988 tonnes), and where the 2007 recaptures from all vessels were added to the New Zealand tag–release and recapture data (median B_0 = 81 100 tonnes, yield = 3 099 tonnes). If tag–release and recapture data for all vessels in all years were used, then the estimated initial biomass was higher (B_0 = 110 130 tonnes), and corresponding yields were also higher (yield = 4 200 tonnes).

WG-FSA-07/38 Rev. 2

The morphology of Antarctic toothfish (*Dissostichus mawsoni* Norman 1937) males and females and new data on its gonad structure in the Ross Sea in the summer period. S.V. Piyanova and N.V. Kokorin (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia, pjanova@vniro.ru; antarctica@vniro.ru), 15 pp. (English, unpublished).

The results of the histological analysis of the Antarctic toothfish (*Dissostichus mawsoni*) gonad structure, caught between December 2004 and February 2005 by the longliner *Yantar* in the Ross Sea (Subareas 88.1 and 88.2), are presented. The morphological parameters and indices of maturity are described. The histological criteria of the assessment of the ovary maturity stages, cytological parameters of oocytes and type of the toothfish oogenesis are determined. The histological state of toothfish testes were analysed, and the abnormal primary fusion renal and generative tissues in testes are revealed. It is shown that, during the fishing period, Antarctic toothfish females with ovaries in early maturity stage III (47.0%), and males with testes in maturity stage III (85.7%) were dominant.

WG-FSA-07/39

Preparing for the Year of the Skate: proposed information collection and tagging protocol for skates. S. Mormede, A. Dunn, J. Fenaughty, M. Francis, S. Hanchet, R. O'Driscoll and N. Smith (Ministry of Fisheries, PO Box 1020, Wellington, New Zealand, sophie.mormede@fish.govt.nz), 13 pp. (English, unpublished).

Skates are an important by-catch of the toothfish fishery in the CAMLR Convention Area and have been identified as priority taxa for which assessments of status are required (e.g. SC-CAMLR-XXIII, paragraphs 4.172, 4.177 and 4.199). While Dunn et al. (2007) and Agnew et al. (2007) have developed preliminary assessment models for skates, they also highlighted that further information was required before a full assessment can be carried out. In 2007, WG-SAM recommended (SC-CAMLR-XXVI, Annex 7, paragraph 8.10) a review of data requirements and a 'Year of the Skate' for 2008/09, whereby data collection effort on by-catch will be concentrated on skate species in that year in order to inform a full skate assessment.

This paper discusses improvements to the fishery-derived data that may be required to better inform an assessment of Ross Sea skates. Options for the appropriate collection of such data from the fishery and a revised skate tagging protocol are proposed. These changes could be piloted in the 2007/08 season by all or a subset of vessels fishing in the Ross Sea. The results from the pilot study may be useful to inform modifications to data collection systems that would be required in 2008/09 for the Year of the Skate. It should be noted that other information requirements, such as determining biological parameters, are not considered.

WG-FSA-07/40

An updated descriptive analysis of the toothfish (*Dissostichus* spp.) tagging program in Subareas 88.1 and 88.2 for 2006/07. A. Dunn, S.M. Hanchet and S.L. Ballara (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Wellington, New Zealand, a.dunn@niwa.co.nz), 25 pp. (English, unpublished).

The descriptive analyses of the toothfish tagging program carried out in Subareas 88.1 and 88.2 since 2001 are updated, including data for the 2007 season for all vessels. This paper provides an update of the preliminary tag–release and tag–recapture data that were presented at the July 2007 meeting of WG-SAM by including revised data and data from non-New Zealand vessels that fished in 2007.

Overall, a total of 15 088 Antarctic toothfish have been reported as released and 458 recaptured, and 911 Patagonian toothfish released and 43 were recaptured since 2001.

