CCAMLR SCIENTIFIC ABSTRACTS 2008

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 2008 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(iii) scientific papers not intended for publication, which are listed as 'unpublished'; and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-XXVII/BG/11 (background document number 11 submitted at the Twenty-seventh Meeting of the Scientific Committee); or WG-EMM-08/8 (document number 8 submitted at the 2008 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Unpublished papers must not be cited without written permission of the author(s).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.

Scientific Committee

SC-CAMLR-XXVII/7 Rev. 1
The implications of climate change for CCAMLR fisheries and for the work of the Scientific Committee. Delegation of the United Kingdom, 2 pp. (English, unpublished).

SC-CAMLR-XXVII/8
Action plan aimed at reducing seabird by-catch in the French EEZs in Statistical Division 58.5.1 and Subarea 58.6. Delegation of France, 11 pp. (French, unpublished).

France's action plan aims to reduce considerably seabird by-catch by longliners operating in the Crozet and Kerguelen EEZs. The aim of the present document is to list the set of measures that France will pursue in the next few years to limit bird mortality.

The plan will also list the measures which have been implemented since 2002 to limit seabird by-catch.

This action plan is submitted in response to the recommendation made during the CCAMLR-XXVI meeting that France should 'urgently submit a strategic plan to eliminate seabird mortality' (SC-CAMLR-XXVI, paragraph 5.6(vii)).

SC-CAMLR-XXVII/10
Summary of French papers regarding recommendations made by the Scientific Committee with respect to the incidental mortality of seabirds. Delegation of France, 5 pp. (French, unpublished).

During its 26th Meeting, the Scientific Committee 'noted the ongoing efforts to use and develop effective mitigation measures in the French EEZ fisheries and that France continues to reduce its total seabird by-catch (13% decrease from the previous season). However, the seabird captures during longline fishing in the French EEZs are the only remaining substantial seabird by-catch in the Convention Area. The Scientific Committee recommended that France strive to eliminate the incidental mortality of seabirds in accordance with CCAMLR policies and practices'.

This document summarises the papers submitted by France in response to the recommendations recorded in paragraph 5.6 of the Scientific Committee report.

Some of these recommendations have been implemented without specific comments being made. Where the recommendations have led to a specific development, study or report, details are given below.

SC-CAMLR-XXVII/12
Environmental, spatial, temporal and operational effects on the incidental mortality of birds in the longline fishery in the Crozet and Kerguelen areas 2003–2006. Delegation of France, 61 pp. (French, unpublished).

During the 2003/04, 2004/05 and 2005/06 seasons, 5 883 seabirds were observed to have been killed incidentally in the legal longline fishery operating in the Crozet and Kerguelen EEZs. The estimate of mortality derived from these observations amounts to between 7 766 and 10 541 birds caught. The great majority (between 84 and 91% depending on the season) were white-chinned petrels, the males of which species seem to be more vulnerable to this type of mortality. Grey petrels were also caught incidentally in large numbers (576 individuals) over the same period, and represent between 9 and 16% of incidental catches, depending on the season. No albatrosses were caught during this period.

A multivariate analysis has helped to highlight the fact that a complex combination of variables, relating to both the environment and fishing techniques, leads to the incidental

capture of white-chinned and grey petrels. Our results suggest that a significant proportion of the mortality of white-chinned and grey petrels can be explained by the effects of season and geographical area. This mortality takes place almost exclusively during the breeding season. The highest mortality of white-chinned and grey petrels occurs during the chick-raising period. White-chinned petrels are mainly caught during the austral summer (from September to April) and grey petrels between April and November. The incidental catch varies according to geographical area, being higher at Kerguelen (where there are geographical disparities) than at Crozet.

On the basis of the conclusions of this analysis we suggest a series of recommendations aimed at reducing this cause of incidental mortality in the two main species affected: the white-chinned petrel and the grey petrel.

It is imperative that urgent note be taken of the considerable impact of the fishery on the grey petrel and that the conservation measures be modified accordingly in order to drastically reduce incidental mortality, failing which the population of grey petrels at Kerguelen will most probably face extinction within thirty years.

Also proposed are recommendations regarding incidental catches during hauling.

SC-CAMLR-XXVII/12 Corrigendum Table 14
Environmental, spatial, temporal and operational effects on the incidental mortality of birds in the longline fishery in the Crozet and Kerguelen areas 2003–2006. Delegation of France, 2 pp. (French, unpublished).

SC-CAMLR-XXVII/13
Notification of vulnerable marine ecosystems in Statistical Division 58.4.1. Delegation of Australia, 13 pp. (English, unpublished).

Conservation Measure 22-06 was adopted to ensure that significant adverse impacts of bottom fishing gear on Vulnerable Marine Ecosystems (VMEs) are avoided. In order to satisfy the requirements of Conservation Measure 22-06 a method is proposed to notify CCAMLR of the presence of VMEs and their location using a simple pro forma. Two VMEs identified during the Australian CEAMARC-CASO cruise are notified using this form from Statistical Division 58.4.1, SSRU H. The use of 5 n mile buffer zones around the location of the observations is proposed to mitigate the risk of spatial uncertainty in the notified position and the deployment of bottom-fishing gear.

SC-CAMLR-XXVII/BG/8
Assessment 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, 92 pp. (French, unpublished).

This report is the final document bringing together the results of a study carried out from 2004 to 2006 with the aim of assessing the impact of longline fisheries on populations of white-chinned petrels and grey petrels at Crozet and Kerguelen. This study was carried out at the request of the Association of Réunion Island Freezer Longliner Owners (SARPC) and the Administration of the French Southern and Antarctic Territories (TAAF).

This task was assigned to the Centre for Biological Studies at Chizé (CNRS), whose Marine Predator team, as part of the work assigned to the Paul Emile Victor French Polar Institute (IPEV), has been working for more than forty years on the ecology of marine birds and mammals of the TAAF.

It was carried out with the financial and logistical assistance of SARPC, TAAF, IPEV and the Ministry for Overseas Territories.

SC-CAMLR-XXVII/BG/10
Seabird by-catch in the French toothfish fishery: report of a cooperative study in 2008. Delegation of France, 76 pp. (English, unpublished).

SC-CAMLR-XXVII/BG/11
Regulatory instruments in place intended to reduce seabird mortality, directly or indirectly. Delegation of France, 5 pp. (French, unpublished).

During its 26th meeting, the Scientific Committee recommended that France submit a paper summarising the set of regulatory instruments in place within its legal system intended to reduce seabird mortality directly or indirectly.

The present document is submitted in this context. It lists the measures which are obligatory for vessels fishing for toothfish within the French EEZs around Kerguelen and Crozet. In addition, it gives a dynamic comparison with the situation as regards regulations in the previous year. These measures are binding and are subject to fines and administrative sanctions in the event of non-compliance. Inspectors permanently stationed on board the relevant vessels have legal capacity to record infractions of these measures. The measures are contained within Decree Nº 2008-62 of 23 July 2008 stipulating the rules governing the conduct of licensed fishing for toothfish (*Dissostichus eleginoides*), skates and rays (*Bathyraja eatonii*, *Bathyraja irrasa*, *Raja taaf*) and grenadiers (*Macrourus carinatus*) within the Kerguelen and Crozet Exclusive Economic Zones. This decree is available for consultation on the TAAF website (http://www.taaf.fr/spip/), together with the complete set of regulations in force within the TAAF.

SC-CAMLR-XXVII/BG/12
Deployment of a bird-scaring system at the hauling point on longliners harvesting toothfish in the French EEZs in Statistical Division 58.5.1 and Statistical Subarea 58.6 – 2007/08 season. Delegation of France, 19 pp. (French, unpublished).

As part of the strategy to reduce seabird by-catch in the French EEZs (Statistical Division 58.5.1 and Subarea 58.6), France has implemented the Scientific Committee's recommendation (paragraph 5.6(v) of the report) that the set of mitigation measures used be broadened, particularly during line-hauling. Details of developments in conservation measures taken by France in this domain are given in a separate document. The present document describes various practical details involved in the deployment of a bird-scaring device at the hauling point.

SC-CAMLR-XXVII/BG/13
The implications of climate change for CCAMLR fisheries and for the work of the Scientific Committee. Delegation of the United Kingdom, 17 pp. (English, unpublished).

SC-CAMLR-XXVII/BG/17
Report on the FAO-sponsored Workshop on Knowledge and Data on Deep-water Fisheries in the High Seas. CCAMLR Secretariat, 4 pp. (English, unpublished).

WG-EMM
Predator Survey Workshop

WG-EMM-PSW-08/4
A population estimate of macaroni penguins (*Eudyptes chrysolophus*) at South Georgia. P.N. Trathan (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, p.trathan@bas.ac.uk), 7 pp. (English, unpublished).

This paper describes methods and results from a recent aerial survey of the macaroni penguin population at South Georgia.

WG-EMM-PSW-08/5
The white-chinned petrel (*Procellaria aequinoctialis*) on South Georgia: population size, distribution and global significance. A.R. Martin, S. Poncet, C. Barbraud, P. Fretwell and E. Foster (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 17 pp. (English, unpublished).

More white-chinned petrels (*Procellaria aequinoctialis*) are accidentally killed in fisheries than probably any other seabird in the world, but the population impact of this mortality is poorly understood, partly because there have been no estimates of the species' abundance in recent decades. The largest breeding aggregation, comprising the majority of the worldwide total, is believed to be on the sub-Antarctic island of South Georgia. We estimated the size of this population by calculating the area of suitable habitat and the density of occupied burrows within it. Just less than one million pairs of white-chinned petrels laid on South Georgia in the survey seasons (2005/06 and 06/07). This is 50% of the previous estimate, but still represents around two-thirds of the global population. If the population is declining due to fishery by-catch off S America, as is likely, the scale of annual mortality in this population alone is at least in the high tens of thousands, and plausibly hundreds of thousands.

WG-EMM-PSW-08/6
Abundance estimates for crabeater, Weddell and leopard seals at the Antarctic Peninsula and in the western Weddell Sea (90°–30°W, 60°–80°S). J. Forcada and P.N. Trathan (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, jfor@bas.ac.uk), 9 pp. (English, unpublished).

This paper presents spatial modelling based abundance and density estimates of pack-ice seals, crabeater, Weddell and leopard seals, based on aerial survey line transect data collected in January 1999 under the Antarctic Pack-Ice Seal (APIS) program. Estimates are reported for the Antarctic Peninsula and the western Weddell Sea region (90º to 30ºW and 60º to 80ºS).

WG-EMM-PSW-08/7
Spatial and temporal variation in attributes of Adélie penguin breeding populations: implications for uncertainty in estimation of the abundance of breeding penguins from one-off counts. C. Southwell, J. McKinlay, R. Pike, D. Wilson, K. Newbery and L. Emmerson (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, colin.southwell@aad.gov.au), 10 pp. (English, unpublished).

Broad-scale surveys of penguin breeding abundance generally rely on on-off counts of adults, nests or chicks across several or many breeding sites, and the timing of these counts is

often outside the control of researchers. Time series counts of Adelie penguin breeding population attributes (adults, nest and chicks) within the breeding period show considerable variability across space and time (between years). Given this variability, there will be substantial uncertainty in correcting one-off counts with date-specific correction factors to estimate the population attempting to breed at the beginning of the breeding season.

WG-EMM-PSW-08/8

Estimating the number of pre- and intermittent breeders associated with the Béchervaise Island Adélie penguin population. L. Emmerson and C. Southwell* (*Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, colin.southwell@aad.gov.au), 19 pp. (English, unpublished).

The size of two of the inaccessible (non-breeding) components of the Adélie penguin population associated with the Béchervaise Island breeding population is estimated over the past decade using a series of mark-recapture analyses and some simple population modelling techniques.

WG-EMM-PSW-08/9

Aspects of population structure, dynamics and demography of relevance to abundance estimation: Adélie penguins. L. Emmerson and C. Southwell* (*Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, colin.southwell@aad.gov.au), 8 pp. (English, unpublished).

Counts of Adélie penguin populations are most conveniently and most often undertaken at breeding sites during the breeding season. The objective of this paper is to identify and describe the aspects of Adélie penguin population structure, dynamics and demography that are relevant to the interpretation of counts made at breeding sites and the estimation of overall population abundance derived from such counts. To appreciate what counts conducted at different times within a breeding season represent, it is important to understand the population dynamics of the different components of the population throughout the breeding season. The conceptual model described here is specifically based on data obtained from the Adélie penguin population at Béchervaise Island, East Antarctica. While the various life stages described here are also likely to represent other Adélie penguin populations, details in the proportion of each category either at the breeding site or at sea may potentially differ.

WG-EMM-PSW-08/10

Flying seabirds in Area 48: a review of population estimates, coverage and potential gaps in survey extent and methods. D. Wilson (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, david.wilson@aad.gov.au), 15 pp. (English, unpublished).

Published accounts of population surveys and population estimates for flying seabirds across Area 48 are reviewed. Spatial coverage of count data and population estimates varies greatly between species across their breeding ranges in Area 48. Most population estimates reviewed date from the 1970s and 1980s. Survey methodologies are often poorly described. Potential biases and uncertainties around existing estimates are rarely discussed.

WG-EMM-PSW-08/11

Seasonal estimation of abundance by bootstrapping inexact research data (SEABIRD): a method for assessing abundance and uncertainty from historical count data using Adélie penguins as a case study. J.P. McKinlay and C.J. Southwell (Australian Antarctic

Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, john.mckinlay@aad.gov.au), 3 pp. (English, unpublished).

In addition to a review of published studies on Adélie penguin abundance at breeding sites in Antarctica, Southwell (2004) proposed a general abundance estimator appropriate for a species of that kind. The present study attempts to implement this estimator in the form of a parametric bootstrap model, utilising as input data published counts of Adélie penguins and estimates of their uncertainty at breeding sites in Antarctica. To achieve this task, a menu-driven suite of routines titled SEABIRD (Seasonal Estimation of Abundance by Bootstrapping Inexact Research Data) has been developed in the R language for statistical computing (R Development Core Team, 2008). Software is reliant on data being presented in a specified format congruent with CCAMLR databases designed to store historical survey data relating to penguin abundance. Usual sampling methodology considerations reported in work of this kind are accommodated, such as availability and perception bias, as well as many of the vagaries associated with combining diverse data collected in a variety of ways over many decades. Of particular concern was to ensure that different types of counts (e.g. nests, chicks or adults), perhaps made at different time points in a breeding season, might usefully be combined in order to obtain regional-scale estimates of abundance. This was achieved by using independent estimates of availability throughout a breeding season collected at a few, frequently sampled sites, in order to standardise historical estimates to a common reference point of breeding chronology. Equally important was the idea that estimates of uncertainty associated with historical counts be faithfully incorporated and preserved, and methods have been developed to allow these to be combined or interpreted in several different ways. In order to help understand how these and other elements of the procedure contribute toward estimates of uncertainty when combining data, as far as practical different components of the estimation process can be switched on or off to assess their effect. Confidence intervals for final estimates at different scales of spatial aggregation are determined by examining the bootstrap distribution of population estimates at selected percentile intervals. While tailored for Adélie penguins, the method and implementation is sufficiently general to potentially be adapted for other Antarctic species showing seasonal variation in availability to sampling methodology. At the time of writing, SEABIRD is well developed but still very much an evolving work. It is anticipated that use of the software and discussion of the estimation issues involved will identify possibilities for improvement.

WG-EMM-PSW-08/12

A brief summary of Adélie penguin count data from East Antarctica. C. Southwell and J. McKinlay (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, colin.southwell@aad.gov.au), 7 pp. (English, unpublished).

This paper very briefly summarises some aspects Adélie penguin count data from East Antarctica to demonstrate the extent and nature of variability in data from this large region, and to provide some background to some aspects of the R program SEABIRD outlined in McKinlay and Southwell (submitted working paper).

WG-EMM-PSW-08/13

Incomplete search effort as a potential source of bias in broad-scale estimates of penguin abundance derived from published count data: a case study for Adélie penguins in East Antarctica. C. Southwell, D. Smith and A. Bender (Australian Antarctic Division,

Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, colin.southwell@aad.gov.au), 10 pp. (English, unpublished).

Potential Adélie penguin breeding habitat (defined as ice-free land with area >4 000 m^2 and within 500 m of the ocean) in the Australian Antarctic Territory (AAT) was mapped using a GIS, and the literature reviewed for evidence of the mapped habitat being searched for occupation by breeding Adélie penguins. The total area of potential breeding habitat was estimated to be close to 700 km^2. Definitive or reasonably strong evidence of search effort was found for 63% of all potential habitat sites and 40% of the total potential habitat area. There were marked regional differences in search effort, and the majority of search effort occurred in the 1980s. Incomplete search effort is a possible source of negative bias for AAT-wide estimates of Adélie penguin breeding abundance derived from published search effort and count data.

WG-EMM-PSW-08/14

Antarctic fur seal pup production and population trends in the South Shetland Islands with special reference to sources of error in pup production estimates. M.E. Goebel, D.E. Torres C., A. Miller, J. Santora, D. Costa and P. Diaz (Antarctic Ecosystem Research Division, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, mike.goebel@noaa.gov), 33 pp. (English, unpublished).

This paper reports the results of a ground survey of fur seal colonies from in the South Shetland Islands in 2007/08. Multiple counts of pups at each colony were conducted to establish confidence limits on pup production. Total pup production was 7 602 (±103) pups down 24.4% from the last census in 2001/02 (10 057 ± 142 pups born). Dead pups accounted for 1.64% of the total. A comparison with previous censuses over a 20-year period (1987, 1992, 1994 and 1996) indicates the rate of increase in fur seal populations has diminished substantially. The averaged annual rate of increase from 1987–1994 was between 13.5–13.9%. From 1994–1996 it was 8.5% and from 1996–2002 the average annual rate was +0.9%. Since 2001/02, pup production for the entire archipelago declined at an average annual rate change of –4.3%. Sources of error in pup production estimates include unobserved neonate mortality prior to census, natality rates of the adult female population and leopard seal predation on pups. Neonate mortality up to 30 days after the median date of pupping was estimated for the years 1997–2007 at 4.5% (±0.60). Adult female natality for the same period was 0.79 (±0.02) and in 2007/08 was below average at 0.73. Leopard seal predation was estimated from the rate of mother-pup failed pairs after pups begin entering the water (~30d after the median date of pupping [MDP]). Leopard seal predation for the first 75d post MDP for 2003–2007 was estimated at 0.376 (±0.043) and for the 2007/08 was above average at 0.522. Thus, higher neonate mortality, reduced natality, and an increase in leopard seal predation all contributed to lower pup production estimates in 2007/08.

WG-EMM-PSW-08/15

Timing of clutch initiation in *Pygoscelis* penguins on the Antarctic Peninsula: towards an improved understanding of off-peak census correction factors. H.J. Lynch, W.F. Fagan, R. Naveen, S.G. Trivelpiece and W.Z. Trivelpiece (Department of Biology, University of Maryland, College Park, MD 20742, USA and Oceanites Inc, PO Box 15259, Chevy Chase, MD 20825, USA, hlynch@umd.edu), 29 pp. *CCAMLR Science*, submitted (English).

Penguin censuses on the Antarctic Peninsula are often subject to logistical challenges that preclude nest censuses being conducted at the peak of egg laying as established by the CCAMLR Ecosystem Monitoring Program (CEMP) (Scientific Committee for the

Conservation of Antarctic Marine Living Resources, 2004). Additionally, the historical literature, necessary for establishing baseline conditions, also includes many census counts with non-standard timing. The challenge is, therefore, to correct 'off-peak' census counts to make them comparable with current standard methods. Census correction involves knowing 1) how the census is timed relative to the peak of egg laying and 2) how nest numbers change through the breeding cycle. In this paper we present an analysis relating to both of these two challenges. Clutch initiation dates for four penguin breeding sites are examined (Cape Shirreff, Livingston Island (62°28'S, 60°46'W), Admiralty Bay, King George Island (62°10'S, 58°30'W), Humble Island (64°46'S, 64°06'W), and Petermann Island (65°10'S, 64°10'W)) in relationship to potential drivers of clutch initiation (e.g. temperature, precipitation, sea ice, sea surface temperature, etc.). We find that mean October temperatures constitute the most consistent significant factor related to the timing of clutch initiation in all three of the penguin species examined (Adélie, gentoo, and chinstrap). We present a statistical model for determining the peak of clutch initiation for any given year and site and, along with a simple estimation of species-specific nest attrition rates, we use this model to step through the procedure for correcting off-peak census counts.