The number of tags recaptured in the Ross Sea in 2007 by New Zealand vessels was the highest annual recapture to date and double the number caught in 2006, although the nature of these recaptures suggests that assumptions of homogeneous mixing may need to be investigated. For the first time, long-distance movements of Antarctic toothfish were observed from toothfish tagged by fishing vessels. Six fish moved 400–600 km from the slope fisheries in SSRUs 881H, I and K to grounds off Terra Nova Bay and Ross Island in SSRU 881J. There was also some evidence that more fish are recaptured after a longer time at liberty on the slope than in the north. In addition, a Patagonian toothfish tagged near Macquarie Island was recaptured in the north of the Ross Sea, after four years at liberty.

Analysis of tag–recapture rates suggested some evidence that rates between New Zealand and non-New Zealand vessels were different, and further, that the rate that tags were recaptured from vessels of different nations were different. The reason for these differences is unclear, but may be related to different survival rates of fish tagged by different vessels, different detection rates of tagged fish on different vessels, and/or incomplete spatial mixing of the fish tagged by different vessels in different local regions. Further investigation is required.

WG-FSA-07/41

Field identification guide to the main fishes caught in the Ross Sea longline fishery. P.J. McMillan, P. Marriott, S.M. Hanchet, J.M. Fenaughty, E. Mackay and H. Sui (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Wellington, New Zealand), 35 pp. (English, unpublished).

A preliminary field identification guide to the main fishes caught by toothfish longline vessels fishing in the Ross Sea was prepared under the New Zealand Ministry of Fisheries Project ANT2005-02 and was used by Ministry of Fisheries observers and fishers during the 2006/07 season. That guide was revised in 2007 following comments and suggestions from the users and now covers 27 taxa. Mostly it provides information for identification to species, but for liparids (snailfishes), zoarcids (eelpouts) and bathydraconids (dragonfishes) identification is at family level, and for *Muraenolepis* (eel cods) and *Pogonophryne* (plunderfishes) identification is to genus. Identification to species for some fish is difficult because of uncertain taxonomic status, e.g. *Pogonophryne*, or scarcity of field characters, e.g. liparids. Some species likely to be seen only in the stomach contents of other fishes are included. Future revisions could be made as taxonomic issues are resolved, and more species are recorded from the Ross Sea. Data and images are stored on a relational database to facilitate revision and easy information retrieval.

WG-FSA-07/42

Mincing, mealing and batching: waste management strategies aimed at reducing seabird interactions with trawl vessels. E. Abraham and J. Pierre (Dragonfly, 10 Milne Terrace, Island Bay, Wellington 6023, New Zealand, edward@dragonfly.co.nz), 30 pp. (English, unpublished).

Experiments were carried out on two fishing trawlers to test whether mincing all waste to a paste before it was discharged reduced the number of seabirds around the vessels. The first trial was on a midwater trawler targeting hoki (*Macruronus novaezelandiae*), and the experiment on this trip compared three treatments: (i) mincing all waste, (ii) discharging unprocessed waste, and (iii) mealing all waste and reducing discharge to sump water. The second vessel was bottom-trawling for squid (*Nototodarus sloanii*). There was no meal plant on board and the mealed treatment was replaced with a batching treatment (iv) where waste was held and discharged in batches. The response to the experimental treatments was determined by counting the number of birds within a 40 m-radius semi-circular sweep zone behind the vessel stern. Results from the first experiment showed that mincing reduced the numbers of large albatross (*Diomedea* spp.) feeding around the vessel, but had no significant effect on other groups of seabirds. In contrast, mealing all waste had a marked effect on several of the bird groups. In particular, the abundance of small albatross (principally *Thalassarche* spp.) within the sweep area was reduced to 5% of the number that were there when unprocessed waste was discharged. On the second trial a smaller mincer was used. The vessel was bottom trawling, and there were problems with rocks going through the waste stream. The batched treatment was compromised by the limited ability of the vessel to hold waste, with only a 10 to 20 minute delay between discharge events being achieved. Despite low numbers of observations on the second trial, the minced treatment suggested a reduction in the numbers of all albatross within the observation area.

WG-FSA-07/43

Preliminary results of testing of PIT-D device in the deep-water longline fishery for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea during the 2006/07 fishing season. N.V. Kokorin, V.V. Bulanov and V.V. Krjukov (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia, antarctica@vniro.ru), 7 pp. (English, unpublished).