Ad Hoc Technical Group on At-Sea Operations (TASO)

TASO-08/4

Description of the French fishery inside the CAMLR area (Subarea 58.6 and Division 58.5.1) for TASO meeting, July 2008. N. Gasco, G. Duhamel and P. Pruvost (La Clotte, L'ermitage, 33550 Tabanac, France, nicopec@hotmail.com), 4 pp. (English, unpublished).

This paper describes French fishery targeting Patagonian toothfish inside CCAMLR area, what are the data collected and how they are checked, a short description of prioritisation of observer's task is given.

TASO-08/5

Performance management of observers in CCAMLR and domestic sub-Antarctic fisheries by the Australian Antarctic Division and the Australian Fisheries Management Authority. D. Welsford, K. O'Regan, T. Lamb and T. Robertson (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, dirk.welsford@aad.gov.au), 12 pp. (English, unpublished).

Australia's sub-Antarctic and Antarctic fisheries observer program is administered by the Australian Fisheries Management Authority (AFMA), with technical and data management support from the Australian Antarctic Division (AAD). Australian observers work on both trawl and longline vessels targeting finfish in the CCAMLR area. As the assessments and conservation measures employed by CCAMLR increase in sophistication, the tasks required to be completed by observers are increasing in number and complexity. Such a set of qualities is rarely available 'off the shelf'. To ensure that observers in these fisheries are able to complete the broad range of task required under the CCAMLR System of International Scientific Observation (SISO) and under domestic legislation, a system of performance management and data quality assurance has been developed. This system covers all aspects of the observers' experience in the work place, from initial recruitment through training,

accreditation and ongoing performance assessment. Australia considers the use of such a performance management system to be essential in ensuring that high quality data continues to be collected by SISO.

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

WG-SAM-08/4

Analysis of the potential for an assessment of toothfish stocks in Divisions 58.4.1, 58.4.2. D.J. Agnew, C. Edwards, R. Hillary, R. Mitchell and L.J. López Abellán (Fisheries Group, Division of Biology, Imperial College London, Prince Consort Road, London SW7 2BP, United Kingdom, d.agnew@imperial.ac.uk), 29 pp. (English, unpublished).

Exploratory fisheries for *Dissostichus* spp. have been operating in these regions for a number of consecutive years with the tagging of toothfish a prerequisite for the legal fishery. This paper presents a detailed study of the catch and effort trends in Divisions 58.4.1 and 58.4.2 and a examines 4 assessment methods based on comparative CPUE trends, local depletions, a constant recruitment model and mark recapture data.

WG-SAM-08/5

Exploratory assessment methods for exploratory fisheries: an example case using catch, IUU catch and tagging data for Sub-area 58.4.3a. R.M Hillary (Division of Biology, Imperial College London, Prince Consort Road, London SW7 2BP, United Kingdom, r.hillary@imperial.ac.uk), 12 pp. *CCAMLR Science*, submitted (English).

This paper details a potential methodology for performing initial stock assessments for exploratory fisheries and by-catch species, where catch data and mark-recapture data are present but more detailed data, specifically age or length structured data on catches or surveys, is either missing or poorly sampled. As an example case we use the catch data, legal and IUU, and the mark-recapture data in Sub-area 58.4.3a to demonstrate the potential uses of the model and also suggest potential catch limits for this stock, based on these results.

WG-SAM-08/6

Defining tag rates and TACs to obtain suitably precise abundance estimates for new and exploratory fisheries in the CCAMLR Convention Area. R.M. Hillary (Division of Biology, Imperial College London, Prince Consort Road, London SW7 2BP, United Kingdom, r.hillary@imperial.ac.uk), 7 pp. *CCAMLR Science*, submitted (English).

This paper outlines a method of calculating suitable tagging rates and total allowable catches (TACs) that would be expected to yield a pre-specified precision in a resultant abundance estimate. With respect to the tagging-based abundance estimator, we use the Lincoln-Petersen method and derive a formula that gives the expected coefficient of variation of the abundance estimate in terms of the number of releases and recaptures, which can in turn be expressed in terms of the tagging rate per tonne caught, the catch taken and the postulated underlying exploitable biomass. This relationship is shown to be extremely useful in terms of defining suitable catch levels and tagging rates required to obtain a given precision in the Petersen abundance estimate. To show the reliability of the precision relationship we predict the expected abundance precision using the mark and recapture data for Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3, and compare this to the precision in the abundance predicted by the integrated stock assessment. To show the usefulness of the

methodology to new and exploratory fisheries we estimate the required TAC, for a given range of observed tagging rates, that would give us an abundance estimate with a coefficient of variation of 30% for the Patagonian toothfish stock in Subarea 48.4.

WG-SAM-08/7

Analysis of Ross Sea tagging and recapture rates. D.J. Agnew (Fisheries Group, Division of Biology, Imperial College London, Prince Consort Road, London SW7 2BP, United Kingdom, d.agnew@imperial.ac.uk), 11 pp. (English, unpublished).

1. A dataset of all possible combinations of release nation, recapture nation, release year and recapture year for tags released and recaptured in the same SSRUs on the slope of 88.1 was compiled for the years 2003–2006. Recapture rate was expressed as tags captured/tags released/fish scanned (caught), all in numbers.
2. The overall size of the dataset was 734 combinations of release year, recapture year, SSRU, release nation and recapture nation, with 193 recaptures. Despite this size, fishing has not been consistent enough between nations to allow the analysis to be definitive. In many cases, release or recapture nation effects were not significant. In the cases where significant differences existed, recapture rates were usually highest with New Zealand tagged and recaptured fish, although there was some evidence for suggesting that recapture rates are highest when the fleet and tagging fish is the same.
3. This method could be used to identify groups of nations that have similar reporting rates, for inclusion in the Ross Sea stock assessment.

WG-SAM-08/8

Towards the balanced stock assessment of Antarctic toothfish in the Ross Sea. D. Vasilyev and K. Shust (VNIRO, 17a V. Krasnoselskaya, Moscow 107 140, Russia, antarctica@vniro.ru), 8 pp. (English, unpublished).

Last two years two different approaches were used for stock assessment of Antarctic toothfish in the Ross Sea. One of them, the CASAL model, (Dunn and Hanchet, 2007; Bull et al., 2007) is mostly based on likelihoods and potentially could insure proper mutual weighting of signals from all available sources of information incorporated into the model. The second one, the TISVPA model (Vasilyev, 2005, 2006; Vasilyev et al., 2006, 2007), takes care about robustness of analysis and includes a number of features aiming at consistent assessment using real (that is usually noisy and containing outliers) data. Besides that, some sorts of data, e.g. tagging data, are used in these models in quite different ways. Comparison of the results shows also that the input to the solution from different sources of information was also quite different: while in TISVPA all sources of data gave rather coherent signals about the stock (Vaslilyev et al., 2007), in CASAL the solution was mostly supported by signals from tagging data (Dunn and Hanchet, 2007), especially strong being the influence of fish tagged in 2006 and caught in 2007, driving the stock estimate down.

WG-SAM-08/9

Reconstruction of size and weight composition of Antarctic toothfish (*Dissostichus mawsoni*) from the data on processed commercial catches of longliners using conversion factor. I. Istomin, K. Shust and V. Tatarnikov (VNIRO, 17a V. Krasnoselskaya, Moscow 107 140, Russia, antarctica@vniro.ru), 17 pp. (Russian and English, unpublished).

Reconstruction of size and weight composition of Antarctic toothfish (*Dissostichus mawsoni*) from the data on processed commercial catches of longliners using conversion factor.

WG-SAM-08/10

Revised estimates of the area of the South Georgia and Shag Rocks shelf (CCAMLR Subarea 48.3). M. Belchier and P. Fretwell (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, markb@bas.ac.uk), 12 pp. *CCAMLR Science*, submitted (English).

A new South Georgia bathymetric dataset (SGDB) was compiled from a variety of primary sources including multi-beam swath bathymetry. Seafloor area (km^2 <500 m depth) within CCAMLR Subarea 48.3 was calculated using this new dataset. Total seafloor area within the region closely matched existing estimates derived from nautical charts (and single point sounding data). However, the reliability of existing seafloor area estimates were found to vary spatially and between different depth strata. The new dataset is considered the most accurate and reliable currently available and should be used for future assessments and for assisting with the stratification of surveys.

WG-SAM-08/11

A proposed 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, anabela.brandao@uct.ac.za), 30 pp. *CCAMLR Science*, submitted (English).

Four Operating Models (OMs) reflecting an 'Optimistic', 'Intermediate', 'Less Pessimistic' 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 TAC recommendations for this resource. The MP uses two data sources: the recent trend in longline CPUE and the mean length of the catches made. A specific MP, with its associated control parameter values, is proposed for implementation based upon the results of the trials. Given the importance of an adequate catch rate for the economic viability of the fishery, the choice of control parameter values focused primarily on a reasonable probability of securing a catch rate increase, whatever the current resource status. MP performance is reasonably robust across a range of sensitivity tests, though does deteriorate in conservation terms if steepness h is low. These tests also indicate that monitoring of future catch-at-length information would be necessary to guard against a change in selectivity towards greater catches of older fish.

WG-SAM-08/12

Extrapolating continuous plankton recorder data through the Southern Ocean using boosted regression trees. M.H. Pinkerton, A.N.H. Smith, B. Raymond, G. Hosie and B. Sharp (National Institute of Water and Atmospheric Research Ltd (NIWA), Private Bag 14901, Wellington, New Zealand, m.pinkerton@niwa.co.nz), 29 pp. (English, unpublished).

Innovative multivariate statistical modelling techniques make it possible to generate spatially comprehensive species distribution layers from discontinuous biological data, by fitting complex and scale-dependent relationship between species abundance and available environmental data. The resulting species-specific distribution layers have many potential applications.

We apply one such method, called BRT (boosted regression trees), to data on the distribution of *Oithona similis*, a small cyclopoid copepod which is abundant through much of near-surface waters of the Southern Ocean. A large dataset (>19 000 records) of abundances of *O. similis* were measured during the SCAR Southern Ocean Continuous Plankton Recorder

(SO-CPR) Survey. We demonstrate that it is possible to obtain a relationship between both the abundance and the probability of presence of *O. similis* and the long-term, broad-scale environmental conditions of the location where the CPR sample was taken. These fitted relationships were used to estimate abundances of *O. similis* through the Southern Ocean.

We present a number of methods for investigating the robustness of the prediction. (1) Non-spatial cross validation tested the relationship against data withheld from the fitting. We found that the data withholding of data from the model fitting must be done on a tow by tow basis as there is significant within-tow correlation. (2) Spatial cross-validation withheld data from particular geographic regions from the fitting process and used these subsequently to test the predictive accuracy of the model. These cross-validation methods showed that the fitted relationships explained 28–38% of the total variance in abundance (depending on method of cross-validation). The area under the ROC for the model predicting presence was 0.77 indicating good discrimination between presence and absence. (3) Spatially-resolved measures were used to test how well the environmental space of the predicted area was spanned by the environmental characteristics associated with the biological samples. This method was applied to the individual environmental data layers singly and to multivariate space defined by all environmental data layers together. The multivariate statistic was used to create a 'mask' which excluded from prediction those geographic areas of the Southern Ocean where environmental conditions were not well represented by the SO-CPR sample locations.

WG-SAM-08/13

Development of a methodology for data quality assessment. D.A.J. Middleton and A. Dunn (NZ Seafood Industry Council (SeaFIC), Private Bag 24-901, Wellington, New Zealand, middletond@seafood.co.nz), 32 pp. (English, unpublished).

Measures are developed which aim to summarise the quality of fishing event, catch, and biological sampling data from a fishing trip. In particular these measures aim to quantify the prevalence of position or time reporting errors, the diversity of catch, the extent to which catch data follow Benford's Law for the distribution of the first significant digit, whether length frequency data have been collected as expected, and the reliability of length-weight measurements. Individually these measures can assist in assessing which data from a trip should be used in an assessment, and can also guide how these data can best be used.

The quality of tag data is hard to assess. A methodology is developed to use data quality measures for other data sets to group trips on the basis of their overall data quality. Ongoing development of this method is intended to provide a consistent basis for selecting the tagging data set that is fitted in an assessment model.

The data quality measures illustrate sometimes substantial variation in the quality of particular data sets from different trips in the Ross Sea Antarctic toothfish fishery. Cluster analyses suggests two groups of trips, one of which can tentatively be considered to have better data. Tags released by trips in this latter group have been recaptured at a higher rate than tags released by the other group of trips.

WG-SAM-08/14

Development of a spatially explicit age-structured statistical catch-at-age population dynamics model for modelling movement of Antarctic toothfish in the Ross Sea. A. Dunn and S. Rasmussen (National Institute of Water and Atmospheric Research Ltd (NIWA), Private Bag 14901, Wellington, New Zealand, a.dunn@niwa.co.nz), 31 pp. *CCAMLR Science*, submitted (English).

We present a generalised spatially explicit Bayesian statistical catch-at-age population dynamics model (SPM) for developing and investigating plausible spatial movement models, and apply a preliminary development version of this model to Antarctic toothfish in the Ross Sea as an age and maturity state spatial movement model.

SPM is an aggregate movement model suitable for use with large numbers of areas, and is implemented as a discrete time-step state-space model that represents a cohort-based population age structure in a spatially explicit manner. The model is parameterised by both population processes (i.e. ageing, recruitment and mortality), as well as movement processes defined as the product of a set of preference functions that are based on known attributes of spatial location. SPM was designed to be flexible, allow for the estimation of both population and movement parameters based on local or aggregated spatially explicit observations, and optimised for speed.

Model validation consisted of three types: implementation checking; development-driven unit tests; and comparative software evaluation. Comparisons with expected output from CASAL and movement processes coded in S+/R were essentially identical, and estimates of example parameters for models implemented in both CASAL and SPM gave essentially identical results.

We have also developed a preliminary model for Antarctic toothfish in the Ross Sea and describe the spatial and population structure and processes, data, observations, and likelihoods used to estimate movement parameters. The model was a single sex model that categorised fish as immature, mature, or spawning. Observations included within the model were spatially explicit commercial catch proportions-at-age and CPUE indices. While we caution that model results are preliminary, we note that they appeared reasonable, and suggested immature fish were located in the southern Ross Sea on the continental shelf, mature fish were located on the continental slope, and spawning fish were located on the northern banks of the Ross Sea. The results also suggested that parameterising of movement based on latitude, depth and distance provided a significantly better fit to the observations than a model where depth was ignored.

However, further development to the SPM model is required, including processes and observation classes to incorporate year class variability, stock recruitment relationships, tag-release and tag-recapture observations, and maturation state observations. Further, the current implementation of the MCMC algorithm in SPM is only partially complete, and there is some further work on parallelisation algorithms for MCMC that could be investigated. And, in order to address the questions of the adequacy of the Antarctic toothfish Ross Sea assessment model, SPM needs to be modified to allow simulation of observations from underlying movement parameters. Finally, once adequate models for Antarctic toothfish in the Ross Sea have been developed using SPM, the current assessment model (Dunn and Hanchet 2007) would need to be evaluated within a simulation-experiment in order to address current assessment model uncertainties.

WG-SAM-08/15

Implementation of FOOSA (KPFM) in the EPOC modelling framework to facilitate validation and possible extension of models used in evaluating krill fishery harvest strategies that will minimise risk of localised impacts on krill predators. A. Constable (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, andrew.constable@aad.gov.au), 41 pp. (English, unpublished).

This paper details how FOOSA, an operating foodweb model for evaluating spatially-structured harvest strategies for krill, has been implemented within the EPOC modelling

framework. It also shows how the parameters developed for use in FOOSA can be adapted for use in EPOC. The paper has three main parts – an outline of the structure of EPOC, consideration of the general FOOSA structure that needs to be implemented and a description of the implementation of FOOSA in EPOC. The latter section includes the methods used for implementing environmental variability, the krill population, generic predators, the krill fishery and the system for setting catch limits. The process of implementing FOOSA in EPOC has been a useful opportunity to consider the functions needed to represent different processes in a minimal realistic model. A number of revised functions are developed as options to reflect different dynamics that may be present in the krill–predator–fishery system in Area 48. Some of these functions and model structures have been generalised to enable more predators to be included in the food web and to provide flexibility in the number of stages of a predator consuming krill. An important step now in the implementation of FOOSA in EPOC is for this implementation to be reviewed by the developers of FOOSA.

WG-SAM-08/16

An ecosystem-based management procedure for krill fisheries: a method for determining spatially-structured catch limits to manage risk of significant localised fisheries impacts on predators. A. Constable and S. Candy (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, andrew.constable@aad.gov.au), 35 pp. *CCAMLR Science*, submitted (English).

In this paper, we develop an ecosystem-based, precautionary management procedure for krill fisheries which draws together past experience in CCAMLR. It provides an empirical ecosystem assessment model, a decision rule for determining local scale catch limits based on a harvest strategy and a single-species assessment of yield, and a method for implementing the procedure. The decision rule for setting catch limits for a given harvest strategy has a straight forward expression of the target conditions to be achieved and the uncertainties that need to be managed and does not assume an understanding of predator-prey dynamics beyond that evident in the data. It is a natural extension of the current precautionary approach of CCAMLR for krill and can utilise existing datasets, including B_0 surveys, local scale monitoring of krill densities, local-scale monitoring of predator performance, monitoring of predator foraging locations and time series of catches from the fishery. This procedure provides a common framework for inserting data, assessment methods and candidate modelling approaches for assessing yield. Consequently, its formalism means there is no need to undertake a staged approach in providing advice. The advice can be updated as improvements are made in any component of the procedure, including the provision of data, implementation of new assessment or projection models or a revision of the decision rule. This framework formalises the decisions that need to be made in dealing with an ensemble of food web models for providing suitably precautionary advice on how to spatially structure krill fisheries to account for the needs of predators. It provides the primary expectation for managing uncertainty, either by obtaining better estimates of parameters for the projection models and/or by altering the harvest strategy. Consequently, a preferred harvest strategy, which is initially untenable because of the uncertainties associated with its ecosystem impacts, could become a suitable option if its related uncertainties are reduced. Conceivably, the procedure outlined here could be used in a spatially-structured feedback management system that can ensure CCAMLR is able to respond to trends in the status of the ecosystem, including trends arising from climate change.

WG-SAM-08/17

An updated description and parameterisation of the spatial multi-species operating model (SMOM). 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), 35 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. The model includes krill as prey and four predator groups (penguins, seals, fish and whales) in each of 15 SSMUs. A number of updates have been made to the model such as linking krill growth rate to sea surface temperature, and these are described here. Moreover, the methodology used to condition the model using the WG-SAM set of reference observations for Area 48 (the SAM calendar) is described. Alternative combinations of model parameters essentially try to bound the uncertainty in, for example, the choice of survival rate estimates as well as the functional relationships between predators and prey. An example is given of how this operating model can be used to develop a management scheme which includes feedback through management control rules.

WG-SAM-08/P1

Resources evaluation of Antarctic krill *Euphausia superba* Dana using areal trawling and hydro-acoustic data. L.A. Kovalchuk. 2004. *Ukrainian Antarctic Journal*, 2: 170–178.

Quantitative method for describing krill mass congestions based on perennial observations using trawling and hydroacoustic data is proposed. Reliable evaluation of krill resources is provided with probability methods and spatial analyses requiring knowledge of statistical distribution rules applicable for natural habitat and equal probability concentrations. Spatial analyses of krill population densities have shown mixed rules of statistical distribution over its natural habitat. Data analyses procedures applied for trawling and hydro-acoustic sampling have to in compliance with the rules of statistical distribution and principles of metrology. Division of natural habitat of the Antarctic krill into regions is based on a principle of equal probability applied for congestions instead of the principle of equal proportions. Metrological features of evaluating population densities of krill are revealed. Standard measures for the population densities of krill in natural habitat are not available, thus it is principally impossible to structure systems and random errors in evaluating process, to define their impact on final evaluation of the resource. Special metrological principles are required and proposed for the correct evaluations based on reproducibility of statistic distribution parameters for krill and minimizing miscalculations in evaluations of congestions. Evaluations regime applied for the population density of krill should be defined by reliability and admissible error of estimated resource. Traditional concepts of observation system concerning the resources of krill should be further developed with applications of rules and parameters dealing with statistical distributions of population density, information about sources of errors, tools and methods of evaluation, standard techniques of minimizing errors in evaluations taking into account biological features of krill development. Methodical standards and uniform evaluation criteria for parameter evaluations of statistical distributions should be proposed to the Countries participating in the Antarctic Treaty as proceedings regarding minimal errors in the evaluation procedure. Reliable evaluation of krill resources requires advanced technical tools and observation systems. Population density values for krill

should be calculated using Aitchison delta distribution. Primary statements regarding the krill in strategic planning for fisheries should include relevant biologically valid evaluations of population numbers for krill with the maintained reliability requirements and reasonable errors in evaluating the density of populations.

WG-SAM-08/P2

Methodology of evaluating the aquatic life resources. L.A. Kovalchuk. 2006. *Report of the National Academy of Science of Ukraine*, 12: 150–157.

The methodology of reliable estimates of the specific concentrations and stocks of aquatic life is developed in accordance with the rules of metrology, mathematical statistics and using the biocenological regularities of water objects. The basis of evaluating the stocks of water life was investigated through biocenotic conditionality in the areas of their equal probability in concentrations. The traditional method of squares in evaluating the stocks of water life was modernized with the use of probabilistic approach, the required knowledge of rules of statistical distributions of its specific concentration. Allocation of borders in the areas of probably equal concentrations of aquatic life applied in the proposed technique offer the mean integral values of probabilities. It is recommended to minimize errors of evaluation of the aquatic life resources using the statistical method of producing the average values if it is stated that casual component is more than two times higher of the regular component in a resulting error of evaluation of the average specific concentration of water life.

WG-SAM-08/P3

SeaBird: Draft User Manual V1.00-2008/06/18. D. Fu and R.I.C.C. Francis. *Final Fisheries Report to the New Zealand Ministry of Fisheries*.

SeaBird is a generalised age- and/or stage-structured seabird population dynamics model that allows a great deal of flexibility in specifying the population dynamics, parameter estimation, and model outputs. The manual provides information on how to use SeaBird, including how to run it, how to set up the input files, descriptions of the population dynamics and estimation methods, and how to generate outputs. It also contains a brief overview of the technical specifications of the software, and examples of models using SeaBird.

SeaBird is designed for flexibility. It allows the user to structure the modelled population in the way that best suits the available data. Depending on these data the user may which to specify the population structure using some or all of the following characteristics: age, life stage (e.g., immature or mature), sex, or behaviour (e.g., in any year mature birds may be classified as breeders or non-breeders). Interactions with fisheries can be modelled and the user can choose the sequence of events in a model year. A wide variety of types of data can be used. Estimation can be by maximum likelihood or Bayesian. As well as generating point estimates of the parameters of interest, SeaBird can calculate likelihood or posterior profiles and can generate Bayesian posterior distributions using Monte Carlo Markov Chain methods. SeaBird can project population status into the future under various alternative scenarios.

SeaBird was designed to share many features and concepts with the fishery stock assessment model CASAL (Bull et al., 2005) and users of the latter program will find it easy to adapt to SeaBird. However, there are some important differences between the programs that are described.

Working Group on Ecosystem Monitoring and Management (WG-EMM)

WG-EMM-08/4

CEMP indices: 2008 update. CCAMLR Secretariat, 95 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 7 Members for 10 sites and 13 different CEMP parameters for the 2007/08 season. No data was submitted from Edmonson Point and Ross Island; however counts from aerial photographs taken at Ross Island for the previous five seasons are being undertaken.

There has been a general decline in the number of parameters submitted from the monitoring sites.

WG-EMM-08/5

Krill fishery report: 2008 update. CCAMLR Secretariat, 26 pp. (English, unpublished).

As reported to the CCAMLR Secretariat, 6 vessels from 5 Contracting Parties are fishing for krill in Area 48 in the 2007/08 season, and these vessels have taken 84110 t of krill to date. The preliminary estimate of the total catch of krill for the season is approximately 108343 t. This compares with 104586 t of krill reported in the STATLANT data for 2006/07. With the exception of Poland, all Contracting Parties have submitted complete sets of haul-by-haul data for 2006/07.

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; Consideration of the Conservation Measures in force in the fishery. Reference information on stock and areas, and parameters used in stock assessment are also included.

WG-EMM-08/6

Summary of notifications for krill fisheries in 2008/09. CCAMLR Secretariat, 129 pp. (English, unpublished).

This paper summarises the notifications received from Members intending to participate in krill fisheries in the CCAMLR Convention Area in the 2008/09 season.

WG-EMM-08/7

Demography of Antarctic krill and other Euphausiacea in the Lazarev Sea – LAKRIS the German contribution to CCAMLR-IPY in summer 2008. V. Siegel, J. Edinger, M. Haraldsson, K. Stürmer, M. Vortkamp (Seafisheries Research Institute, Palmaille 9, 22767 Hamburg, Germany, volker.siegel@vti.bund.de), 10 pp. (English, unpublished).

A standardised krill net sampling survey was conducted in the Lazarev Sea (CCAMLR Subarea 48.6) in austral summer during December/January 2007/08 (LAKRIS, Lazarev Krill Study) as a German contribution to CCAMLR-IPY 2008. At the start of the survey period the entire survey area was completely covered with seasonal pack-ice, but rapidly retreating until the end of the survey in late January. 52 samples were taken by RMT 8 and RMT 1 along three transects south of 60°S. Krill and other Antarctic Euphausiacea species densities were

estimated from both RMT net samples. Length and maturity stage composition and seasonal development of maturity stages were analysed. Distribution and density of krill larvae are provided for the Lazarev Sea.

WG-EMM-08/8
Report of the Predator Survey Workshop. (Hobart, Australia, 16 to 20 June 2008), 54 pp. (English, unpublished).

WG-EMM-08/9
Report from Invited Expert to WG-EMM-PSW-08. R. Fewster (Invited Expert, University of Auckland, Department of Statistics, Faculty of Science, r.fewster@auckland.ac.nz), 4 pp. (English, unpublished).

WG-EMM-08/10
Reference observations for validating and tuning operating models for krill fishery management in Area 48. S. Hill, J. Hinke, E. Plagányi and G. Watters (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, sih@bas..ac.uk), 17 pp. (English, unpublished).

In 2007 WG-SAM defined a set of reference observations for validating and tuning proposed models to evaluate krill catch allocation options for Area 48 (the SAM calendar). The observations, which were endorsed by WG-EMM, were largely qualitative and relative. We used available data to translate these observations into numerical terms (the numerical calendar). We provide spatially-resolved reference points for the density of krill, and the abundance of "generic" seals, penguins and whales in 1970, 2007 and at least one intermediate year. Recent work on baleen whales indicates a higher growth rate than that suggested by WG-SAM, so the numerical calendar for this taxon deviates from the SAM calendar. The numerical calendar is a partly subjective interpretation of limited data and should not be considered a definitive description of the relevant dynamics. This exercise resulted in population sizes for several taxa that are adjusted for asynchronous observations and are potentially more suitable for initialising models than those published in Hill et al. (2007).

WG-EMM-08/11
Proposed small-scale management units for the krill fishery in Subarea 48.4 and around the South Sandwich Islands. P.N. Trathan, A.P.R. Cooper and M. Biszczuk (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, p.trathan@bas.ac.uk), 13 pp. (English, unpublished).

Relatively little ecological information is available for the South Sandwich Islands, so the diversity of information available to determine potential SSMU boundaries is limited. Nevertheless, a suggested SSMU is proposed, based on the foraging distance of the most abundant land-based consumer of krill breeding on the islands, the chinstrap penguin. The proposed SSMU represents a single ecological entity with no internal boundaries. It is based on the best information currently available.

WG-EMM-08/12
Allocating the precautionary catch limit for krill amongst the small-scale management units in Area 48: the implications of data uncertainties. P.N. Trathan and S.L. Hill (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, p.trathan@bas.ac.uk), 34 pp. (English, unpublished).

Over the past few years WG-EMM has been developing a management procedure for the krill fishery in Statistical Area 48. This procedure will involve, inter alia, subdivision of the precautionary catch limit among a set of small-scale management units. So far the Working Group has identified six candidate methods for subdividing the catch limit and rejected one of them as unsuitable (Option 1 - subdivision based on the distribution of historical catches). In recognising the need for a "staged development" of the management procedure, the Working Group has agreed to defer the development and evaluation of two further options (Option 5 - adjustable catch limits within SSMUs and Option 6 - structured fishing) until a future date. The remaining three options propose subdividing the catch limit according to the distribution of predator demand (Option 2), krill standing stock (Option 3), or the difference between these two (Option 4). In this paper we review the uncertainties relating to the spatial distribution of predator demand and krill standing stock and assess their potential implications. We consider that a strong case can be made against Option 4, which is likely to increase ecosystem risk when the underlying estimates of consumption and/or standing stock are uncertain, especially when they are biased. We suggest that the data documenting the distribution of krill standing stock are likely to be more reliable than those documenting the distribution of predator demand, leading us to favour the use of Option 3. However, we note that though Option 3 appears to be the most favourable, there is little documentary information about temporal variability in the spatial distribution of krill biomass, emphasising the need for monitoring and model-based risk assessments. Finally, we conclude that WG-EMM cannot delay the subdivision of the precautionary catch limit without incurring some risk.

WG-EMM-08/13

Developing four plausible parameterisations of FOOSA (a so-called reference set of parameterisations) by conditioning the model on a calendar of events that describes changes in the abundances of krill and their predators in the Scotia Sea. G.M. Watters, J.T. Hinke and S. Hill (Southwest Fisheries Science Center, NOAA Fisheries, Protected Resources Division, 1352 Lighthouse Avenue, Pacific Grove, CA 93950, USA, george.watters@noaa.gov), 29 pp. (English, unpublished).

We tuned four parameterizations of FOOSA to provide predictions that are consistent with the agreed calendar, as specified by the WG-SAM, that describes changes in the abundances of krill and their predators in the Scotia Sea. First, we compiled a set of base parameterizations from information in the literature and following specifications laid out by the WG-SAM. These base parameterizations cover a combinatorial framework that considers krill movement (or lack thereof) and the shape of a relationship determining how the effective abundance of breeding predators depends on foraging success during the breeding season. We also added a new functional relationship to FOOSA: a relationship that determines the degrees to which the survival of juvenile predators depends on foraging success in their first winter of life. The dynamics predicted by our base parameterizations were loosely consistent with the direction and timing of changes in predator abundance specified by the numerical calendar from Hill et al. (2008). This indicated that our base parameterizations were reasonable and that tuning to the numerical calendar would be feasible. Second, we tuned, via sums of squares, one stock-recruitment parameter for each predator population in each parameterization to the "empirical abundance estimates" for predators reported by Hill et al. (2008). Tuning the peak recruitment by all 19 predator populations was sufficient to predict the empirical abundance estimates almost exactly for all predators by all parameterizations. The dynamics predicted by these tuned parameterizations often had trends and changes in magnitude that were roughly consistent with those in the numerical calendar, lending

additional support to the validity of the initial conditions, un-tuned parameters, and functional forms used in this application of FOOSA. Finally, we tuned, via an objective function that minimizes the sum of absolute proportional differences in abundance, one or two stock-recruitment parameters for each predator population to the numerical calendar itself. Parameterizations tuned in this last step constitute our reference set and predict plausible dynamics by reasonably matching the timing of events and magnitude of changes that are specified in numerical calendar. This reference set encapsulates hypotheses that go beyond the basic contrasts between krill movement and predator response to foraging success in the breeding season, implying a diverse set of hypotheses that includes SSMU-specific views about the productivities of individual predator populations and the effects of winter foraging conditions on juvenile survival. All four parameterizations in our reference set imply ongoing trends in predator populations, and, in forward simulations, changes in abundance predicted from these ongoing trends will likely need to be separated from changes caused by krill fishing. Although we believe that all four parameterizations in our reference set are plausible to some degree, we do not think that they are equally plausible. We suggest plausibility ranks for these four parameterizations that might be useful for synthesizing the output of future modelling efforts and simplifying communications with decision makers. After completing our analytical work and writing most of this paper, we found a small error in the initial conditions used in one of our four parameterizations. We discuss why this error does not affect the conclusions presented here or in our follow-on effort to conduct a risk assessment using the reference set.

WG-EMM-08/14

Developing models of Antarctic marine ecosystems in support of CCAMLR and IWC. A. Constable (Antarctic Climate and Ecosystems Cooperative Research Centre & Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, andrew.constable@aad.gov.au), 34 pp. (English, unpublished).

Ecosystem models are being developed to explore a range of issues globally. This paper is currently in draft form open to comment and is being developed to provide an introduction to the CCAMLR-IWC Workshop to review input data for Antarctic marine ecosystem models. It summarises background to the use of ecosystem models in CCAMLR and the IWC and a history of the developmental work in those organisations. It also provides an outline of the nature of modelling for these purposes and the general issues that need to be considered in parameterising a model, providing input data for those models and for addressing uncertainties in this process. Lastly, it summarises the modelling platforms being developed in CCAMLR and the IWC and the manner in which uncertainties surrounding data inputs to these models are being addressed by the Joint CCAMLR-IWC Workshop to be held in August 2008.

WG-EMM-08/15

CCAMLR-IWC Workshop to review input data for Antarctic marine ecosystem models: update on progress 2008. A. Constable and N. Gales (Co-conveners, Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, andrew.constable@aad.gov.au), 10 pp. (English, unpublished).

The "CCAMLR-IWC Workshop to review input data for Antarctic marine ecosystem models" will be held at the CCAMLR Headquarters in Hobart Australia on 11-15 August 2008. This paper provides an update on progress towards the holding of this workshop at the

CCAMLR Secretariat . A revised budget is presented for consideration primarily to take account of the review materials being produced without expenditure from the budget, the re-costing of hosting the workshop by the CCAMLR Secretariat and the possible cost of publication. This has enabled the funding of more experts to attend the workshop. Coordinators have been appointed for all the data groups with the exception of the flying birds group, the work for which is being discussed with scientists involved in ACAP. An additional expert group has been added early in 2008 to review the state of the datasets on the exploitation of Southern Ocean species, including seals, whales, finfish and krill. A metadatabase has been established. The groups of experts have been assembled and work has been progressing within the individual groups. It is expected that all groups will have papers ready for consideration at the workshop, except for flying birds. The JSG agreed that the synthesis work will occur at the workshop rather than being attempted prior to the workshop. The workshop is open to members of the SC-CAMLR and SC-IWC and their working groups. Many relevant experts have been invited to attend with funding limited to one expert from each group, some experts that cover a number of groups and a group of experts familiar with statistics, assessments and ecosystem modelling. Originally, the outcomes of the Workshop were envisaged to comprise a paper from each of the expert groups, the metadatabase and a short report summarising the workshop and outcomes. When the material is outlined as a complete set the contents reveals itself to be a potentially exciting volume in parts and in total. It is apparent that such a volume could have appeal as book that could be incorporated into library collections by scientists, universities and others interested in the Southern Ocean and the issues faced by the CCAMLR and IWC. The paper describes how such a book might be organised. It also provides commentary on what might be included in the papers and a workshop report. In the case of the latter, it suggests that the workshop report be divided into a number of general categories on the different estimation and modelling tasks. SC-CAMLR (through WG-EMM) and SC-IWC are asked to consider and comment on the progress being made by the expert groups, the issues considered in the paper by the JSG and surrounding publication of the outcomes and whether a book would be a suitable outcome from this work.

WG-EMM-08/16

Distribution of krill at threshold densities suitable for fishing in the Atlantic sector: analysis of the 2000 synoptic survey data. S. Hill and D. Agnew (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, sih@bas.ac.uk), 14 pp. (English, unpublished).

1. We used the CCAMLR 2000 synoptic survey acoustic dataset to compare pelagic and shelf SSMUs in terms of the frequency of 1nm integration units with krill densities above and below a range of threshold values.
2. In general pelagic SSMUs had markedly lower frequencies of fishable integration units where the threshold density for fishing was set at 100 gm2 following Kasatkina (2003).
3. This was also true with other threshold values in the range 25 to 200 gm^2 although the difference was smaller for higher thresholds.
4. The contrasting probability of encountering fishable concentrations in pelagic and shelf SSMUs suggests that the fishery will be less efficient and, perhaps, less economically viable in pelagic SSMUs. This is despite the fact that the absolute abundance of both krill and fishable concentrations of krill is higher in pelagic than in shelf SSMUs.

5. We also derived empirical relationships between SSMU-scale krill density and the frequency of fishable integration units for the full range of threshold levels. These relationships will be useful for linking the scale represented in operating models with those that affect the behaviour and performance of the fishery.

WG-EMM-08/17

A re-appraisal of the total biomass and annual production of Antarctic krill. A. Atkinson, V. Siegel, E.A. Pakhomov, M.J. Jessopp and V. Loeb (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, aat@bas.ac.uk), 45 pp. *Deep-Sea Research I*, submitted (English).

Despite much research on *Euphausia superba*, estimates of their total biomass and production are still very uncertain. Recently, circumpolar krill databases, combined with growth models and revisions in acoustics have made it possible to refine previous estimates. Net-based databases of density and length frequency (KRILLBASE) yield a summer distributional range of ~19 $x10^6$ km^2 and a mean total abundance of $8x10^{14}$ postlarvae with biomass of 379 million tonnes (Mt). These values are based on a standardised net sampling methodology but they integrate over the period 1926-2004, during which krill abundance has fluctuated. To estimate krill biomass at the end of last century we combined the KRILLBASE map of relative krill density around Antarctica with the most recent, acoustics-derived, value for the CCAMLR Synoptic Survey of the Scotia Sea area (37.3 Mt). Thus the CCAMLR 2000 survey area contains 28% of the total stock, with total biomass of ~133 Mt in January-February 2000. Gross postlarval production is estimated conservatively at 342-536 Mt y^{-1}, based on three independent methods. These are high values, within the upper range of recent estimates, but consistent with the concept of high energy throughput for a species of this size. The similarity between the three production estimates reflects a broad agreement between the three growth models used, plus the fact that, for a given population size, production is relatively insensitive to the size distribution of krill at the start of the growth season. These production values lie within the envelope of what can be supported from the Southern Ocean primary production system and what is required to support an estimated predator consumption of 128-470 Mt y^{-1}. Given the current debate over acoustic methodology, plus the need for precautionary management of the developing krill fishery, our net-based data help to set a conservative estimate of total krill biomass.

WG-EMM-08/18

Preliminary report of the New Zealand RV *Tangaroa* IPY-CAML survey of the Ross Sea region, Antarctica, in February–March 2008. S.M. Hanchet, J. Mitchell, D. Bowden, M. Clark, J. Hall, R. O'Driscoll, M. Pinkerton and D. Robertson (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, s.hanchet@niwa.co.nz), 14 pp. (English, unpublished).

During February and March 2008 New Zealand carried out a major research voyage into the Ross Sea region in support of the International Polar Year Census of Antarctic Marine Life (IPY-CAML). The 50 day voyage on the research vessel *Tangaroa* involved an extensive survey of marine organisms from viruses to pelagic and demersal fish and cephalopods from the surface down to depths of 3 500 m, and from the continental shelf and slope of the Ross Sea to unexplored seamounts and abyssal plains immediately to the north. Pelagic and benthic sampling gear, including plankton nets, mid-water and demersal trawls, seabed cameras, sleds, and corers were deployed in each habitat to obtain samples for a broad range of research programmes led by scientists from several New Zealand research institutes and universities with collaborating scientists from the USA and Italy. Despite some of the

worst ice conditions for 30 years, a total of 282 gear deployments were made at 39 sites covering a wide range of habitats. Almost 120 fish and cephalopod species were collected and nearly 4,000 benthic invertebrate sample lots were brought back for identification and further study. A total of 55 hours of seabed video and 12,500 still images were also taken using a deep towed imaging system (DTIS).

The results of the survey will be directly relevant to many aspects of the work of CCAMLR and its working groups. An important aspect of the survey was to collect data on key species or species groups such as mesopelagic fish that will provide quantitative inputs to the Ross Sea ecosystem model. Physical and biological data collected during the survey will also contribute to work being carried out on the biodiversity and bioregionalisation in the Southern Ocean. The benthic sampling using DTIS, sleds, and trawls has already improved our understanding of the distribution and abundance of benthic invertebrates (e.g., corals, sponges) found in vulnerable marine ecosystems in the Ross Sea region, and when combined with physical data should improve our ability to predict other areas where these species are likely to occur.

WG-EMM-08/19

Calibration error in the AMLR plankton time series. C. Reiss (Antarctic Ecosystem Research Division, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, christian.reiss@noaa.gov), 9 pp. (English, unpublished).