Preliminary results of testing a PIT-D device for independent measurements of temperature and pressure in the deep-water longline fishery for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea during the 2006/07 fishing season are presented. Diagrams of a Spanish-type longline sink rate at deployment and water temperature on various horizons are shown.

WG-FSA-07/44

Preliminary assessment of the exploratory fishery for *Dissostichus* spp. on BANZARE Bank (Division 58.4.3b), based on the analysis of fine-scale catch and effort data. J.P. McKinlay, D.C. Welsford, A.J. Constable and G.B. Nowara (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, john.mckinlay@aad.gov.au), 37 pp. *CCAMLR Science*, submitted (English).

In 2006 the CCAMLR Scientific Committee noted several features of exploratory *Dissostichus* fisheries in the southern Indian Ocean (Subarea 58.4) which gave cause for concern as to the status of the resource in this area, and the lack of a scientific basis for setting catch limits in this area (SC-CAMLR-XXV, paragraphs 4.184 to 4.192).

In its management advice for this and other exploratory fisheries, the Scientific Committee requested urgent consideration by Members of methods for collecting data and assessing these stocks.

At its meeting in July 2007, WG-SAM agreed that fine-scale analysis of catch and effort would be a useful way of progressing an assessment of the BANZARE fishery (SC-CAMLR-XXVI, Annex 7, paragraphs 3.1 to 3.7), including:

- identification of grounds through analysis of spatial patterns in catch and effort
- exploration of standardising CPUE series for each ground
- analysis of CPUE of *Dissostichus* spp. to provide initial estimates of biomass and rates of depletion in each ground.

This paper develops further the initial exploration of the C2 fine-scale catch and effort data held by CCAMLR for the fishery in Division 58.4.3b presented to WG-SAM in 2007, as well as descriptive analyses of the B2 biological data submitted by scientific observers on board vessels in the BANZARE fishery.

Data were too few, or with insufficient overlap between seasons, to permit meaningful standardisation for a depletion analysis. However, these preliminary analyses indicate there is strong evidence for depletion of toothfish at the scale of individual fishing grounds in the 2004/05 and 2005/06 seasons. There are also several inconsistencies noted between historical catch rates and catch compositions and those reported in the 2006/07 season, with Patagonian toothfish dominating in catches in one ground for the first time, and some observers reporting no biological information on important by-catch groups reported in the vessels' catch records.

It is recommended that WG-FSA evaluate management options in Division 58.4.3b, including the lowering of catch limits commensurate with the rapid and unsustainable depletion seen in the fishery, the development of SSRUs to better represent the concentrated nature of the fishery in Division 58.4.3b, commensurate management of areas that are obviously depleted, and the design of a longline survey to attempt to verify some of the trends in catch rates and catch composition seen in the main fishing areas.

WG-FSA-07/45

Summary of holdings of Patagonian toothfish (*Dissostichus eleginoides*) otoliths and size-at-age estimates from Heard and McDonald Islands (Division 58.5.2). D.C. Welsford and G.B. Nowara (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, dirk.welsford@aad.gov.au), 11 pp. (English, unpublished).

Scientific observers on board vessels in the Australian fisheries in Division 58.5.2 have collected *Dissostichus eleginoides* otoliths since the fishery commenced in the 1996/97 season. This program has yielded data which has assisted with understanding age structure and growth rates of toothfish in this division. This paper summarises the otolith collection housed at the Australian Antarctic Division, including individuals collected during research and commercial fishing, tag recaptures, and those individuals which have been processed by the Central Ageing Facility to provide size-at-age estimates. Over 21 000 otoliths have been collected from toothfish in Division 58.5.2, and more than 2 500 otolith pairs have been collected from recaptured tagged fish. More than 3 200 otoliths have been processed to provide size-at-age estimates from fish captured between 1997 and 2003. A growth model based on these size-at-age data is currently used in the assessment to predict growth and assign length-at-age to catch-at-age, however an alternative method to assign catch-at-age is age–length keys. Relatively few otoliths have been collected or aged from the annual trawl survey or the longline fishery, making constructing historical season-by-season age–length keys for these fisheries impossible. It is likely that sufficient otoliths have been collected from the main trawl ground to construct age–length keys, however the feasibility and benefit of proceeding to age–length keys in terms of precision of stock assessment requires simulation analysis.

WG-FSA-07/46

Report on a random stratified trawl survey to estimate distribution and abundance of *Dissostichus eleginoides* and *Champsocephalus gunnari* conducted in the Heard Island region (Division 58.5.2), May–June 2007. G.B. Nowara and T. Lamb (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, gabrielle.nowara@aad.gov.au), 12 pp. (English, unpublished).

Since the commencement of commercial fishing in Australian waters on the Heard Island Plateau in 1997, an annual random stratified trawl survey (RSTS) has been conducted to assess the stocks of Patagonian toothfish (*Dissostichus eleginoides*) and mackerel icefish (*Champsocephalus gunnari*). The 2007 survey had two main aims:

- to assess the abundance of juvenile and adult *D. eleginoides* on the shallow and deep parts of the Heard Island Plateau;
- to assess the abundance of *C. gunnari* on the Heard Island Plateau.

The survey had the same design as the 2006 RSTS survey in the number of stations chosen for sampling in each stratum. This paper describes the conduct of the survey on the FV *Southern Champion* during June and July 2007 and the resulting catches and biological sampling.

The most abundant species in the catch was *D. eleginoides*, followed by *Lepidonotothen squamifrons*, *Channichthys rhinoceratus*, *C. gunnari* and *Macrourus* spp. Catches of these five main fish species were very similar to those in 2006, with the exception of *L. squamifrons* which was much more abundant in 2007. Holothurians, poriferans, medusae and anemones were the most common invertebrate biota caught in the net.

WG-FSA-07/47

Preliminary assessment of mackerel icefish (*Champsocephalus gunnari*) in the vicinity of Heard Island and McDonald Islands (Division 58.5.2), based on a survey in July 2007, using the generalised yield model. D.C. Welsford (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, dirk.welsford@aad.gov.au), 11 pp. (English, unpublished).

A survey of mackerel icefish (*Champsocephalus gunnari*) was undertaken in Division 58.5.2 in the vicinity of Heard Island in July 2007 to provide information for an assessment of short-term annual yield in the 2007/08 CCAMLR season. This paper provides a preliminary assessment of yield for the area of Division 58.5.2 to the west of 79°20'E using standard CCAMLR methods. Evidence of strong 1+ year class recruiting to the population has led to an increase in the estimated biomass of mackerel icefish, and an increase on the recommended catch over the projection. Based on a similar cohort structure seen in the population in 2003, this estimate is likely to increase further as this cohort is more fully selected.

WG-FSA-07/48 Rev. 1

Overview and update of Australia's scientific tagging program in the Patagonian toothfish (*Dissostichus eleginoides*) fishery in the vicinity of Heard and McDonald Islands (Division 58.5.2). D.C. Welsford, T. Lamb and G.B. Nowara (Department of the Environment and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, dirk.welsford@aad.gov.au), 9 pp. (English, unpublished).

Australia has conducted a scientific tagging program in the *Dissostichus eleginoides* fishery in Division 58.5.2 since the 1997/98 season. This program has yielded data which has assisted with understanding growth rates of toothfish, small- and large-scale movements, stock structure and local abundance. This paper serves as an overview of the tagging dataset, and an update to previous summary papers. Tagging effort and recaptures are very concentrated in a relatively small area of this species' habitat in this division. Furthermore, as toothfish appear to have complex patterns of movement in space and time, being generally sedentary, but occasionally moving large distances, using tagging data to assess the status of stock in Division 58.5.2 remains difficult, and is likely to remain so until sufficient data to provide unbiased estimates of movement rates between areas and fisheries can be included in an integrated assessment framework.