Analysis of the time series of the volume of water filtered during tows using a 1.8 m Isaac-Kidd Midwater Trawl (IKMT) from 1992 to 2007 showed a marked decline (~35%) in the volume of water filtered beginning in 2000. Analysis of tow time duration, reported ship speed during tows, and mean number of rotor counts from the flow meters showed no significant trends. The discrepancy in volume is traced to a simple arithmetic error in the calculation of the mouth area of the net. Since 2000, the net area was not calculated and instead only the length of the net was used in the determination of the flow constant. Thus, since 2000, the abundance of all zooplankton taxa have experienced a false increase in abundance. Representative corrected time series of Antarctic krill and three species of other Antarctic species is reported. The database has been corrected and protocols are in place to increase the quality control of data in order to ensure data integrity.

WG-EMM-08/20

Letter to Drs Reid, Watters and Jones in regard to 'disappearance of toothfish from McMurdo Sound'. D.G. Ainley, S.F. Ackley, K. Arrigo, G. Ballard, J.P. Barry, L. Blight, P. Broady, B. Davison, P. Dayton, A.L. DeVries, K. Dugger, J.T. Eastman, S.D. Emslie, C. Evans, R.A. Garrott, G. Hofmann, S. Kim, G. Kooyman, S.S. Jacobs, G. Lauriano, A. Lescroël, D.R. MacAyeal, M. Massaro, S. Olmastroni, P.J. Ponganis, E. Robinson, D.B. Siniff, W.O. Smith, I. Stirling and P. Wilson (H.T. Harvey & Associates, Los Gatos, CA 95032, USA, dainley@penguinscience.com), 6 pp. (English, unpublished).

We the undersigned wish to bring to your attention a potentially grave situation that needs to be addressed without significant delay. Together we have worked in the Ross Sea and vicinity for more than 300 person-years, and in the process have gained considerable knowledge about the Ross Sea ecosystem. Several recent findings indicate that the Antarctic toothfish (*Dissostichus mawsoni*) is rapidly disappearing from McMurdo Sound and vicinity, coincident with the maturation of the Ross Sea toothfish fishery from its initial experimental stage to its current near-quota status. Evidence is detailed in the EMM submitted document, "Decline of the Antarctic toothfish and its predators in McMurdo Sound and the southern Ross Sea, and recommendations for restoration." We are concerned that this is the first sign

that the Ross Sea ecosystem is being irreparably altered, and the 40-50 year time series of unequaled climate records and responses of the biota to climate change are in jeopardy of being compromised. The Ross Sea climate record heretofore had been free of confounding factors related to fishing and other, direct anthropogenic factors.

WG-EMM-08/21

Decline of the Antarctic toothfish and its predators in McMurdo Sound and the southern Ross Sea and recommendations for restoration. A.L. DeVries, D.G. Ainley and G. Ballard (Department of Animal Biology, University of Illinois, Urbana, IL 61801-3704, USA), 20 pp. (English, unpublished).

Ichthyologists, including those interested in the behavioural ecology, physiology and ecology of fish, beginning with the mere acquisition of specimens needed in experiments, began logging fishing effort in McMurdo Sound in 1971. This scientific fishing effort grew and interest turned also toward understanding annual and seasonal variation in the presence of Antarctic toothfish (*Dissostichus mawsoni*) in the area. Since 1971, more than 4000 Antarctic toothfish (*Dissostichus mawsoni*) have been captured, measured, tagged and released, by ichthyologists in McMurdo Sound. Total captures per year once numbered in the scores (200-500 per year), but recently, with similar effort, numbers are nearly zero. These dramatic declines are cause for alarm, and call into question the sustainability of the industrial toothfish fishery in place, at least for the Ross Sea region (SSRUs 88.1H-L). Aside from reporting a preliminary summary of these data, here we describe methods used and a history of the scientific fishing. The entire data set awaits computerization, but the summary we present (from a subset of the data) clearly shows the marked decline in catch per unit effort in McMurdo Sound once a Ross Sea industrial fishery, which began in the 1996-97 austral summer, reached its maturity after 2001-02. The length-frequency of fish caught in McMurdo Sound once matched that of the Ross Sea fishery but very few fish and no adults have been caught since 2004-05, indicating a potential contraction in the range of the species. Thus far 17 tagged-fish have been recaught, of those tagged since 1972, and at least one marked in McMurdo Sound was taken as far away as 1300 km to the north. Coincident with the virtual disappearance of toothfish from McMurdo Sound and the southern Ross Sea, the number of fish-eating Killer Whales (*Orcinus orca*) observed in the area has decreased, and the prevalence of silverfish (*Pleuragramma antarcticum*), the main prey of toothfish over the Ross Sea shelf, has increased markedly in the diet of Adélie penguins (*Pygoscelis adeliae*), another major silverfish predator. We posit that the fishery has caused a trophic cascade as the food web begins to adjust to the disappearance of its most important predator. We recommend that the Total Allowable Catch of the fishery be reduced, including a moratorium on fishing over the Ross Sea shelf until the McMurdo Sound toothfish population is restored and a program is in place to monitor ecosystem effects of the fishery.

WG-EMM-08/22

Addressing uncertainty over the importance of Antarctic toothfish as prey of seals and whales in the southern Ross Sea: a review. D. Ainley and D. Siniff (H.T. Harvey & Associates, Los Gatos, CA 95032, USA, dainley@penguinscience.com), 21 pp. (English, unpublished).

An uncertainty heretofore has existed over the importance of Antarctic toothfish (*Dissostichus mawsoni*) as prey of top predators in the Ross Sea. We reviewed the literature to assess the relative weight that should be given to direct, observational evidence of predator diet composition, as opposed to indirect evidence from scat and biochemical analysis. As a result of this assessment, it is evident that toothfish are an important prey of Weddell seals

(*Leptonychotes weddellii*). Recent findings show the seals do not eat toothfish hard parts, thus providing the reason that toothfish have seldom been detected in scat or stomach samples; biochemical samples have been taken only from seal populations where toothfish do not occur. On the basis of data from an under ice observation platform, non-breeding seals in McMurdo Sound take 0.8-1.3 toothfish per day. Seals with video recording equipment were seen to closely encounter toothfish but for unknown reasons did not often pursue for capture. It is estimated that the non-breeding portion of the seal population in McMurdo Sound, during spring and summer, consume about 52 tonnes of toothfish. Too many unknowns exist to estimate what the larger, breeding portion consumes during that and other parts of the year, although it should not be trivial. Much less is known quantitatively about the importance of toothfish to type-C (fish-eating) killer whales (*Orcinus orca*), but observational evidence indicates toothfish consumption to be common. A decline in the abundance of toothfish in McMurdo Sound appears already to be leading to a decline in the number of foraging killer whales. Care must be taken in managing the Ross Sea toothfish fishery, as the potential is great that, given the high degree of trophic overlap and competition among top predators, likely cascades will lead to dramatic changes in the populations of charismatic megafauna, particularly the seals, should the toothfish, probably the most important predator of fish in the system, become overly depressed.

WG-EMM-08/23

Aerial surveys of Weddell seals during 2007/08, with notes on the history of aerial censuses in the Ross Sea and recommendations for continued count effort. D. Siniff and D. Ainley (Department of Ecology, Evolution and Behavioral Biology, University of Minnesota, St Paul, MN 55108, USA), 11 pp. (English, unpublished).

Weddell seals (*Leptonychotes weddellii*) have proved to be an important predator of Antarctic toothfish (*Dissostichus mawsoni*), and currently there is no ecosystem monitoring program (CEMP) in place under CCAMLR with respect to the Ross Sea toothfish fishery. In a previous paper submitted to EMM in 2007 (WG-EMM 07/13), we described procedures whereby aerial photography could be used to monitor Weddell seals along the Victoria Land coast. That area would be important to monitor changes in distribution and abundance, as seals from all the colonies along that coast likely forage in CCAMLR SSRUs 88.1H and 88.1J (WG-EMM 06/29). Herein, we compare air with ground counts made in Erebus Bay, McMurdo Sound, in November 2007, and summarize historical results of aerial surveys made along the coast of Victoria Land. The high correspondence between air and ground counts shows that aerial photography can successfully be used to document changes in distribution and abundance of Weddell seals. Ground counts of Erebus Bay colonies made annually, 1974-2007, demonstrate the sensitivity of count data to environmental variability and the variance that could be expected over a time when the Ross Sea system was without influence from industrial fishing. On the basis of this and the previous paper, a Weddell seals monitoring program can now be put into effect under CEMP, begun with a one-time survey to identify all important haul out locations and the ones that best lend themselves to aerial surveillance.

WG-EMM-08/24

State of Antarctic krill (*Euphausia superba*) fisheries in Statistical Subarea 48.2 in 2008. V.A. Bibik and N.N. Zhuk (Southern Scientific Research Institute of Marine Fisheries and Oceanography (YugNIRO), Kerch, AR Crimea, Ukraine; Laboratory of the Ecology of Antarctic, National Academy of Science of Ukraine, Kiev, krill@kerch.net), 12 pp. (English, unpublished).

The article is based on the data sampled by the authors in the 29th cruise of F/V *Konstruktor Koshkin* (shipowner is the company "Interrybflot", Sevastopol, Ukraine) in Subarea 48.2 from March till April 2008. The paper has analysed the distribution of commercial aggregations of krill, their fishable biomass in the different periods of observations, krill biological state, hydro meteorological and ice conditions. Results of fisheries are given. Some ideas about allocation of limits of krill catch between SSMUs in Subarea 48.2.

WG-EMM-08/25

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). (Previously submitted as SC-CAMLR-XXVI/BG/25 Rev. 1), 10 pp. (English, unpublished).

Presented research on feeding and the dietary structure by species of minke whales, conducted on board the whaling fleet *Sovietskaya Ukraina* during the 1982/83 - 1985/86 seasons. Whaling was conducted in all four seasons. There have been no noticeable increase of the population size of large whales over the years after the cessation of whaling. The role of a short and profitable from the energy point of view trophic chain «phytoplankton - krill - baleen whales», which is of main interest due to the potential meaning of its last link for the commercial exploitation, reduced significantly.

WG-EMM-08/26

Comparison of the biomass of Antarctic krill (*Euphausia superba*) around the South Shetland and South Orkney Islands in three years: 1999, 2000 and 2008. C. Reiss and A. Cossio (Antarctic Ecosystem Research Division, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, christian.reiss@noaa.gov), 28 pp. (English, unpublished).

Using a combination of techniques, we examine data from three cruises in 1999, 2000 and 2008 to calculate the biomass and demographic characteristics of Antarctic krill (*Euphausia superba*) surrounding the South Orkney and South Shetlands Islands. Net tow data show that length frequency distributions of krill between Elephant Island and the South Orkney Islands were similar. The similarity in length frequency distributions suggest that acoustic data collected as part of US AMLR finfish surveys may be useful in deriving biomass estimates for the South Orkney Islands in 1999. We use a simple bootstrap approach to illustrate our ideas. We re-analyse the data from 2000, including some CCAMLR data, and report on the biomass from a survey conducted in 2008. Biomass estimates in 2008 are calculated using the traditional Jolly-Hampton (1991) methodology, and represent the first estimate of biomass in this region. Together the data from these three years suggest that biomass in the South Orkney Islands is similar to the biomass in the South Shetland Islands, especially the Elephant Island region. The results are promising and suggest that where possible future data, derived from ancillary studies, can be used to better resolve the temporal trends in krill biomass in this region. Such data would benefit the future development of management strategies based on small scale units.

WG-EMM-08/27

Trophic study of Ross Sea Antarctic toothfish (*Dissostichus mawsoni*) using carbon and nitrogen stable isotopes. S.J. Bury, M.H. Pinkerton*, D.R. Thompson, S. Hanchet, J. Brown and I. Vorster (*National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14-901, Kilbirnie, Wellington, New Zealand, m.pinkerton@niwa.co.nz), 41 pp. (English, unpublished).

This report amalgamates stable isotope analyses of fish (n=476), squid (n=50) and octopod (n=17) samples obtained from long-line fishing vessels from four CCAMLR SSRUs (88.1C, 88.1H, 88.1I and 88.1J) during two fishing seasons 2005/6 and 2006/7. The species sampled were: 6 fish: Antarctic toothfish (*Dissostichus mawsoni*, n= 100), Patagonian toothfish (*Dissostichus eleginoides*, n=8), deep sea cod/blue antimora (*Antimora rostrata*, n=103), icefish (*Chionobathyscus dewitti*, n=83), moray (or eel) cod (*Muraenolepis microps*, n=75), and Whitson's grenadier (*Macrourus whitsoni*, n=107); 4 squid: *Galiteuthis glacialis* (Gg, n=3), *Kondakovia longimana* (Kl, n=20), *Psychroteuthis glacialis* (Pg, n=20) and the Colossal squid, *Mesonychoteuthis hamiltoni* (Mh, n=7); and 3 benthic octopods: *Octopodid* sp. 1 (Oct-1, n=3), *Octopodid* sp. 2 (Oct-2, n=5) and *Cirroctopus glacialis* (Cg, n=9).

Length and SSRU were the most significant variables in explaining the variation of $\delta^{15}N$ and $\delta^{13}C$. Positive relationships between length and $\delta^{15}N$ indicate that, very generally, larger fish consume prey of a higher trophic level than smaller fish. There were substantial residual within-species variations in $\delta^{15}N$ and $\delta^{13}C$. *Dissostichus mawsoni* exhibited a range of 7 ‰ (9–16 ‰) in $\delta^{15}N$, which is equivalent to two trophic steps. All fish, except *Antimora rostrata* (2.7 ‰ range) showed a $\delta^{15}N$ range greater than 3.4 ‰ spanning more than one trophic step. This implies that the diet of all species sampled was variable, or that individual species were eating a similar diet which itself varied in size and trophic status. Overall, *Dissostichus mawsoni* and *Dissostichus eleginoides* occupied a trophic level equivalent to orca (*Orcinus orca*) and Weddell seals (*Leptonychotes weddellii*). *Antimora rostrata*, *Muraenolepis microps* and *Macrourus whitsoni* all occupied a trophic level below them. *Chionobathyscus dewitti* occupied the lowest trophic level of all fish analysed. There was considerable isotopic overlap in both $\delta^{15}N$ and $\delta^{13}C$ for all four fish prey species. Squids, excluding *Mesonychoteuthis hamiltoni* were found to be at a lower trophic level than fish species sampled, whereas on average octopods occupied a similar trophic level to the four fish prey species. The squid $\delta^{13}C$ signature was more depleted (indicating a pelagic signature) than the octopods, which were all benthic feeders. Large variations in $\delta^{13}C$ for each species (around 3 ‰ for each species) indicated a variation in source of carbon within individual species. Species with enriched $\delta^{13}C$ may be feeding further north in warmer waters or may have a stronger benthic compared to pelagic source of carbon.

There was no significant difference in *Dissostichus mawsoni* $\delta^{15}N$ and $\delta^{13}C$ values between the Northern Area, Ross Sea Slope and Terra Nova Bay Trench. In contrast, all of the four potential prey species caught in the Northern Area had enriched ^{13}C values compared to the Ross Sea Slope, most likely due to warmer temperatures to the north. Since this increased $\delta^{13}C$ signature is not picked up by *Dissostichus mawsoni*, then this suggests that Dissostichus mawsoni either move between and feed equally within the Northern Area and the Ross Sea Slope, or that they predominantly feed on the Ross Sea Slope.

WG-EMM-08/28

The Antarctic krill and ecosystem survey with RV *G.O. Sars* in 2008. S.A. Iversen, W. Melle, E. Bagøien, D. Chu, B. Edvardsen, B. Ellertsen, E. Grønningsæter, K. Jørstad, E. Karslbakk, T. Klevjer, T. Knutsen, R. Korneliussen, H. Kowall, B. Krafft, S. Kaartvedt, P.B. Lona, S. Murray, L. Naustvoll, L. Nøttestad, M. Ostrowski, V. Siegel, Ø. Skagseth, G. Skaret, H. Søiland, X. Zhao and C.B. Årnes (Institute of Marine Research, PB 1870 Nordnes, 5817 Bergen, Norway, svein.iversen@imr.no), 22 pp. (English, unpublished).

This report describes the multipurpose AKES survey (Antarctic Krill and Ecosystem Studies) carried out with R/V *G. O. Sars*, 4.01-27.03.08, including some selected results. The main purposes for the AKES project were to

- evaluate the links between the krill resources and distribution in the area and Bouvetøya based mammals and birds;
- study krill biology and ecology;
- establish TS (Target strength; the ability of an organism to reflect sound) for krill and ice fish;
- study aggregations of krill, fish and plankton relative to the hydrography;
- compare aggregations and abundance of krill and plankton relative to hydrography in Antarctica and Nordic Seas;
- stomach contents and feeding behavior of krill and fish.

WG-EMM-08/29

***In situ* measurements of tilt angle distribution and target strength in Antarctic krill (*Euphausia superba*).** G. Skaret, S.A. Iversen, T. Knutsen, R.J. Korneliussen, E. Ona, R. Pedersen, A. Totland, T. Torkelsen and X. Zhao (IMR, PO Box 1870 Nordnes, N-5817 Bergen, Norway, georg.skaret@imr.no), 9 pp. (English, unpublished).

Knowledge of the scattering properties of Antarctic krill (*Euphausia superba*) is crucial for biomass estimates of the species, but in situ investigations regarding this are still very scarce. We conducted a field study in the Southern Ocean where one of the objectives was to acquire data on orientation angles and target strength of Antarctic krill. The main investigations were done off South Georgia and the Bouvet Island and we here in part present the methods applied and give examples of data acquired. The post-processing and analyses are ongoing and the results from this work will be presented in future reports.

WG-EMM-08/30

A risk assessment to advise on strategies for subdividing a precautionary catch limit among small-scale management units during stage 1 of the staged development of the krill fishery in Subareas 48.1, 48.2 and 48.3. G.M. Watters, J.T. Hinke and S. Hill (Southwest Fisheries Science Center, NOAA Fisheries, Protected Resources Division, 1352 Lighthouse Avenue, Pacific Grove, CA 93950, USA, george.watters@noaa.gov), 29 pp. (English, unpublished).

We used FOOSA and the reference set of parameterizations developed by Watters et al. (2008) to assess the risks and tradeoffs associated with various management strategies for subdividing the precautionary krill catch limit among SSMUs in Area 48. Our methodological approach follows directly from specifications made by the WG-SAM and the WG-EMM. We predict that the tradeoffs inherent in selecting among Fishing Options 2, 3, and 4 are tradeoffs between the risks to predator populations and fishery performance; risks to krill are relatively insensitive to differences among these options. Implementation of Fishing Option 2 (using the subdivisions reported here) will require that the fishery mostly operate in pelagic SSMUs. Up to harvest rates of 0.5 x γ, this subdivision is unlikely to reduce predator populations to 75% or less of the abundances that might occur in the absence of fishing; the risks of such depletion are, however, likely to increase as harvest rates increase beyond 0.5 x γ. Although we predict that catches can be highest and relatively less variable in pelagic SSMUs, the risks that krill densities will fall below thresholds which necessitate involuntary changes in the behavior of the fleet are substantially increased in pelagic SSMUs. We are uncertain about relative catchabilities in pelagic versus coastal SSMUs, and we do not know how much fishing effort might actually be required to catch the SSMU-level quotas that would be allocated to each SSMU given the subdivisions reported here. Implementation of Fishing Option 3 will also require substantive fishery operations in pelagic SSMUs, but, if krill move, to a lesser extent than Fishing Option 2. Up to harvest rates defining the current

trigger level (i.e., 0.15 x γ), implementation of Fishing Option 3 is unlikely to reduce predator populations to 75% or less of the abundances that might occur in the absence of fishing. As harvest rates are increased past that defining the current trigger level, the risks of depleting penguin and fish populations increase in some SSMUs. In general, the risks of depleting penguin and fish populations are greater for Fishing Option 3 than for Fishing Option 2 because the former option requires slightly more fishing in coastal SSMUs. Nevertheless, fishery performance under Fishing Option 3 is comparable to that for Fishing Option 2. Implementation of Fishing Option 4 will, relative to the other two options, substantially limit the spatial distribution of the fishery. Furthermore, since Fishing Option 4 would concentrate fishing in a few coastal SSMUs, implementing this option would increase the risks that predator populations will be reduced to 75% or less of the abundances that might occur in the absence of fishing. In fact, in a few SSMUs, such risks even occur at harvest rates near the rate defining the current trigger level. Relative to Fishing Options 2 and 3, fishery performance under Option 4 is also poor, with decreased catches and increased variations in catch. Nevertheless, since Fishing Option 4 concentrates fishing in coastal SSMUs, there is a reduced risk (again relative to the other options) that krill densities will fall below thresholds which necessitate involuntary changes in the behavior of the fleet. Although many management strategies (i.e., the combination of γ and a fishing option) are not likely to increase the risks that predator populations will be reduced to 75% (or less) of the abundances that might occur in the absence of fishing, fishing can nevertheless push some populations, particularly penguins, into states where there is some risk that recovery will not occur, even after a period of 20 years without fishing. Furthermore, the risks that some populations may not recover can increase rapidly as harvest rates increase past the rate defining the current trigger level. Our reference set of parameterizations includes depensatory recruitment dynamics for all predator populations except fishes, and this is the mechanism that causes such risks to be borne.

WG-EMM-08/31

Relationships between oceanographic environment and distribution of 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, T. Iwami 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), 54 pp. (English, unpublished).

We have surveyed the ecological interactions between the oceanography and biological ecosystem in the Ross Sea and its adjacent waters with a joint survey the R/V *Kaiyo Maru* and the Japanese Whale Research Program in the 2004/05 austral summer. We compared the relationship between the geographical distribution of the main biological prey and predator populations such as krill including other zooplankton and fishes as well as baleen whales with an oceanographic environment index (namely MTEM-200 which is the averaged temperature in degrees Celsius from the surface to 200 m; note all temperatures given below are MTEM-200 values). - Antarctic krill mainly distributed in the waters between 0 to -1°C of MTEM-200, which approximated the area covered by the Antarctic Surface Water (ASW) zone, and slightly extended in the waters less than -1°C of the Shelf Water (SW) zone. Ice krill distributed in the waters colder than -1°C (SW) but did not occur in ASW (warmer than -1°C). Other zooplankton and fishes also showed distribution patterns that could be approximately segregated patterns with MTEM-200. Humpback whales mainly distributed in the waters warmer than 0°C, which agreed with the Antarctic Circumpolar Current (ACC)

zone, with a high density around 0°C near the Southern Boundary of ACC. Antarctic minke whales mainly distributed in the ASW and SW zones with high density around -1 °C in a continental shelf slope frontal zone. The interaction between distributions of krill and baleen whales with MTEM-200 could give quantitative information to identify the boundary of distribution of Antarctic krill and ice krill for biomass estimations using acoustic data. We summarized a geographical image between oceanography relating water mass and circulation pattern of the surface layer with MTEM-200, the distribution and abundance of krill and baleen whales. We conclude that this is useful for characterizing the Ross Sea and adjacent waters ecosystem and comparing other areas in the Antarctic Ocean.

WG-EMM-08/32

Relationship between distribution of Antarctic krill (*Euphausia superba*) and environmental index MTEM-200 in the Antarctic Ocean throughout the year. M. Naganobu, T. Kitamura and K. Hasunuma (National Research Institute of Far Seas Fisheries, 2-12-4 Fukuura, Kanazawa-ku, Yokohama, Kanagawa, 236-8648 Japan, naganobu@affrc.go.jp), 38 pp. *CCAMLR Science*, submitted (English).

Antarctic krill (Euphausia superba) is the key species of the Antarctic marine ecosystem and human fishing resources. Essentially, relationships between krill distribution and oceanographic conditions have been an age-old recurrent problem and many papers have been published on the subject since the British Discovery Reports. However, there was no remarkable achievement in particular the entire Antarctic Ocean. To clarify the relationship between krill distribution of krill and oceanographic environment, we have analysed two datasets combined. One is krill fishing records from 1973 to 2008 from the CCAMLR database. Another is accumulated water temperature data of the World Ocean Database. We here focus mean-field (climatologic analysis) in all season. First, we have examined fishing depth. The peak of fishing catches clearly appeared around 50 m and 94% of all krill fishing catches occurred in water shallower than 200 m. Furthermore, horizontal distribution of krill fishing points concentrated in three waters in the east Antarctic Ocean, the Scotia Sea, and north of South Georgia Island. From the above results, we calculated mean temperature from the surface to 200 m (MTEM-200) and compared it with horizontal distribution of fishing. The result indicated the strong correlation between krill fishing locations and MTEM-200 in the entire Antarctic Ocean. Waters that were efficient and stable for fishing were distributed in a narrow range with steep meridional gradients between -1.0 and 1.0°C. Large fishing catches indicated the remarkable two peaks; -0.5~0.1°C and 0.5~0.8°C which located in the Scotia Sea, and north of South Georgia Island, respectively. Similarly, the historical krill distribution based on the Discovery Report's net sampling coincided with this study results and each of the isopleths of MTEM-200 substantially corresponded with each oceanic front in the Southern Ocean. MTEM-200 can be applied for the further analysis of seasonal and/or annual variability.

WG-EMM-08/33

Time series of Drake Passage Oscillation Index (DPOI) during 1952–2008 and its possible influence on environmental variability. M. Naganobu, J. Kondo and K. Kutsuwada (National Research Institute of Far Seas Fisheries, 2-12-4 Fukuura, Kanazawa-ku, Yokohama, Kanagawa, 236-8648 Japan, naganobu@affrc.go.jp), 9 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 during 1982-1998. Fluctuations in the westerlies across the Drake Passage were referred to as the Drake Passage Oscillation Index (DPOI). They found significant correlations between krill recruitment and DPOI. Additionally, we calculated a new time series of DPOI from January 1952 to March 2008. In addition, we tried to draw a comparison between DPOI and oceanographic condition using CTD data in the Antarctic Peninsula waters during 1990-2007. As a result, DPOI had a significant correlation with mean temperature from the surface to 200 m (MTEM-200). DPOI suggests influence on the variability of oceanic condition and thus for Antarctic krill ecosystem.

WG-EMM-08/34

Systematic coverage by scientific observers on krill fishing vessels. Delegation of Japan, 4 pp. (English, unpublished).

A work plan to establish an observer scheme for krill fishery was agreed at the previous Scientific Committee and the Commission. The first step was to consider 'systematic coverage' of the observers. In this document, Japan proposes a framework for scientific observer system for krill fishery in order to obtain 'systematic coverage'.

WG-EMM-08/35

Distribution patterns and biomasses of Antarctic krill (*Euphausia superba*) and ice krill (*E. crystallorophias*) with note on distribution of Antarctic minke whales (*Balaenoptera bonaerensis*) in the Ross Sea in 2005. H. Murase, H. Yasuma, R. Matsukura, Y. Takao, K. Taki, T. Hayashi, T. Yabuki, T. Tamura, K. Konishi, K. Matsuoka, K. Miyashita, S. Nishiwaki and M. Naganobu (The Institute of Cetacean Research, 4-5 Toyomi-cho, Chuo-ku, Tokyo, 104-0055, Japan, murase@cetacean.jp), 15 pp. (English, unpublished).

Distribution patterns and biomasses of Antarctic and ice krill in the Ross Sea in austral summer in 2005 were studied using a multi-disciplinary survey data set combining cetacean, krill and oceanography data. Two research vessels, KM and KS2, conducted the hydroacoustic surveys independently in the same area. Distribution patterns and length frequency information for two species were obtained from samples of RMT hauls and stomach contents of Antarctic minke whales. Ice krill was distributed on the continental shelf region (shallower than 1000m water depth). In contrast, Antarctic krill was distributed mainly in the oceanic waters where water depth is deeper than 1000m though it distributed on the continental shelf where the mean water temperature between 0-200m was higher than -1°C. The Ross Sea was stratified into two strata based on the distribution patterns of two krill species to estimate their biomasses. Biomass densities of Antarctic krill using KM and KS2 data were estimated as 5.13±7.14 and 2.53±2.25 g/m^2, respectively. Biomass densities of ice krill using KM and KS2 data were estimated as 2.58±1.47 and 1.13±0.65 g/m^2, respectively. Because there was no significant difference between the biomass density estimates from both vessels, two data sets were combined to estimate the biomass. The biomasses of Antarctic and ice krill in this study were estimated as 1.40 (CV=0.32) and 0.60 (CV=0.18) million t, respectively. School sizes of Antarctic minke whales were large where the densities of Antarctic krill were high. Distribution pattern of Antarctic minke whales in the Ross Sea could be regulated by distribution patterns of Antarctic krill.

WG-EMM-08/36

Community structure of copepods in epipelagic layers in the Ross Sea and neighbouring waters. Y. Watanabe, S. Sawamoto, T. Ishimaru and M. Naganobu* (*National Research Institute of Far Seas Fisheries, 2-12-4 Fukuura, Kanazawa-ku, Yokohama, Kanagawa, 236-8648 Japan, naganobu@affrc.go.jp), 9 pp. (English, unpublished).

During the 9th research cruise of the R/V *Kaiyo-maru*, copepod samples were collected from three layers between the surface and 200 m with RMT 8m^2 along the three longitudinal lines in the Ross Sea and its neighboring waters. Twenty three copepod species belonging to 13 families were identified and 8 unidentified taxa appeared in the study area. Samples were categorized into four major groups by cluster analysis based on species abundance and composition. Group 1 located in the north of the Southern Boundary of the Antarctic Circumpolar Current was characterized by high abundance (157.5-2279.5; mean 610.5 inds. 1000 m^{-3}) and dominance of Rhincalanus gigas (mean 88.4%). Group 2 located off the Ross Sea (175°E; north of 72°S, 170°W; north of 75°S) was characterized by high abundance (22.6-1542.1; mean 301.9 inds. 1000 m^{-3}) and high composition of Calanus plopinquus (mean 19.0%), Rhincalanus gigas (mean 23.2%) and Calanoides acutus (mean 38.7%). Group 3 and 4 located in the Ross Sea (175°E; south of 72°S, 170°W; south of 75°S) were characterized with low abundances (2.6-5.2; mean 3.6 inds. 1000 m^{-3}, 6.5-50.6; mean 18.5 inds. 1000 m^{-3}).

WG-EMM-08/37

A risk management framework for avoiding significant adverse impacts of bottom fishing gear on vulnerable marine ecosystems. K. Martin-Smith (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, keith.martin-smith@aad.gov.au), 24 pp. (English, unpublished).

CCAMLR adopted a new conservation measure in 2007 (CM 22-06) to ensure that significant adverse impacts of bottom fishing gear on Vulnerable Marine Ecosystems (VMEs) are avoided. Due to the high levels of uncertainty surrounding both the evidence of VME presence and the consequences of interaction with different types of gear, a risk management framework is proposed, similar to that which has been used successfully by IMAF to minimise the effects of longline fishing mortality on seabirds. The aim of this risk management is to avoid significant adverse impacts on VMEs from bottom fishing activities. The framework consists of four steps: (1). Risk analysis of current and proposed fishing activities; evidence of potential VMEs; scale of interactions between fishing activities and VMEs; impact of interactions on VMEs; and recovery potential of VMEs. (2) Risk evaluation. Combine information on likelihood and consequences of interactions of bottom fishing gear with VMEs and associated uncertainties from risk analysis to produce risk metrics. (3) Risk elimination or mitigation. Unacceptable levels of risk from bottom fishing activities to VMEs must be eliminated or reduced to acceptable levels through the use of management measures including, inter alia, closed areas around identified VMEs, open and closed management areas, bycatch limits for VME-forming organisms, gear modification or spatial distribution of fishing effort. (4). Review. All of the above steps should be reviewed regularly to ensure that all relevant or new information has been included, appropriate scientific research and data collection plans are in plan and that risk mitigation measures are successful in their implementation.

WG-EMM-08/38

Notification of vulnerable marine ecosystems in Statistical Division 58.4.1. (Delegation of Australia), 13 pp. (English, unpublished).

Conservation Measure 22-06 was adopted to ensure that significant adverse impacts of bottom fishing gear on Vulnerable Marine Ecosystems (VMEs) are avoided. In order to satisfy the requirements of CM 22-06 a method is proposed to notify CCAMLR of the presence of VMEs and their location using a simple pro-forma. Two VMEs identified during the Australian CEAMARC-CASO cruise are notified using this form from Statistical Area 58.4.1, SSRU H. The use of 5 nm buffer zones around the location of the observations is proposed to mitigate the risk of spatial uncertainty in the notified position and the deployment of bottom-fishing gear.

WG-EMM-08/39

Krill fishery behaviour in the southwest Atlantic. S. Kawaguchi (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, so.kawaguchi@aad.gov.au), 26 pp. *CCAMLR Science*, submitted (English).

10 years worth of recent finescale haul-by haul krill data were used to characterize behaviour of krill fishery. Analysis of travel distance in relation to catch level revealed a pattern that mean travel distances are longer after the least catch levels, and the travel distances decreases as catch level increases to certain catch levels but distance increase again above that catch level. However, this pattern only holds for operations by Japan. Preferred level of catch by Japan derived through the analysis was 15-30 tonnes/haul, which is higher than the 1980s information (5-10 tonne/haul). Other nations do not have a preference for an upper limit of catch. Locations of operations were very close even after considerable number of hauls. The scales of distance after 50 tows from the original tows were 10-15 nm, which is the scale of a single concentration. However, there was considerable year to year variability in the probabilities of operating within a local range after a number of tows. In the 1999/2000 season the probability that hauls would be made within a 30nm range after 300 hauls was only 0.1, but in the 2004/05 season it was 0.7. Fishery behaviour differentiates between market type considerations/strategies which are often the argument for changing fishing patterns and catching efficiency/operational requirements in an area. These kinds of analysis show the importance of good year-round data from observers from all vessels participating krill fishery to assist in interpreting the annual fishing results.

WG-EMM-08/40

Krill fishery behaviour in the 1999/2000 season. S. Kawaguchi (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, so.kawaguchi@aad.gov.au), 16 pp. (English, unpublished).

This document provides information on krill fishery behaviour and fishing ground condition in 1999/2000 season to assist consideration of the regional krill density and distributional conditions observed in the CCAMLR 2000 synoptic survey. The vessels seemed to have been moving around more compared to other fishing seasons to look for preferred targets. The 1999/2000 fishing season was the most mobile season in the last 10 years. Through the analysis of relation between catch level and vessel travel distance, it was suggested that Japanese vessels were catching average of 13-15 tonnes per tow within their preferred fishing concentration, which seemed to be the lower end of their preference.

WG-EMM-08/41

Updated krill recruitment data for the Elephant Island region of the South Shetland Islands, Antarctica: 2002–2008. C. Reiss (Antarctic Ecosystem Research Division, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, christian.reiss@noaa.gov), 10 pp. (English, unpublished).

The proportional krill recruitment index is updated from 2002 to present using data from the US AMLR surveys around Elephant Island, Antarctica. Proportional recruitment indices were derived from the CMIX procedure, and were also derived as a proportion of the <30 mm length class for day and night samples. All indices showed that high recruitment (R1) occurred in 2003 and in 2008, with low recruitment occurring during the intervening years. Significant differences in the proportional recruitment indices occurred between legs within years indicative of the changing pattern of krill within the Elephant Island region.

WG-EMM-08/42

A preliminary balanced trophic model of the ecosystem of the Ross Sea, Antarctica, with emphasis on apex predators. M.H. Pinkerton, J.M. Bradford-Grieve and S.M. Hanchet (National Institute of Water and Atmospheric Research Ltd (NIWA), Private Bag 14901, Wellington, New Zealand, m.pinkerton@niwa.co.nz), 21 pp. *CCAMLR Science*, submitted (English).

We report on the development of a mass balanced carbon-budget trophic model of the Ross Sea as a step towards investigating ecosystem effects of the fishery for Antarctic toothfish (*Dissostichus mawsoni*). The model has 30 trophic groups representing all the major biota of the Ross Sea. Many of the lower trophic level species in the model are grouped by functional role because information is not available at greater taxonomic resolution. The model separates the following apex predators by species: emperor penguin, Adélie penguin, crabeater seal, Weddell seal, orca, sperm whale, Antarctic toothfish. A survey of the available literature and both published and unpublished data provided an initial set of parameters describing the abundance (seasonally and spatially resolved where possible, imports, exports), energetics (growth, reproduction, consumption), and trophic linkages (diets, key predators) for each model group. We also estimated the relative level of uncertainty on these parameters. We describe the method we used to adjust the parameters to give a balanced model taking into account estimates of parameter uncertainty and the large range of magnitude (>6 orders of magnitude) in trophic flows between different groups of organisms. Biomass, production, consumption, export and diet fractions are adjusted simultaneously. We set ecotrophic efficiency to unity for all non-primary producers. Changes to the initial set of parameters needed to obtain balance were significant, especially for bacteria. Excluding bacteria, the adjustments required for balance from the parameters estimated *a priori* were <46% (biomass), <15% (production, consumption), and <28% (diet fractions). The balanced model presented here has not yet been validated and should be considered a work in progress.

WG-EMM-08/43

Trophic overlap of Weddell seals (*Leptonychotes weddelli*) and 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 Ltd (NIWA), Private Bag 14901, Wellington, New Zealand, m.pinkerton@niwa.co.nz), 16 pp. (English, unpublished).

We present information to investigate the significance of Antarctic toothfish as a prey item for Weddell seals in the Ross Sea.

- We summarise the life history of Weddell seals to provide an overview of their use of the Ross Sea. As consumption of prey by Weddell seals (both the amount and type of

prey) will vary between different life history stages at different times of the year in different areas, this is relevant to the question of whether seals predate significantly on toothfish.

- There is evidence that Antarctic toothfish have lower densities near to seal breeding colonies in McMurdo Sound than further away (Testa et al. 1985).
- Direct information on diet of the Weddell seals, including diver observations, animal-mounted camera information, and observations from field scientists in the McMurdo Sound region suggest that toothfish are a significant prey item for Weddell seals.
- In contrast, research using seal stomach contents, vomit and scats provides no evidence that Weddell seals consume toothfish at all. Diver observations suggest that seals may feed selectively on only parts of toothfish so that otoliths and vertebrae may be under-represented in remains.
- Indirect information using stable isotopes of carbon and nitrogen, even including recent analyses that have not been previously reported, remains inconclusive. We recommend further research using stable isotope analysis of blood samples from seals not at the breeding colonies, and samples of muscle or other slower-turnover tissue of seals at the breeding colonies.
- Information from fatty acids or other biomarkers could potentially be used to investigate the importance of toothfish as a prey item for seals, but no results are available.
- We have compared mortality of Antarctic toothfish in McMurdo Sound to consumption by Weddell seals. The estimates, although preliminary and subject to uncertainty, indicate that it is possible that toothfish comprise a substantial proportion of the diet of seals in McMurdo Sound between October and January.

We conclude that while there is strong evidence that toothfish are a prey item for Weddell seals in McMurdo Sound between October and January, it is plausible but unproven that they are an important prey item.

WG-EMM-08/44

Conditioning SMOM using the agreed calendar of observed changes in predator and krill abundance: a further step in the development of a management procedure for krill fisheries in Area 48. 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), 20 pp. (English, unpublished).

The updated version of the Spatial Multi-species Operating Model (SMOM) of krill-predator-fishery dynamics described in an accompanying paper is conditioned using the WG-SAM set of reference observations for Area 48 (the SAM calendar). Results are presented for two implementations of SMOM, one with the time series of krill abundance fixed on input, and the other incorporating an explicit model of krill dynamics. Additional versions of SMOM that may need to be conditioned are discussed. In general the two SMOM implementations are broadly successful in reproducing the direction and timing of observed changes in predator abundance. The main method of conditioning involved estimating a shape parameter (the "steepness") of the predator-prey interaction formulation. The steepness values estimated suggest that penguins respond sooner than other predators to decreasing levels of krill abundance. Given data on fish catches, the model estimates the starting (1970) fish abundance level, with results suggesting that fish populations in several of the SSMUs are much reduced compared to their 1970 levels. The conditioned operating models presented here constitute a further step towards the development of a spatially-structured Management

Procedure (MP) for the krill fishery by contributing to the set of such operating models to be used to simulation test candidate MPs for robust performance. The next step involves agreeing the relative plausibilities (weights) for the different operating models. An outline of suggested future steps in the MP development process is discussed.

WG-EMM-08/45

Potential requirements for scientific data from the krill fishery. CCAMLR Secretariat, 17 pp. (English, unpublished).

CCAMLR has agreed that there is a requirement for systematic observation from the krill fishery, however, current levels of observer coverage are not distributed evenly across years, regions or vessels. The number of observer days as a proportion of the number of days fished varied between c10% (Subareas 48.1 and 48.2) and c30% (in Subarea 48.3). 13 of the 16 vessels that have fished for krill in 48.3 have carried observers at some time, compared to 6 of 15 in 48.1 and 4 of 15 in 48.2. An analysis of existing observer data submitted to the Secretariat indicates that measuring 200 krill from 5 hauls should produce a sufficiently precise length frequency distribution and would free up time for other priority tasks of observers. Suggestions are provided for a revision of the *Scientific Observer Manual* for consideration by the Working Group.