WG-FSA-07/49

Results of a study of the oogenetic characteristics of Antarctic toothfish (*Dissostichus mawsoni* Norman 1937) (Nototheniidae) from Subareas 88.1 and 88.2 (Ross Sea). S.V. Piyanova and A.F. Petrov (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia, pjanova@vniro.ru, antarctica@vniro.ru), 13 pp. (English, unpublished).

The authors present results of histological analyses of the reproductive system of Antarctic toothfish (*Dissostichus mawsoni*), caught between December 2004 and March 2005 by the longliner *Volna* in Subareas 88.1 and 88.2 in the Ross Sea. A description of morphological parameters and gonad indices is given. Histological criteria for the assessment of ovarian maturity stages, cytological parameters of oocytes and type of toothfish oogenesis were determined. As toothfish ovaries develop through stages II to IV, a slow increase in oocyte diameter is observed. It was found that for Antarctic toothfish during the fishing period, individuals with gonads in late maturity III stage were predominant. Their ovaries contained three size groups of oocytes: a cytoplasmic group and two groups of vitellogenous oocytes. The type of the toothfish oogenesis has been defined as intermittent. Large oocytes from the most recent spawning season, with an average diameter 1 000–1 200·10^{-6} m, comprised 5.4%

of total cell numbers. Oocytes in the ovaries of analysed fish did not reach maximum size; thus Antarctic toothfish were not mature for spawning in the Ross Sea during the study period.

WG-FSA-07/50

Description of the most important species of finfish and cephalopods in the diet of Antarctic toothfish (*Dissostichus mawsoni* Norman, 1937) (Perciformes, Nototheniidae) in the Amundsen Sea in 2006–2007. A.F. Petrov and J.A. Filippova (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia, antarctica@vniro.ru), 13 pp. (English, unpublished).

Feeding of Antarctic toothfish (*Dissostichus mawsoni*) was studied in a new fishing ground for this species in the Pacific sector of the Southern Ocean – the Amundsen Sea (Subarea 88.2). In terms of occurrence, the most important fish items in toothfish diet were: Whitson's grenadier (*Macrourus whitsoni*), crocodile icefish (*Chionobathyscus dewitti*), antimora (*Antimora rostrata*), Antarctic jonasfish (*Notolepis coatsi*) and other species.

Cephalopod beaks were quite abundant in the stomachs of toothfish. These beaks were identified as belonging to large Antarctic squids: *Mesonychoteuthis hamiltoni*, *Psychroteuthis glacialis* and *Kondakovia longimana.* Analysis of distribution and ecology of species prayed by Antarctic toothfish shows that *D. mawsoni* apparently represents a fast-swimming predator with wide feeding spectrum. Its diet includes bottom, bathy- and mesopelagic fish as well as large squids.

WG-FSA-07/51

Integrated weight longlines: potential for reduction of skate by-catch in demersal longline fisheries. K. Dietrich and E. Melvin (Washington Sea Grant, University of Washington, USA, kdiet@u.washington.edu), 9 pp. (English, unpublished).

Data collected during 2005 seabird mitigation experiments on integrated weight (IW) longlines in a demersal fishery for effects on skate by-catch were analysed. Trials took place on two vessels targeting Pacific cod (*Gadus macrocephalus*) over a five-month period in the Bering Sea, Alaska, USA. The skate catch rate was 11% lower on the IW gear compared to unweighted gear. Location, month and depth were also significant predictors of skate catch rates. While results indicate IW shows the potential to reduce skate catch rates, further evaluation and analysis by individual species should be performed in specific regions where skate by-catch is a problem.

WG-FSA-07/52

Long-term changes in the size composition of fjord *Notothenia rossii, Gobionotothen gibberifrons* and *Notothenia coriiceps* at Potter Cove, after the 1978–1980 fishery in the area. E.R. Marschoff, E.R. Barrera-Oro and N.S. Alescio (Instituto Antártico Argentino, Ministerio de Relaciones Exteriores, Commercio Internacional y Culto, Cerrito 1248, 1010 Buenos Aires, Argentina, marschoff@dna.gov.ar), 15 pp. (English, unpublished).