WG-EMM-08/46

Catch uncertainty in krill fisheries. CCAMLR Secretariat, 5 pp. (English, unpublished).

Catch uncertainty is a component of uncertainty that is not routinely considered by CCAMLR. However, given the currently reported variability in conversion factors for krill, a nominal reported catch of 600 000 tonnes could actually represent a catch in 'green weight' of 2.5 million tonnes. Quantifying the level of uncertainty in reported catches of krill would require information on product specific conversion factors (including the time-scale over which those conversion factors were produced) as well as the product composition of catches.

WG-EMM-08/47

Progress towards expert group manuscripts for the CCAMLR-IWC Workshop to review input data for Antarctic marine ecosystem models: update on progress 2008. A. Constable and N. Gales (Co-conveners) (Australian Antarctic Division, Department of Environment and Heritage, 203 Channel Highway, Kingston, Tasmania 7050, Australia, andrew.constable@aad.gov.au), 8 pp. (English, unpublished).

This document summarises progress by expert groups towards having manuscripts ready for the CCAMLR-IWC Workshop to review input data for Antarctic marine ecosystem models: update on progress 2008. Data collation is progressing well for all groups, except for flying birds. Draft manuscripts will be available for review at WG-EMM or from the convenors on request.

WG-EMM-08/48

Multiple time scales of variability in the krill population at South Georgia. K. Reid, J. Watkins, E. Murphy, P. Trathan, S. Fielding and P. Enderlein (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge, CB3 0ET, UK British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom, Current address: Commission for the Conservation of Antarctic Marine Living Resources, PO Box 213, North Hobart, Tasmania 7002, Australia, keith@ccamlr.org), 31 pp. *Mar. Ecol. Prog. Ser.* (to be submitted) (English).

The South Georgia region supports a high biomass of krill that is the subject to high inter-annual variability. The lack of a self-sustaining krill population at South Georgia means that

understanding the mechanism underlying these observed population characteristics is essential to a successful ecosystem-based management of any krill fishery in the region. Krill acoustic density data from surveys conducted in the early, middle and late period of the summers of 2001 to 2005, together with krill population size structure over the same period from predator diet data, were used with a krill population dynamics model to evaluate potential mechanisms behind the observed changes in krill biomass. Krill abundance was highest during the middle of the summer in 3 years and in the late period in 2 years; in the latter there was evidence that krill recruitment was delayed by several months. A model scenario with empirically derived estimates of both the magnitude and timing of recruitment in each year showed the greatest correlation with the acoustic series. The results are consistent with a krill population with allochthonous recruitment entering a retained adult population; i.e. oceanic transport of adult krill does not appear to be the major factor determining the dynamics of the adult population. The results highlight the importance of the timing of recruitment, especially where this could introduce a mismatch between the peak of krill abundance and the peak demand from predators which may exacerbate the effects of changes in krill populations arising from climate change.

WG-EMM-08/49

Proposed approach for the identification of important marine areas for conservation: using 'MARXAN' software to support systematic conservation planning. S.M. Grant, J. Tratalos and P.N. Trathan (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, suan@bas.ac.uk), 16 pp. (English, unpublished).

We provide a worked example of how a systematic conservation planning methodology (Margules and Pressey, 2000) might be used to identify important areas for conservation of biodiversity in the pelagic environment, using Subarea 48.2 (South Orkney Islands) as a pilot study area. The aim of the worked example is not to identify areas for protection or management at this stage, but rather to test the utility of this methodology, and to demonstrate the types of data and the range of decisions that would be required to undertake such an analysis. 'MARXAN' software (Ball and Possingham, 2000; Game and Grantham, 2008) is used to objectively determine the possible contribution of individual areas towards meeting conservation targets, using example datasets for pelagic species, bioregions and other environmental characteristics. It is concluded that this methodology could be used to provide meaningful results with those datasets currently available. With further refinement, the results from this type of analysis could be used to inform the implementation of a range of actions to conserve marine biodiversity.

WG-EMM-08/50

Flexible foraging strategies of gentoo penguins help buffer the impacts of interannual changes in prey availability. 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), 29 pp. (English, unpublished).

Gentoo penguins (*Pygoscelis papua*) show considerable plasticity in their diet, diving and foraging behaviours among colonies; we expected that they might exhibit similar variability over time, at a single site, since flexible foraging habits would provide a buffer against changes in prey availability. We examined inter-annual changes in the foraging strategies and diet of gentoo penguins in the South Shetland Islands, Antarctica, over five years. Antarctic krill (*Euphausia superba*) was the primary diet item, and fish the secondary, though the importance of these items varied among years. Diving behaviour also varied over time; different dive depth-distributions were observed in each year. Nonetheless, chick-rearing

success remained relatively constant, indicating that gentoo penguins were able to cope with differences in prey availability by altering their foraging strategy among years. We suggest that this flexibility may contribute to why gentoo penguin populations have remained stable in the region, while their congeners with less flexible foraging strategies have declined.

WG-EMM-08/51

Down-scaling FOOSA to model the Admiralty Bay Pygoscelid penguin colonies: a work in progress. J.T. Hinke, G.M. Watters and W.Z. Trivelpiece (Marine Biology Research Division, Scripps Institution of Oceanography, UC San Diego, La Jolla, CA, 92093, USA, jefferson.hinke@noaa.gov), 11 pp. (English, unpublished).

We apply FOOSA at the scale of interactions among the 3 breeding penguin colonies, krill, and environmental variability at the long-term research site in Admiralty Bay, King George Island. This work-in-progress serves 2 purposes: 1) to use historical data to estimate parameters in a model-fitting framework for the purpose of model validation, and 2) to add and explore functionality in FOOSA to investigate alternative, competing hypotheses about juvenile penguin survival. Our preliminary results suggest that FOOSA capably captures the general trends in adult abundance at Admiralty Bay with minimal formal estimation. Preliminary examination of top-down and bottom-up forcing on juvenile penguin survival further helps to explain trends in adult abundance. From a bottom-up perspective, there appears to be a trade-off between per-capita productivity at low adult abundance and the sensitivity of juvenile survival to foraging conditions during the first winter of life. From a top-down perspective, strong depensatory stock-recruitment dynamics suggest that understanding predatory effects on juveniles may be fundamental for understanding penguin dynamics at our study colony. To better capture the inter-annual variability in the adult abundance data, we propose future work that includes, *inter alia*, expanding the spatial scope to account for seasonal movement of the penguins, incorporating alternative environmental drivers, and continued hypothesis testing to make strong inference about the dominant drivers of the penguins at Admiralty Bay.

WG-EMM-08/52

Proposal for a joint CEP/SC-CAMLR workshop in 2009. CCAMLR Secretariat, 5 pp. (English, unpublished).

At its meeting in 2007 CCAMLR endorsed the proposal from the Scientific Committee for a joint CEP/SC-CAMLR workshop. The CEP discussed this at its meeting in June 2008 and suggested a theme of 'Opportunities for collaboration and practical cooperation between the CEP and SC-CAMLR'. The CEP suggested that areas of common interest might include, though may not be limited to:

- climate change research
- ecosystem and environmental monitoring
- protected areas and spatial management measures
- species requiring special protection
- marine pollution
- biodiversity and non-native species.

WG-EMM is invited to consider CCAMLR input into the workshop agenda and work plan to inform SC-CAMLR at its meeting in October 2008.

WG-EMM-08/53

Preliminary estimation of penguin breeding abundance at spatial-scales of relevance to CCAMLR: incorporating uncertainty in count data. H. Lynch, R. Naveen, J. McKinlay, C. Southwell*, P. Trathan, W. Trivelpiece, S. Trivelpiece and D. Ramm (*Australian

Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, colin.southwell@aad.gov.au), 8 pp. (English, unpublished).

One recommendation from the Predator Survey Workshop was the undertaking of some immediate inter-sessional work to be reported to WG-EMM-08. The work to be undertaken included preliminary estimation of SSMU-specific gentoo and Adélie breeding abundance in Area 48, and similar analyses of East Antarctic data for Adélie penguins. It was recognised that the abundance estimates would not be corrected for availability (e.g. nest failure) and hence would to some extent be biased estimates of the breeding population, and would only account for uncertainty in the accuracy of the count data. However, the work was seen as useful in illustrating both the database of penguin count data compiled for the workshop, and the underlying basis of new estimation procedures presented to the workshop. At an SSMU level, uncertainty associated with accuracy or repeatability of the counts varied substantially between SSMUs (95% C.I. as a percent of the count ranged from 1.5% to 37.1%).

WG-EMM-08/54

Net-based verification of acoustic techniques used to identify Antarctic krill. J. Watkins and S. Fielding (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, jlwa@bas.ac.uk), 13 pp. (English, unpublished).

We validate the acoustic target classification protocols developed for the Stochastic Distorted-Wave Born Approximation (SDWBA) model using three frequency acoustic data and concurrent net hauls that were collected during two cruises to the South Georgia region in 1996. For each krill aggregation sampled by net we calculated the difference between acoustic backscatter at 120 and 38 kHz ($S_{v120-38}$) and at 200 and 120 kHz ($S_{v200-120}$). We considered the performance of 4 different acoustic target identification algorithms for krill: (i) '3 freq model' - using the SDWBA to set the acceptance windows for both $S_{v120-38}$ and $S_{v200-120}$, (ii) '2 freq model' - using the SDWBA to set the acceptance window for just $S_{v120-38}$, (iii) '2 freq 2-16' - where the $S_{v120-38}$ window was fixed at 2-16 dB and (iv) '2 freq 2-12' - where the $S_{v120-38}$ window was fixed at 2-12 dB. The overall aggregation dB difference for 120 – 38 kHz for every net fell within the SDWBA model derived target id window, however, for 200 - 120 kHz the SDWBA model derived target id window only identified krill in 6 of the 16 nets correctly. The '2 freq 2-16' algorithm attributed more than 90% of the total backscatter to krill in all but 1 aggregation with the '2 freq model' using a smaller window but still attributing more than 90% of the total backscatter to krill in 12 out of the 16 nets. The '2 freq 2 – 12' window only attributed more than 90% of the total backscatter to krill in 6 nets while the '3 freq model' attributed only just greater than 50% of the backscatter to krill in only 2 aggregations, and in 6 aggregations attributed less than 10% of the total backscatter to krill. Therefore the SDWBA(11,4) using 38, 120 and 200 kHz in the present configuration to set variably sized windows is likely to substantially underestimate krill. In contrast the SDWBA(11,4) used at 38 and 120 kHz identifies very well the krill detected during these net hauls and because it uses a window substantially smaller than the fixed 2-16 window, will at the same time reduce the amount of by-catch that may occur when targets other than Antarctic krill are present in the water column.

WG-EMM-08/55

Properties of krill distribution in pelagic and coastal SSMUs of the South Orkney Islands subarea according to the data of scientific observations and fishery. S.M.

Kasatkina and V.N. Shnar (Atlantic Scientific Research Institute of Marine Fisheries and Oceanography, (AtlantNIRO), 5 Dmitry Donskoy Street, Kaliningrad, 236000 Russia, ks@atlant.baltnet.ru), 19 pp. *CCAMLR Science*, submitted (English).

In this paper the krill spatial distribution in the in coastal and pelagic SSMUs of the Subarea 48.2 depending on oceanological factors is considered. Estimates of krill biomass and aggregation characteristics, and krill transport factors according to different modifications of Antarctic water mass are presented based on the CCAMLR 2000 Survey data. It is shown, that despite the high biomass concentrated in the South Orkney Pelagic Area (SOPA) during the CCAMLR 2000 Survey, the krill aggregation patterns did not meet the requirements of the present day fishery. Krill distribution and water mass circulation according to CCAMLR 2000 Survey (January-February 2000) are compared with those obtained from the data of long-term observations and fishery in Subarea 48.2. The types of geostrophic current fields and correspondent fishing ground allocations in the South Orkney Islands area revealed from 1962 to 1997 are presented.

It is concluded that the development of options for krill stock management call for actual materials, describing annual and seasonal changes in biomass and characteristics of krill distribution in the SSMUs areas.

WG-EMM-08/56 Rev. 1

Measurements of sound-speed density contrasts of Antarctic krill (*Euphausia superba*) onboard RV *Kaiyo Maru*. Y. Takao, H. Yasuma, R. Matsukura, K. Amakasu and M. Naganobu (National Research Institute of Fisheries Engineering, Fisheries Research Agency, 7620-7 Hasaki, Kamisu, Ibaraki 314-0408, Japan, ytakao@affrc.go.jp), 11 pp. (English, unpublished).

In order to calculate the target strength of Antarctic krill (*Euphausia superba*) using an acoustical scattering model, information on size, morphology, orientation, sound–speed and mass-density contrasts between the animal and the surrounding water are required.

Sound-speed and mass-density of krill were measured during the Antarctic surveys conducted by the Japanese RV *Kaiyo Maru* in 1999/2000 and 2004/2005. Samples of krill were caught by a RMT(1+8). Mass-density of krill was measured by density bottle method. The mean total length and the mean mass-density contrast were 43.5mm and 1.028 near South Shetland Islands in February 2000. These were 21.7mm and 1.049, and 45.1mm and 1.043 in the Ross Sea in January and February 2005. Sound-speed was measured using the 'time of flight' method. The corresponding sound-speed contrast of krill with mean total lengths of 44.2mm was 1.011 in the South Shetland Islands. These contrasts of krill with mean total lengths of 25.1mm and 48.6mm were 1.044 and 1.035 respectively in the Ross Sea. To examine the effect of these parameter differences, the target strength and its directivity of krill were calculated using the stochastic DWBA model.

WG-EMM-08/57

By-catch of fishes caught by the krill fishing vessel *Niitaka Maru* in the South Georgia area (August 2007). T. Iwami and M. Naganobu (Laboratory of Biology, Tokyo Kasei Gakuin University, Tokyo, 194-0292 Japan), 4 pp. (English, unpublished).

Scientific observation on the species composition and abundance of fishes incidentally caught during Antarctic krill (*Euphausia superba* Dana) fisheries by FV *Niitaka Maru* (5 200 tonnes) were made from 6 August to 30 August to the north of South Georgia Is. Among 87 net hauls quantitatively examined, by-catch fish was recognized in 26 trawl catches (29.9%) and only one fish was found as by-catch in 21 hauls. Among a total of 7 fish species, Myctophidae 3, Zoarcidae 1, Nototheniidae 1 and Channichthyidae 2, recognized,

Krefftichthys anderssoni of Myctophidae occurred most frequently (38.5% of net hauls containing by-catch fish). Owing to the small amount of by-catch, no clear relationships between krill CPUE and fish by-catch could be confirmed in the present study.

WG-EMM-08/P1

Adult Antarctic krill feeding at abyssal depths. A. Clarke and P.A. Tyler. 2008. *Current Biology*, 18: 282–285, doi: 10.1016/j.cub.2008.01.059.

Antarctic krill (*Euphausia superba*) is a large euphausiid, widely distributed within the Southern Ocean, and a key species in the Antarctic food web. The *Discovery* Investigations in the early 20th century, coupled with subsequent work with both nets and echosounders, indicated that the bulk of the population of postlarval krill is typically confined to the top 150 m of the water column. Here, we report for the first time the existence of significant numbers of Antarctic krill feeding actively at abyssal depths in the Southern Ocean. Biological observations from the deepwater remotely operated vehicle Isis in the austral summer of 2006/07 have revealed the presence of adult krill (*Euphausia superba* Dana), including gravid females, at unprecedented depths in Marguerite Bay, western Antarctic Peninsula. Adult krill were found close to the seabed at all depths but were absent from fjords close inshore. At all locations where krill were detected they were seen to be actively feeding, and at many locations there were exuviae (cast molts). These observations revise significantly our understanding of the depth distribution and ecology of Antarctic krill, a central organism in the Southern Ocean ecosystem.

WG-EMM-08/P2

Climatically driven fluctuations in Southern Ocean ecosystems. E.J. Murphy, P.N. Trathan, J.L. Watkins, K. Reid, M.P. Meredith, J. Forcada, S.E. Thorpe, N.M. Johnston and P. Rothery. 2007. *Proc. R. Soc. B*, 274: 3057–3067, doi: 10.1098/rspb.2007.1180.

Determining how climate fluctuations affect ocean ecosystems requires an understanding of how biological and physical processes interact across a wide range of scales. Here we examine the role of physical and biological processes in generating fluctuations in the ecosystem around South Georgia in the South Atlantic sector of the Southern Ocean. Anomalies in sea surface temperature (SST) in the South Pacific sector of the Southern Ocean have previously been shown to be generated through atmospheric teleconnections with El Niño Southern Oscillation (ENSO)-related processes. These SST anomalies are propagated via the Antarctic Circumpolar Current into the South Atlantic (on time scales of more than 1 year), where ENSO and Southern Annular Mode-related atmospheric processes have a direct influence on short (less than six months) time scales. We find that across the South Atlantic sector, these changes in SST, and related fluctuations in winter sea ice extent, affect the recruitment and dispersal of Antarctic krill. This oceanographically driven variation in krill population dynamics and abundance in turn affects the breeding success of seabird and marine mammal predators that depend on krill as food. Such propagating anomalies, mediated through physical and trophic interactions, are likely to be an important component of variation in ocean ecosystems and affect responses to longer term change. Population models derived on the basis of these oceanic fluctuations indicate that plausible rates of regional warming of 1°C over the next 100 years could lead to more than a 95% reduction in the biomass and abundance of krill across the Scotia Sea by the end of the century.

WG-EMM-08/P3

Rapid warming of the ocean around South Georgia, Southern Ocean, during the 20th Century: forcings, characteristics and implications for lower trophic levels. M.J. Whitehouse, M.P. Meredith, P. Rothery, A. Atkinson, P. Ward and R.E. Korb. 2008. *Deep-Sea Res. I*, 55 (10): 1218–1228, doi:10.1016/j.dsr.2008.06.002.

The Southern Ocean is known to have warmed considerably during the second half of the 20th century but there are few locations with data before the 1950s. In addition, assessments of change in this region are hampered by the strong seasonal bias in sampling, with the vast majority of data collected during the austral summer. However, oceanographic measurements near South Georgia span most of the last century, and we here consider almost year-round data from this location over an 81-year period (1925 to 2006). Based on these data, we observe significant warming between the early and late 20th century, with differential warming between summer and winter months and an indication that late 20th century summer temperatures peaked ~6 days earlier. To quantify the long-term warming trend in this highly variable data, a mixed model utilising a Residual Maximum Likelihood (REML) method was used. Over the 81-year period, a mean increase of ~0.9°C in January and ~2.3°C in August was evident in the top 100 m of the water column. Warming diminished below 100 m and approached zero at 200 m. Thus the long-term warming around South Georgia is substantial – more so than documented previously for the circumpolar warming of the Southern Ocean. We examine potential causal effects of this trend, including local atmospheric and cryospheric change, the influence of upstream waters and the role of coupled modes of climate variaibility. It is likely that all of these play a part in the observed temperature increase. However, the role of the Southern Annular Mode (SAM) is strongly indicated, via its likely role in the circumpolar warming trend in the Southern Ocean, and also due to the atypical response of the South Georgia region to changes in heat fluxes associated with the SAM. In addition, we consider the implications that long-term warming has for South Georgia's lower trophic levels. For *Euphausia superba*, we find a significant negative relationship between summer South Georgia water temperatures and mean summer density of *E. superba* across the southwest Atlantic sector of the Southern Ocean. Simple abundance and growth rate relationships with our long-term temperature data appear to show declining habitat suitability for *E. superba*. In general, the warming trend is likely to favour other macro- and mesozooplankton species that occupy the more northerly parts of the Antarctic Circumpolar Current and it is likely to promote phytoplankton growth.

WG-EMM-08/P4

Oceanic circumpolar habitats of Antarctic krill. A. Atkinson, V. Siegel, E. A. Pakhomov, P. Rothery, V. Loeb, R.M. Ross, L.B. Quetin, K. Schmidt, P. Fretwell, E.J. Murphy, G.A. Tarling and A.H. Fleming. 2008. *Mar. Ecol. Progr. Ser*., 362: 1–23, doi: 10.3354/ meps07498.