Fish samples collected during a period of 24 years at Potter Cove after the impact of the fishery in the area in 1978–1980, allowed comparison of variations in mean annual lengths and density distributions of the commercially exploited species *Notothenia rossii* and *Gobionotothen gibberifrons* with the ecologically similar but unexploited *N. coriiceps*. The sharp decline in the abundance of *N. rossii* reported for the period 1983–1991/92 is consistent with the increase in mean size observed between 1983 and 1986/87 and the duration of the inshore phase of the species, which is known to last for six to seven years. In the following years, until 1991/92, the decreasing abundance is consistent with the entrance of low-strength cohorts with the consequent reduction in mean size. The above interpretation is supported by the length distributions observed between 1982/83 and 1985/86, where the modal age changes

from 2–3 to 6–7 years. After 1991/92 the densities, mean sizes and abundances do not depend on a single forcing event but on several interacting factors. The length data of *G. gibberifrons*, available from 1986, show a decrease until 1991/92, exhibiting a similar pattern to that of *N. rossii*. After a period of relative stability in mean sizes (1992–1994) a sharp increase is associated with a continuous decline in relative abundance, suggesting that it is due to increasingly low recruitments. The length-frequency distributions of *N. coriiceps* through the whole study period do not show any definite change in modal size, nor a pattern in mean lengths as is the case with *N. rossii* and *G. gibberifrons*.

WG-FSA-07/53 Rev. 1

An integrated stock assessment for the Patagonian toothfish (*Dissostichus eleginoides*) in Division 58.5.2 using CASAL. S.G. Candy and A.J. Constable (Department of Environment the and Water Resources, Australian Antarctic Division, 203 Channel Highway, Kingston 7050, Tasmania, Australia, andrew.constable@aad.gov.au), 44 pp. (English, unpublished).

This paper further develops an integrated assessment for Patagonian toothfish in Division 58.5.2. It updates the model used at WG-FSA in 2006, using data from the 2007 season as well as 2006 data not available for WG-FSA in 2006. It also includes the following refinements: (i) estimation of the coefficient of variation (CV) for length given age, (ii) use of non-informative priors for year-class strength parameters, (iii) separate selectivity parameters used for the pre-2006 compared to the 2006–2007 fishing seasons for the main trawl ground, (iv) separate selectivity parameters for the late (within-year) season compared to the combined early (within-year) seasons for the main trawl ground, and (v) the use of an improved method of determining effective sample size for commercial catch-at-length data. The estimated long-term yield was 2 500 tonnes with depletion probability of 0.081 and escapement probability of 0.505. As expected, the assessment was sensitive to the inclusion of different datasets and to the choices of parameters used in both the stock assessment and projections. It is concluded that until the difficulties with the use of mark–recapture data are resolved, recruitment surveys provide the best means of establishing current stock status as an absolute index of abundance.

WG-FSA-07/55

Spawning periods and locations of *Champsocephalus gunnari* in Subarea 48.3 (South Georgia and Shag Rocks): a review. S. Clarke, M. Belchier and M.A. Collins (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, markb@bas.ac.uk), 27 pp. *CCAMLR Science*, submitted (English).

Analysis of recent commercial catch, research survey and larval data for mackerel icefish (*Champsocephalus gunnari*) recorded from CCAMLR Subarea 48.3 coupled with historical information indicates that they spawn inshore close to the bays and over the shelf to the northeast. There is also evidence that spawning is protracted and occurs from January to July. The majority of commercial fishing activities for this species take place to the northwest of South Georgia over 12 n miles from the coast and do not overlap with important spawning areas. Therefore, the current conservation measure restricting the total allowable catch during the assumed spawning period from March to May is unlikely to protect spawning aggregations of *C. gunnari* but could, inadvertently, increase the risk of brooding seabirds being caught as by-catch.

WG-FSA-07/56

Preliminary report of the UK winter icefish survey, South Georgia (CCAMLR Subarea 48.3), 27 August to 21 September 2007. M. Belchier, M.A. Collins, J. Moir-Clark, S. Fielding, J. Lawson, C. Main and A. Pande (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, markb@bas.ac.uk), 29 pp. (English, unpublished).