Surveys of *Euphausia superba* often target localised shelves and ice edges where their growth rates and predation losses are atypically high. Emphasis on these areas has led to the current view that krill require high food concentrations, with a distribution often linked to shelves. For a wider, circumpolar perspective, we compiled all available net-based density data on postlarvae: 8 137 mainly summer stations from 1926 to 2004. Unlike Antarctic zooplankton, the distribution of *E. superba* is highly uneven, with 70% of the total stock concentrated between longitudes 0° and 90°W. Within this Atlantic sector, krill are abundant over both continental shelf and ocean. At the Antarctic Peninsula they are found mainly over the inner shelf, whereas in the Indian–Pacific sectors krill prevail in the ocean within 200 to 300 km of the shelf break. Overall, 87% of the total stock live over deep

oceanic water (>2 000 m) and krill occupy regions of moderate food concentrations (0.5 to 1.0 mg chl *a* m^{-3}). Advection models suggest some northwards loss from these regions and into the low chlorophyll belts of the Antarctic Circumpolar Current (ACC). We found possible evidence for a compensating southwards migration, with an increasing proportion of krill found south of the ACC as the season progresses. The retention of krill in moderately productive oceanic habitats is a key factor in their high total production. While growth rates are lower than those over shelves, the ocean provides a refuge from shelf-based predators. The unusual circumpolar distribution of krill thus reflects a balance between advection, migration and top–down and bottom–up processes.

WG-EMM-08/P5

Life history buffering in Antarctic mammals and birds against changing patterns of climate and environmental variation. J. Forcada, P.N. Trathan and E.J. Murphy. 2008. *Global Change Biology*, 14 (11): 2473–2488, doi 10.1111/j.1365-2486.2008.01678.x.

The consequences of warming for Antarctic long-lived organisms depend on their ability to survive changing patterns of climate and environmental variation. Among birds and mammals of different Antarctic regions, including emperor penguins, snow petrels, southern fulmars, Antarctic fur seals and Weddell seals, we found strong support for selection of life history traits that reduce interannual variation in fitness. These species maximise fitness by keeping a low inter-annual variance in the survival of adults and in their propensity to breed annually, which are the vital rates that influence most the variability in population growth rate (λ). All these species have been able to buffer these rates against the effects of recent climate-driven habitat changes except for Antarctic fur seals, in the Southwest Atlantic. In this region of the Southern Ocean, the rapid increase in ecosystem fluctuation, associated with climate variability observed since 1990, has limited and rendered less predictable the main fur seal food supply, Antarctic krill. This has increased the fitness costs of breeding for females, causing significant short-term changes in population structure through mortality and low breeding output. Changes occur now with a frequency higher than the mean female fur seal generation time, and therefore are likely to limit their adaptive response. Fur seals are more likely to rely on phenotypic plasticity to cope with short-term changes in order to maximize individual fitness. With more frequent extreme climatic events driving more frequent ecosystem fluctuation, the repercussions for life histories in many Antarctic birds and mammals are likely to increase, particularly at regional scales. In species with less flexible life histories that are more constrained by fluctuation in their critical habitats, like sea-ice, this may cause demographic changes, population compensation and changes in distribution, as already observed in penguin species living in the Antarctic Peninsula and adjacent islands.

WG-EMM-08/P6

Environmental forcing and Southern Ocean marine predator populations: effects of climate change and variability. P.N. Trathan, J. Forcada and E.J. Murphy. 2007. *Phil. Trans. R. Soc. B*, 362: 2351–2365, doi: 10.1098/rstb.2006.1953.

The Southern Ocean is a major component within the global ocean and climate system and potentially the location where the most rapid climate change is most likely to happen, particularly in the high-latitude polar regions. In these regions, even small temperature changes can potentially lead to major environmental perturbations. Climate change is likely to be regional and may be expressed in various ways, including alterations to climate and weather patterns across a variety of time-scales that include changes to the long interdecadal background signals such as the development of the El Niño–Southern Oscillation (ENSO). Oscillating climate signals such as ENSO potentially provide a unique opportunity to explore

how biological communities respond to change. This approach is based on the premise that biological responses to shorter-term sub-decadal climate variability signals are potentially the best predictor of biological responses over longer time-scales. Around the Southern Ocean, marine predator populations show periodicity in breeding performance and productivity, with relationships with the environment driven by physical forcing from the ENSO region in the Pacific. Wherever examined, these relationships are congruent with mid-trophic-level processes that are also correlated with environmental variability. The short-term changes to ecosystem structure and function observed during ENSO events herald potential long-term changes that may ensue following regional climate change. For example, in the South Atlantic, failure of Antarctic krill recruitment will inevitably foreshadow recruitment failures in a range of higher trophic-level marine predators. Where predator species are not able to accommodate by switching to other prey species, population-level changes will follow. The Southern Ocean, though oceanographically interconnected, is not a single ecosystem and different areas are dominated by different food webs. Where species occupy different positions in different regional food webs, there is the potential to make predictions about future change scenarios.

WG-EMM-08/P7

Ecological repercussions of historical fish extraction from the Southern Ocean. D. Ainley and L. Blight. 2008. *Fish and Fisheries*, published online: doi 10.1111/j.1467-2979.2008.00293.x.

A major mid-1980s shift in ecological structure of significant portions of the Southern Ocean was partially due to the serial depletion of fish by intensive industrial fishing, rather than solely to climate factors as previously hypothesised. Over a brief period (1969-1973), several finfish stocks were on average reduced to <50%, and finally (mid-1980s) to <20%, of original size. Despite management actions, few stocks have recovered and some are still declining. Most affected species exhibit K-selected life-history patterns, and before exploitation presumably fluctuated in accordance with infrequent strong year classes, as is true of such fish elsewhere. A climate regime, the Southern Annular Mode, once oscillated between two states, but has remained in its "positive mode" since the time of the fish extraction. This may have increased finfish vulnerability to exploitation. As breeding stocks decreased, we hypothesize that availability of annually-produced juvenile fish fed upon by upper-level predators remained low. Correlations between predator populations and fish biomass in predator foraging areas indicate that southern elephant seal *Mirounga leonina*, Antarctic fur seal *Arctocephalus gazella*, gentoo penguin *Pygoscelis papua*, macaroni penguin *Eudyptes chrysolphus* and "imperial" shag *Phalacrocorax* spp. — all feeding extensively on these fish, and monitored at Marion, Crozet, Kerguelen, Heard, South Georgia, South Orkney and South Shetland islands, where fishing was concentrated — declined simultaneously during the two periods of heavy fishing. These patterns indicate the past importance of demersal fish as prey in Antarctic marine systems, but determining these interactions' ecological mechanisms may now be impossible.

WG-EMM-08/P8

The summertime plankton community at South Georgia (Southern Ocean): comparing the historical (1926/27) and modern (post 1995) records. P. Ward, M.P. Meredith, M.J. Whitehouse and P. Rothery. 2008 *Progress in Oceanography*, 78 (3): 241–256.

The earliest comprehensive plankton sampling programme in the Southern Ocean was undertaken during the early part of last century by Discovery Investigations to gain a greater scientific understanding of whale stocks and their summer feeding grounds. An initial survey

was carried out around South Georgia during December 1926 and January 1927 to describe the distribution of plankton during the summer, and to serve as a baseline against which to compare future surveys. We have reanalysed phytoplankton and zooplankton data from this survey and elucidated patterns of community distribution and compared them with our recent understanding of the ecosystem based on contemporary data. Analysis of Discovery data identified five groups of stations with characteristic phytoplankton communities which were almost entirely consistent with the original analysis conducted by Hardy and Gunther (1935). Major groupings were located at the western end of the island and over the northern shelf where *Corethron* spp. were dominant, and to the south and east where a more diverse flora included high abundances of *Nitzschia seriata*. Major zooplankton-station groupings were located over the inner shelf which was characterised by a high abundance of *Drepanopus forcipatus* and in oceanic water >500 m deep that were dominated by Foraminifera, *Oithona* spp., *Ctenocalanus vanus*, and *Calanoides acutus*. Stations along the middle and outer shelf regions to the north and west, were characterised by low overall abundance. There was some evidence that groupings of stations to the north of the island originated in different water masses on either side of the Southern Antarctic Circumpolar Current Front, the major frontal system in the deep ocean close to South Georgia. However, transect lines during 1926/27 did not extend far enough offshore to sample this frontal region adequately. Interannual variability of zooplankton abundance was assessed from stations which were sampled repeatedly during 7 recent British Antarctic Survey cruises (1995-2005) to the region and following taxonomic harmonization and numerical standardization, a subset of 45 taxonomic categories of zooplankton (species and higher taxa) from 1926/27, were compared with similar data obtained during the BAS cruises using a linear model. Initially comparisons were restricted to BAS stations that lay within 40 km of Discovery stations although a comparison was also made using all available data. Despite low abundance values in 1926/27, in neither comparison did Discovery data differ significantly from BAS data. Calculation of the percentage similarity index across cruises did not reveal any systematic differences in species composition between 1926/27 and the present. In the light of ocean warming trends, the existence of more subtle changes in species composition is not ruled out, but an absence of finely resolved time-series data make this impossible to determine.

WG-EMM-08/P9

Histopathology of Antarctic krill, *Euphausia superba*, bearing black spots. S. Miwa, T. Kamaishi, T. Matsuyama, T. Hayashi and M. Naganobu. 2008. *J. Invertebr. Pathol.*, 98 (3): 280–286, doi:10.1016/j.jip.2008.04.004.

Small black spots have been noticed on the cephalothorax of Antarctic krill, *Euphausia superba*, since January, 2001. To study the nature of the black spots, the krill were sampled in the winter of 2003, 2006, and 2007 in the South Georgia region, the Antarctic Ocean. Histological observations revealed that the black spots were melanized nodules that were composed of hemocytes surrounding either bacteria or amorphous material. In the 2007 samples, 42% of the krill had melanized nodules. Most of the nodules had an opening on the body surface of the krill. A single melanized nodule often contained more than one type of morphologically distinct bacterial cell. Three bacteria were isolated from these black spots, and classified into either *Psychrobacter* or *Pseudoalteromonas* based on the sequences of 16S rRNA genes. More than three bacterial species or strains were also confirmed by in situ hybridization for 16S rRNA. The melanized nodules were almost always accompanied by a mass of atypical, large heteromorphic cells, which were not observed in apparently healthy krill. Unidentified parasites were observed in some of the krill that had melanized nodules. These parasites were directly surrounded by the large heteromorphic cells. Histological

observations suggested that these heteromorphic cells were attacking the parasites. These results suggest the possibility that the krill had been initially affected by parasite infections, and the parasitized spots were secondary infected by environmental bacteria after the parasites had escaped from the host body.

WG-EMM-08/P10

Horizontal and vertical distribution and demography of euphausiids in the Ross Sea and its adjacent waters in 2004/05. K. Taki, T. Yabuki, Y. Noiri, T. Hayashi and M. Naganobu. 2008. *Polar Biol*., 31 (11): 1343–1356, doi: 10.1007/s00300-008-0472-6.

The horizontal and vertical distribution and population structure of euphausiids in the Ross Sea and its adjacent waters were investigated during the summers of 2004/2005 using stratified towed samples. Nine species of euphausiids occurred in the survey area. Among them, *Euphausia triacantha* was dominant in biomass north of the southern boundary of the Antarctic circumpolar current (SB). *Thysanoessa* spp. was widely distributed north of the continental slope, while *E. superba* was distributed from the SB to the slope, where it showed the highest biomass. Juvenile *E. superba* was distributed offshore near the SB and remained at the surface, but gravid females were dominant in the slope and mainly occurred in the middle layers (400–600 m). Adult and juvenile *E. crystallorophias* were found at 200–300 m in the colder water of the continental shelf. In general, the peak biomass of euphausiids was found in the mid layers of the Ross Sea area. The life span and the number of spawns for major species are also discussed.

WG-EMM-08/P11

The power of ecosystem monitoring. K. Reid, J.P. Croxall and E.J. Murphy. 2008. *Aquat. Conserv*., 17 (S1): 79–92, doi: 10.1002/aqc.909.

1. Implementing an ecosystem approach to fisheries management requires an effective ecosystem monitoring programme, the utility of which depends upon its ability (measured by the statistical power) to detect effects that trigger management action.
2. Using data from a long-term ecosystem monitoring programme of the predators of Antarctic krill *Euphausia superba* at South Georgia together with a krill population model to simulate natural and fisheries induced variability in krill abundance, the power to detect the effects of different levels of fishing was examined.
3. The power to detect the effects of fishing using either the krill population or a combined predator response index was low (20–40% power after 20 years with the probability of a type I error (α) = 0.05). The power increased to >50% when α was increased to 0.2 when the ability to detect change was greater with the predator response index than using the krill population itself.
4. The results indicate that although this monitoring programme has a proven ability to detect the effects of natural variability in krill abundance, its ability to detect the effects of fishing may be limited if there is a requirement for statistical significance at the 95% level. A situation where changing α produces a marked increase in statistical power, and the difference in the relative ecological costs of making type I and type II errors is likely to be high, may require a more flexible approach to choosing significance levels required to trigger management action.
5. Although long-term monitoring provides a wealth of basic ecological information it is essential to evaluate, the ability to detect specific changes in order that management action is not delayed because of an inability to detect an effect rather than the lack of an effect of the fishery.

WG-EMM-08/P12

Interannual spatial variability of krill (*Euphausia superba*) influences seabird foraging behaviour near Elephant Island, Antarctica. J.A. Santora, C.S. Reiss, A.M. Cossio and R.R. Veit. 2009. *Fish. Oceanogr*., 18 (1): 20–35.

We investigate the influence of krill (principally *Euphausia superba*) patchiness on the foraging distributions of seabirds to understand how variation in krill influences patch dynamics between krill and birds. At sea surveys were conducted near Elephant Island, Antarctica for three years (2004-2006) during the annual U.S. Antarctic Marine Living Resources (AMLR) program. Standardized strip-transect surveys were used to map seabirds, and a combination of acoustic and net surveys was used to map krill. We measured patch size of krill and seabirds and elucidated how krill patch dynamics influence foraging seabirds. The spatial association between krill and predators was influenced by the size and arrangement of krill patches. We found a negative relationship between abundance and patchiness of krill and predators, indicating that when krill is less abundant, krill and its predators are less abundant and concentrated. We conclude that annual patch dynamics of krill strongly influences the local abundance and distribution of seabirds. Such information should be used to interpret potential interactions between seabirds and krill fisheries operating near Elephant Island.

Joint CCAMLR-IWC Workshop

CCAMLR-IWC-WS-08/2

CCAMLR-IWC Workshop to review input data for Antarctic marine ecosystem models. Coordinators: A. Constable and N. Gales (Co-conveners, Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, andrew.constable@aad.gov.au), 21 pp. (English, unpublished).

CCAMLR-IWC-WS-08/3

Models of Antarctic marine ecosystems in support of CCAMLR and IWC: background. Coordinator: A. Constable (Co-convener, Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, andrew.constable@aad.gov.au), 26 pp. (English, unpublished).

Ecosystem models are being developed to explore a range of issues globally. This paper is currently in draft form open to comment and is being developed to provide an introduction to the CCAMLR-IWC Workshop to review input data for Antarctic marine ecosystem models. It summarises background to the use of ecosystem models in CCAMLR and the IWC and a history of the developmental work in those organisations. It also provides an outline of the nature of modelling for these purposes and the general issues that need to be considered in parameterising a model, providing input data for those models and for addressing uncertainties in this process. Lastly, it summarises the modelling platforms being developed in CCAMLR and the IWC.

CCAMLR-IWC-WS-08/4

A review of abundance, trends and foraging parameters of baleen whales in the southern hemisphere. Coordinator: A. Zerbini (AFSC/National Marine Mammal Laboratory, 7600 Sand Point Way NE, Bldg 4, Seattle, WA 98115, USA, alex.zerbini@noaa.gov), 51 pp. (English, unpublished).

CCAMLR-IWC-WS-08/5
Report of review group of data sources on odontocetes in the Southern Ocean in preparation for IWC/CCAMLR Workshop in August 2008. Coordinator: R. Leaper (Canal House, Banavie PH33 7LY, United Kingdom, rleaper@ivyt.demon.co.uk), 14 pp. (English, unpublished).

CCAMLR-IWC-WS-08/6
A review of bias and uncertainty in Antarctic pack-ice seal abundance estimates. Coordinator: C. Southwell (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, colin.southwell@aad.gov.au), 39 pp. (English, unpublished).

While the Joint CCAMLR-IWC Workshop will consider a number of parameters for species groups, including abundance, trends in abundance, habitat utilisation, foraging and growth, this review of pack-ice seals focuses primarily on abundance and to a lesser extent trends in abundance. The review addresses population surveys and abundance estimates for the four species of phocid seal commonly encountered in the pack-ice and fast-ice surrounding Antarctica (crabeater seal *Lobodon carcinophaga*, Ross seal *Ommatophoca rossii*, leopard seal *Leptonyx hydrurga* and Weddell seal *Leptonychotes weddellii*). The spatial scope covers the circumpolar extent of pack-ice, and the temporal scope spans a period of more than 50 years from when pack-ice seal surveys were first undertaken and reported in the 1950s to the present day. The review of abundance surveys is presented chronologically, and in doing so tries to provide a sense of evolution and development of methodologies over a 50 year period of application. The methodologies employed in individual survey efforts are described, and the likely biases and uncertainties in resulting abundance estimates are discussed. Abundance estimates from individual and collective survey efforts are provided. It is difficult to derive trends in abundance from these abundance estimates because there have been very few repeat surveys in the same or similar regions, methodologies have evolved and improved over time, and uncertainty around abundance estimates is substantial.

CCAMLR-IWC-WS-08/7
Report of the review group on sources of data on Antarctic fur seals *Arctocephalus gazella* in the Southern Ocean in preparation for the CCAMLR-IWC workshop, August 2008. Coordinator: K. Reid (CCAMLR Science Officer, keith@ccamlr.org), 7 pp. (English, unpublished).

CCAMLR-IWC-WS-08/8
A review of the uncertainties associated with penguin population and abundance estimates for the CCAMLR region. Coordinator: P. Trathan (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, p.trathan@bas.ac.uk), 38 pp. (English, unpublished).

This report reviews the availability of data describing penguin abundance in the CCAMLR Convention area, and the uncertainties in deriving overall abundance estimates from these counts. Counts of breeding colonies are available from a variety of sources and, when combined, coverage is thought to be reasonably comprehensive for some areas, but less complete for others.

One key problem is that counts have been collected using various demographic units, and the timing of these have varied relative to availability of these units. Counts therefore have to be standardised prior to being summed, but the adjustment data required to achieve this are only available for a small number of site-year combinations. The other fundamental problem

is that the latest site counts are of variable ages, and since penguin populations are known to vary with time the assumption of population stability since the most recent count cannot always be justified.

Modelling approaches that may reduce these uncertainties are recommended and the errors and biases that are likely to arise from fitting these to penguin count data are discussed.

CCAMLR-IWC-WS-08/9

The role of fish as predators of krill (*Euphausia superba*) and other pelagic resources in the Southern Ocean. Coordinator: K.-H. Kock (Institut für Seefischerei, Johann Heinrich von Thünen Institut, Palmaille 9, D-22767 Hamburg, Germany, karl-hermann.kock@vti.bund.de), 81 pp. (English, unpublished).

CCAMLR-IWC-WS-08/10

Review of input data for Antarctic ecosystem models: pelagic cephalopods. Coordinator: P. Rodhouse (British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, p.rodhouse@bas.ac.uk), 17 pp. (English, unpublished).

CCAMLR-IWC-WS-08/11

Krill population trends. Coordinator: S. Nicol (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston 7050, Tasmania, Australia, steve.nicol@aad.gov.au), 36 pp. (English, unpublished).

Krill (*Euphausia superba*) distribution and abundance data are available from a number of sources: from net surveys (the longest historical series of available date), from acoustic surveys, from fisheries data and from the distribution of krill predators. Each of these forms of data collection has its own biases and limitations and our current understanding of krill distribution and abundance comes from utilising the various forms of data to the maximum extent possible. Time series data are really only available from the South Atlantic where scientific netting programs and annual acoustic surveys have been carried out annually. The South Atlantic is also the area where the fishery has concentrated for the last 20 years. There have been suggestions of changes in the distribution and abundance of Antarctic krill, based mainly on analysis of available scientific net data. There is also evidence of intense inter- and intra-annual variability of krill abundance within regions. These fluctuations in abundance make detection of long-term trends difficult to detect. This review examines the main types of data available for Antarctic krill and will present an indication of the extent and limitations of the available datasets and will present the currently accepted state of knowledge concerning krill distribution, abundance and trends.