This is a preliminary report of the results of the 11th UK South Georgia groundfish survey, the first to be conducted during the austral winter since 1997. Preliminary biomass estimates are provided for *Champsocephalus gunnari* whilst new information on the winter distribution and ecology of the demersal fish fauna at South Georgia is provided.

WG-FSA-07/57 Rev. 1

BirdLife International Global Procellariiform Tracking Database. B. Sullivan (BirdLife International), 2 pp. (English, unpublished).

WG-FSA-07/58

Stones in toothfish stomachs: an unusual source of geological information from closed regions of the Antarctic shelf and slope. N.V. Kokorin, D.S. Klucharev and M.A. Sukhoruchenkov (VNIRO, 17a V. Krasnoselskaya, Moscow 107140, Russia, antarctica@vniro.ru), 4 pp. (English, unpublished).

The rocks from stomachs of *Dissostichus mawsoni* were used as a source of geological information about the sea bottom. The authors suggest that toothfish pick up stones randomly from the bottom. These stones may be used for a geological description of the closed areas of the Antarctic shelf and slope. In this respect, *D. mawsoni* may be considered as a 'dredge' with a wide area of sampling. Preliminary analyses allow qualitative estimations of the geological structure of the Antarctic shelf and continental slope in different areas.

WG-FSA-07/P1

The biology of the spiny icefish (*Chaenodraco wilsoni* Regan, 1914). K.-H. Kock, L.V. Pshenichnov, C.D. Jones, J. Gröger and R. Riehl. 2007. *Polar Biol*., 31 (3): 381–393.

The most abundant icefish species observed in catches off the northern tip of the Antarctic Peninsula in the last 25–30 years has been the spiny icefish *Chaenodraco wilsoni* Regan 1914. *C. wilsoni* has been exploited on a commercial scale from the late 1970's to the end of the 1980's off Joinville–D'Urville Islands (CCAMLR Statistical Subarea 48.1) and in the Cosmonauts and Cooperation Seas and Prydz Bay in the Indian Ocean sector (CCAMLR Statistical Division 58.4.2). This paper presents new information on biological features and life history characteristics of *C. wilsoni*, based on research survey collections along the northern Antarctic Peninsula in 2006 and 2007 and samples taken in the commercial fishery in 1987. Length frequency compositions from the research surveys demonstrated that fish 21–34 cm long predominated in the catches. Sexual maturity is attained at 24–25 cm. Absolute fecundity and relative fecundity is low (1 000–2 500 eggs; 6–12 eggs). Oocyte diameter varied from 4.3 to 4.8 mm very close to spawning. Spawning at the tip of the Antarctic Peninsula is likely to occur in October–November. Remotely Operated Vehicle deployments in the northern Weddell Sea demonstrated that *C. wilsoni* exhibit parental nest guarding where males protect the eggs. The incubation period is likely to be 8 months long. Fish feed primarily on Antarctic krill (*Euphausia superba*) in the Antarctic Peninsula region and in the Cosmonauts and Cooperation Seas while fish take ice krill (*E. crystallorophias*), *Pleuragramma antarcticum* and myctophids to some extent in other areas. Age determination still awaits validation. Preliminary ageing attempts suggested a maximum age of about 8–10 years.

WG-FSA-07/P2

CCAMLR process of risk assessment to minimise the effects of longline fishing mortality on seabirds. S.M. Waugh, G.B. Baker, R. Gales and J.P. Croxall. *Mar. Pol*. (in press).

We describe the process used in the fisheries management system of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) to minimise seabird bycatch, and the risk assessment methodology developed to assist this. We examine the progress of several Regional Fishery Management Organisations in taking steps to address seabird bycatch. CCAMLR has the most advanced system of management among the RFMOS covered in this review, and has made the most demonstrable progress in reducing seabird bycatch levels in its longline fisheries. A combination of proven mitigation measures, extensive monitoring by independent observers, annual expert review of seabird by-catch rates and evolving fishery and mitigation practices have been instrumental in reducing seabird bycatch in CCAMLR fisheries.

WG-FSA-07/P3

Distribution, growth, diet and foraging behaviour of the yellow-fin notothen (*Patagonotothen guntheri*) on the Shag Rocks shelf (Southern Ocean). M.A. Collins, R. Shreeve, S. Fielding and M. Thurston. 2008. *J. Fish Biol*., 72 (1): 271–286.

The distribution, length-frequency and diet of *Patagonotothen guntheri* are described from 14 bottom trawl surveys conducted on the Shag Rocks and South Georgia shelves in the austral summers from 1986 to 2006. *P. guntheri* (80–265 mm L_T) were caught on the Shag Rocks shelf from depths of 111 to 470 m, but no specimens were caught on the South Georgia shelf. Multiple cohorts were present during each survey and length-frequency analysis of these cohorts suggests that growth is slow (K = 0.133). Evidence from stomach contents and acoustic data (2005 and 2006) show that *P. guntheri* is primarily a pelagic feeder, migrating from the seafloor towards the surface to feed during daylight. The diet of smaller fish (<140 mm) was dominated by copepods, predominantly *Rhincalanus gigas*, whilst larger fish principally consumed the pelagic hyperiid amphipod, *Themisto gaudichaudii* and Antarctic krill (*Euphausia superba*). Some larger fish also took benthic prey.

WG-FSA-07/P4

Distribution and diet of juvenile Patagonian toothfish on the South Georgia and Shag Rocks shelves (Southern Ocean). M.A. Collins, K.A. Ross, M. Belchier and K. Reid. 2007. *Mar. Biol.*, 152: 135–147.

The distribution and diet of juvenile (<750 mm) Patagonian toothfish are described from 4 annual trawl surveys (2003–2006) around the island of South Georgia in the Atlantic sector of the Southern Ocean. Recruitment of toothfish varies interannually, and a single large cohort dominated during the four years surveyed. Most juveniles were caught on the Shag Rocks shelf to the NW of South Georgia, with fish subsequently dispersing to deeper water around both the South Georgia and Shag Rocks shelves. Mean size of juvenile toothfish increased with depth of capture. Stomach contents analysis was conducted on 795 fish that contained food remains and revealed that juvenile toothfish are essentially piscivorous, with the diet dominated by notothenid fish. The yellow-finned notothen, *Patagonotothen guntheri*, was the dominant prey at Shag Rocks whilst at South Georgia, where *P. guntheri* is absent, the dominant prey were Antarctic krill and notothenid fish. The diet changed with size, with an increase in myctophid fish and krill as toothfish grow and disperse. The size of prey also increased with fish size, with a greater range of prey sizes consumed by larger fish.

WG-FSA-07/P5

Distribution and ecology of *Chaenocephalus aceratus* (Channichthyidae) around South Georgia and Shag Rocks (Southern Ocean). W.D.K. Reid, S. Clarke, M.A. Collins and M. Belchier. 2007. *Polar Biol*., 30 (12): 1523–1533.

Chaenocephalus aceratus (Family Channicthyidae) is one of the dominant species of demersal fish living on the South Georgia shelf where it is caught in low numbers as by-catch in the mackerel icefish and Antarctic krill commercial fisheries. Data collected during 14 demersal fish surveys, from 1986 to 2006, are analysed to investigate biomass, distribution, growth and diet. Biomass estimates from a swept area method ranged from 4 462 tonnes to 28 740 tonnes on the South Georgia and Shag Rock shelves although few fish were caught at Shag Rocks. Analysis of length frequency data indicated that growth was fast in the first five years with males and females attaining lengths at first spawning of 440 mm TL and 520 mm TL. The diet was comprised of fish and crustaceans, with an ontogenetic shift in diet from *Euphausia superba* and mysids to benthic fish and decapods observed to begin at 250 mm TL. In larger fish (>500 mm TL) the diet was dominated by fish. *C. aceratus* diet is sufficiently different from the other species of channichthyids around South Georgia to suggest that these species have undergone resource partitioning.