CCAMLR-IWC-WS-08/12

Zooplankton in Southern Ocean food web models: a critique of available data. Coordinator: A. Atkinson (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, aat@bas.ac.uk), 59 pp. (English, unpublished).

This overview provides a critical evaluation of the strengths and weaknesses of zooplankton data that may be used in Southern Ocean food web models. It is based on the authors' own practical experience in sampling, experimentation and in compiling datasets on Southern Ocean zooplankton. There is a plethora of data on Southern Ocean zooplankton, but most is on abundance and biomass, with very little on functional rate processes. Most of the data are not in any central database, and we provide pointers to the papers where some of this resides. These papers emphasise the dominant role of copepods, although the relative importance of other groups varies regionally. A recurring theme in our overview is that

straightforward-sounding issues can make compilations of data at best confusing and at worst totally misleading if appropriate allowances are not made. Some of these issues are general to any assimilation of zooplankton datasets, such as the sensitivity of recorded abundance values to the variable identification of larval stages. Likewise the time of year, depth of sampling and mesh size of net used have great influence on recorded abundance, since the populations can make seasonal vertical migrations and their pulsed reproduction causes great seasonal changes in size structure and abundance. Other issues are specific to polar environments, for example, lipid storage which leads to significantly different relationships between vital rates and body mass than are found more generally. Likewise stenothermy (narrow temperature tolerance) means that more general literature compilations of metabolic rates with temperature and Q10-type relationships must be applied with great caution in Antarctica. We identify datasets and approaches to combat these issues, and suggest four simple functional groups based on biomass and ecology (mesozooplankton, salps, krill and remaining macrozooplankton). This review also highlights some of the strengths and weaknesses in methodology and data coverage in feeding studies. The zooplankton show a wide range of feeding behaviour from omnivory to carnivory – there are no true herbivores. We examine the range of food chain types, concluding that protozoans/micrometazoa (<200 μm) must indeed be the main grazers in the Southern Ocean, since larger zooplankton typically remove <30% of primary production. This emphasises the dominant role of microbial food chains relative to the classical diatom-krill-whale type food chains. Overall, the great diversity in zooplankton size and ecology, combined with their specific adaptations to Antarctica, requires care both in assembling comparable datasets and in modelling their rate processes.

CCAMLR-IWC-WS-08/13

CCAMLR-IWC Export Group Report: Primary productivity and phytoplankton. Coordinator: P. Strutton (College of Oceanic and Atmospheric Sciences, Oregon State University, USA, strutton@coas.oregonstate.edu), 22 pp. (English, unpublished).

This report summarizes the satellite ocean color (chlorophyll) data that are currently available, from missions beginning with the Coastal Zone Color Scanner in the late 1970s through to the SeaWiFS and MODIS sensors that have been providing data for the last ten years. The characteristics of these data and limitations such as cloud cover and high solar zenith angle are discussed with regard to their use in the Southern Ocean. A brief history of algorithms linking ocean color to primary productivity is presented, focusing on the vertically generalized production model (VGPM) and more recent regional, carbon-based approaches. Using monthly climatologies of SeaWiFS chlorophyll, a phenology of phytoplankton blooms is presented for the major provinces surrounding Antarctica. Some of the published information regarding phytoplankton species composition and succession is summarised. Finally, a review of ecosystem and biogeochemical models for the Southern Ocean is presented, with a focus on those models that have been validated using satellite ocean color data.

CCAMLR-IWC-WS-08/14

Observing and modelling Antarctic sea ice habitats – Sea Ice Expert Group Report to the CCAMLR-IWC Workshop to Review Input Data for Marine Ecosystem Models. Coordinator: R. Massom (Ecosystems Cooperative Research Centre, Private Bag 80, c/o University of Tasmania, Hobart, Tasmania 7001, Australia, r.massom@utas.edu.au), 68 pp. (English, unpublished).

CCAMLR-IWC-WS-08/15
An overview of data and models for Southern Ocean studies. Coordinator: E. Hofmann (Center for Coastal Physical Oceanography, Old Dominion University, Norfolk, VA 23508, USA, hofmann@ccpo.odu.edu), 26 pp. (English, unpublished).

CCAMLR-IWC-WS-08/16
CCAMLR-IWC Workshop metadatabase. Coordinator: S. Doust (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston 7050, Tasmania, Australia, susan.doust@aad.gov.au), 16 pp. (English, unpublished).

CCAMLR-IWC-WS-08/17
Conveners' guide to generating a synopsis of papers from expert groups to assist with general discussions. Coordinators: A. Constable and N. Gales (Co-conveners, Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, andrew.constable@aad.gov.au), 8 pp. (English, unpublished).

CCAMLR-IWC-WS-08/18
Food consumption by flying seabirds in the Southern Ocean. Coordinator: B. Wienecke (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia), 9 pp. (English, unpublished).

Working Group on Fish Stock Assessment (WG-FSA)

WG-FSA-08/4
CCAMLR fisheries: 2008 update. CCAMLR Secretariat, 9 pp. (English, unpublished).

Information on CCAMLR fisheries of relevance to the work of WG-FSA is summarised, including availability of data, data-related developments in 2007/08, catches in assessed and exploratory fisheries, and updates to WG-FSA's Fishery Reports. Additional fishery-related information can be found in WG-FSA-08/5 to 08/8 (summaries of observer data), SC-CAMLR-XXVII/BG/1 (catches in the Convention Area) CCAMLR-XXVII/12 (summary of notification for new and exploratory fisheries), WG-FSA-08/10 (estimates of IUU catches) and CCAMLR-XXVII/BG/15 (implementation of fishery-related conservation measures).

WG-FSA-08/5 Rev. 1
A summary of observations on board longline vessels operating within the CCAMLR Convention Area during the 2007/08 season. CCAMLR Secretariat, 28 pp. (English, unpublished).

WG-FSA-08/6 Rev. 1
Summary of observations aboard trawlers operating in the Convention Area during the 2007/08 season. CCAMLR Secretariat, 14 pp. (English, unpublished).

WG-FSA-08/7 Rev. 2
A summary of scientific observations related to Conservation Measures 25-02 (2007), 25-03 (2003) and 26-01 (2006). CCAMLR Secretariat, 15 pp. (English, unpublished).

WG-FSA-08/8
Summary of observations aboard pot vessels operating in the Convention Area during the 2007/08 season. CCAMLR Secretariat, 6 pp. (English, unpublished).

WG-FSA-08/9
Review of CCAMLR activities on monitoring marine debris in the Convention Area. CCAMLR Secretariat, 20 pp. (English, unpublished).

CCAMLR Members monitor beached debris, entanglement of marine mammals, marine debris associated with seabird colonies and animals contaminated with hydrocarbons at a number of sites, primarily in Area 48.

Overall non-fishing debris items (mostly packaging items) have made up the majority of debris reported from monitoring sites. Relatively large amounts of fishing items have been reported at Bird Island, South Georgia over the last 13 years, but only small amounts from the other sites.

Since 1991, data on entanglements of Antarctic fur seals has been received from 3 Members for 4 different sites, however only two of these sites have reported data for consecutive seasons. The most common entangling materials were plastic packaging bands, synthetic string/longline and fishing nets.

The wandering albatross has more debris reported from its colonies than any other species monitored at Bird Island with the majority of debris items being fishing lines and hooks.

A total of 49 cases of hydrocarbon soiling for 8 species of seabirds have been reported to the Secretariat. The wandering albatross is the most frequently recorded and the most common type of soiling agent was oil.

Plastic packaging bands have been found regularly at sites monitored for beach debris and entangled on fur seals, despite their prohibition (for securing bait boxes) or restricted use (other plastic packaging bands) in Conservation Measure 26-01.

There is no evidence of a decrease in the occurrence of marine debris over the past 10 years at any of the sites monitored. Although the amount of beached marine debris reported from Bird Island and Signy Island, South Orkney in the last decade has decreased from the numbers reported in the mid-nineties.

The Secretariat encourages all Members who collect marine debris information to submit it for inclusion in the CCAMLR marine debris database.

WG-FSA-08/10 Rev. 2
Estimation of IUU catches of toothfish inside the Convention Area during the 2007/08 fishing season. CCAMLR Secretariat, 9 pp. (English, unpublished).

The paper presents an estimate of IUU catches of toothfish during the 2007/08 fishing season, using the standard methodology.

WG-FSA-08/11
Fishing activity and seabird-vessel attendance near the northern Antarctic Peninsula. J.A. Santora, K.S. Dietrich and D. Lombard (Antarctic Ecosystem Research Division, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA, jasantora@gmail.com), 15 pp. *Marine Ornithol.*, submitted (English).

We conducted a survey to investigate the factors influencing the number of seabirds attending a research vessel during scientific trawling activities near the northern Antarctic Peninsula. Our objective was to assess whether seabirds exhibited differing levels of attendance that may be attributed to fishing activity. Counts of seabirds attending the vessel were made during non-fishing periods, net deployment, towing, and retrieving. We also monitored environmental variables (e.g. pressure, wind speed and direction) and discards of

fish and offal to determine whether they could be used to explain variability in seabird attendance. Three species, the black-browed albatross *Thalassarche melanophrys*, Cape petrel *Daption capense* and Wilson's storm petrel *Oceanites oceanicus* were the most common seabirds attending the vessel. We found that abundance of seabirds did not differ among fishing activities, although the presence of discard caused an increase in numbers of petrels and albatrosses. Our study is the first to examine seabird-vessel attendance to scientific trawling activities in Antarctic waters where there is a moratorium on commercial finfish fishing. By comparison to other studies, the level of fishing conducted during this study is not anywhere near that of commercial fishing (i.e. catch rate and fishing duration). Nevertheless, it is important to monitor seabird attendance to fishing vessels so that proper mitigation and conservation actions are met to protect seabirds.

WG-FSA-08/12

Comparative characteristics of basic biological parameters of two toothfish species in high-latitude seas of the Antarctic. A.K. Zaytsev (YugNIRO, 2 Sverdlov Street, Kerch, 98300, Ukraine, akz2006@yandex.ru), 8 pp. (English, unpublished).

Scientific data were obtained during the fishery cruise of Spanish long-liner *Tronio* in the areas of the Ross Sea and the Antarctic continental shelf (Statistical Subareas 88.1 and 58.4.1) outside the exclusive (marine) economic zones of foreign states, in the period from 5 November, 2007 till 24 March, 2008. In the paper size characteristics of Antarctic and Patagonian toothfishes caught in different areas of the Antarctic shelf were given as well as characteristics of maturity level of gonads and nutrition of the examined fish.

WG-FSA-08/13

New records of deep-sea skates (Rajidae, Chondrichthyes) from the Crozet Archipelago. S.P. Iglésias, N. Gasco and G. Duhamel (Muséum national d'Histoire naturelle, 43 rue Cuvier, 75231 Paris Cedex 05, France, iglesias@mnhn.fr), 4 pp. (English, unpublished).

Two species of deep-sea skates (Rajidae, Chondrichthyes) are newly recorded from the slope of the Crozet Archipelago. Specimens are preserved in collections, morpho-anatomical observations and molecular barcoding are currently in process to identify that species.

WG-FSA-08/14

Some field materials on area and season of Antarctic toothfish spawning. V. Prutko (YugNIRO, 2 Sverdlov Street, Kerch, 983000, Crimea, Ukraine), 10 pp. (English, unpublished).

On the results of some field materials collected from 2002 till 2008, on the basis of length composition analysis of individuals, weight of females' gonads and sex ratio an attempt was made to select locations and periods of Antarctic toothfish mass spawning in some areas of the Pacific Ocean and Indian Ocean sectors of the Antarctic. In the Ross Sea area the most probable areas are the Pacific Antarctic Ridge and the Amundsen Ridge in the Amundsen Sea area. In the Cooperation Sea area the most possible mass spawning place is the BANZARE Bank. Obviously, the mass spawning is stretched and falls on the winter season, sometimes covering part of autumn or spring season.

WG-FSA-08/15

CCAMLR tagging program. CCAMLR Secretariat, 6 pp. (English, unpublished).

WG-FSA-08/16

Operational difficulties in implementing the CCAMLR tagging protocol in Division 58.4.1 in 2007/08. A.T. Lozano and O. Pin (Comisión Interministerial CCRVMA

Uruguay, Ministerio de Relaciones Exteriores, Colonia 1206, 2do piso, Montevideo, Uruguay, comcruma@mrree.gub.uy), 3 pp. (Spanish, unpublished).

The Uruguayan-flagged longliner *Banzare* experienced sea-ice related, operational difficulties in implementing the CCAMLR Tagging Protocol in Division 58.4.1 in 2007/08. Extensive sea-ice cover greatly increased the transit times between research haul locations, which resulted in long soak times and a high mortality rate of fish on these lines; only fish with a high chance of survival were tagged. In brief:

- The vessel started fishing in Division 58.4.1 SSRU E on 6 January 2008 but only completed one haul (no catch) due to adverse ice conditions, and the vessel exited that division;
- The vessel returned to Division 58.4.1 SSRU C and resumed fishing on 27 January 2008, completing 16 hauls including 10 research hauls. The vessel then moved to SSRU E on 3 February 2008 and completed 3 hauls (note: SSRU G was closed on 30 January 2008).
- The vessel caught a total of 9.757 tonnes of *Dissostichus mawsoni* in Division 58.4.1 and tagged and released 10 fish (tagging rate: 1.02 fish/tonne), which was below the tagging rate of 3 fish tagged per tonne of green weight caught required in Conservation Measure 41-11(2007).

The vessel and authorities were aware that the extensive sea-ice cover had prevented the vessel from tagging fish in Division 58.4.1 at the rate required by CCAMLR. As a result, the vessel made every effort to tag fish in excess of the required rate when the opportunity arose:

- in Division 58.4.3a the vessel tagged fish at a rate of 4.9 fish/tonne;
- in Division 58.4.3b the vessel tagged fish at a rate of 4.6 fish/tonne.

WG-FSA-08/17

Age estimation and lead-radium dating of Antarctic toothfish (*Dissostichus mawsoni*). C.M. Brooks, A.H. Andrews, J.R. Ashford, G.M. Cailliet, N. Ramanna and C. Lundstrom (Moss Landing Marine Laboratories, 8272 Moss Landing Road, Moss Landing, CA 95039, USA, cbrooks@mlml.calstate.edu), 39 pp. (English, unpublished).

Antarctic toothfish (*Dissostichus mawsoni*) are subject to an increasingly important commercial fishery in the Southern Ocean, yet many of their life history characteristics, including vital rates, remain unknown. In this study, Antarctic toothfish were aged using otolith age estimation criteria established for Patagonian toothfish, *D. eleginoides*, a closely related species. To validate estimated ages, the radioactive disequilibrium of lead-210 and radium-226 in otolith cores was measured and used as an independent chronometer to determine age. Age estimates indicated Antarctic toothfish live to at least 39 years of age. Estimated and radiometric ages were in close agreement, confirming age estimation criteria and an annual periodicity of otolith growth zones. Von Bertalanffy growth function parameters indicate Antarctic toothfish are relatively slow-growing (k = 0.111; t_0 = –0.605), especially in relation to their maximum size (L_∞ = 158.9 cm). These vital rates are discussed in the context of the growing Antarctic toothfish fishery.

WG-FSA-08/18

Spatial distribution and age structure of the Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea, Antarctica. C.M. Brooks and J.R. Ashford (Moss Landing Marine Laboratories, 8272 Moss Landing Road, Moss Landing, CA 95039, USA, cbrooks@mlml.calstate.edu), 33 pp. (English, unpublished).

The Ross Sea has been geologically characterized by tectonic and glacial processes. These processes have created diverse habitat, including distinct banks and basins. For many fish

species the availability of habitat is critical to the long-term viability of the population. Antarctic toothfish (*Dissostichus mawsoni*) are subject to an increasingly important commercial fishery in the Ross Sea and yet little is known about habitat associations for different life history stages. To define and assess the availability of habitat for Antarctic toothfish a benthic habitat map of the Ross Sea was created based on the habitat mapping scheme developed by Greene et al. (1999). Fish age data from the long-line fishery in the Ross Sea were superimposed on the habitat map and broken into discrete spatial areas. Differences in age distributions between these areas were found using ANOVA. These distributions were consistent with an ontogenetic movement of fish from shallow continental shelf habitats to deep-water continental slope was documented. Younger, less mature fish were located on the continental shelf and older fish were located on the continental slope. In addition, the older and most mature individuals were found on ridges in the northern Ross Sea, consistent with the hypothesis of an austral summer spawning migration from continental slope to the ridge habitat of the North Ross Sea. An effective management strategy might focus on protecting the northern ridge habitat to maintain long-term viability of Antarctic toothfish populations.

WG-FSA-08/19

Classification guide for potentially vulnerable invertebrate taxa in the Ross Sea longline fishery. S. Parker, D. Tracey, E. Mackay, S. Mills, P. Marriott, O. Anderson, K. Schnabel, D. Bowden and M. Kelly (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Wellington, New Zealand, s.parker@niwa.co.nz), 6 pp. (English, unpublished).

Conservation Measure 22-06, in the absence of site-specific or other conservation measures to prevent significant adverse impact on vulnerable marine ecosystems, requires specific actions to be taken when evidence of a Vulnerable Marine Ecosystem (VME) is encountered in the course of fishing operations. Monitoring fishing operations for encounters with evidence of a potential VME entails identification of specific taxonomic groups of invertebrates, such as sponges or corals. Identification of these organisms to the appropriate taxonomic grouping has not been a standard procedure, and no identification guide specific to both indicative VME taxa and Antarctic species has been developed. The objective of this guide is to provide observers on long-line vessels with a potential VME-taxa specific, quick, on-deck guide to aid in the classification of invertebrate by-catch into the appropriate groupings. The format of the guide is a 'compare and contrast table', using photographs and key characteristics to correctly classify likely VME taxa to the appropriate grouping. It also identifies those commonly mistaken for other taxa. It is printed as an A2 waterproof poster for display in the vessel factory or on deck for easy reference. Once classified, these observations can be used for monitoring evidence of a potential VME. Additional invertebrate identification guides are still needed for fine taxonomic resolution for all invertebrate by-catch.

WG-FSA-08/20

Updated biological parameters for the Antarctic starry skate (*Amblyraja georgiana*) from the Ross Sea. M.P. Francis and S. Mormede (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Wellington, New Zealand, m.francis@niwa.co.nz), 15 pp. (English, unpublished).

Photographs of skates taken by observers on New Zealand toothfish longliners in the Ross Sea were identified to species. Sample sizes were small, but indicated a ratio of 10.75:1 of *Amblyraja georgiana* to *B.* cf. *eatonii*, which is consistent with a previous estimate based on a

large sample of tagged skates. Biological parameters were reviewed and updated for *Amblyraja georgiana*. Revised length-weight regression relationships for male and female *A. georgiana* confirmed that male and female relationships differ significantly. Better estimates of median length at maturity were made possible through a combination of improved observer staging of skates, and a moderate-sized sample of whole skates that was examined in the laboratory. There was no significant difference between the median length at maturity for male and female *A. georgiana*, which was estimated to be 67.3 cm pelvic length (= 96.5 cm total length). Nearly all of the skates caught were returned to the sea (discarded or tagged). A considerable proportion of these were returned in good condition and were considered likely to survive. Estimates of the proportion released in good condition are in the range 50–80%, depending on assumptions about whether skates were double counted, and whether all tagged skates were in good condition. Improved data recording using new fate and condition classes and a new data logsheet should provide better estimates of this parameter next year.

WG-FSA-08/21

Revised age and growth estimates for Antarctic starry skate (*Amblyraja georgiana*) from the Ross Sea. M.P. Francis and M.J. Gallagher (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Wellington, New Zealand, m.francis@niwa.co.nz), 12 pp. *CCAMLR Science*, submitted (English).

A previous study on the age and growth of *Amblyraja georgiana* in the Ross Sea suggested that these skates initially grow very rapidly for about five years, after which growth almost ceases (Francis and Ó Maolagáin, 2005). We present an alternative interpretation of age and growth in *A. georgiana* that is radically different from the published interpretation. By counting fine growth bands in the caudal thorns instead of broad diffuse bands, we have generated growth curves that suggest much slower growth, greater ages at maturity (about 20 years compared with 6–11 years) and greater maximum ages (28–37 years compared with 14 years). Several pieces of circumstantial evidence support the new interpretation, but a validation study is required to determine which growth scenario is correct.

WG-FSA-08/22

A characterisation of the toothfish fishery in Subareas 88.1 and 88.2 from 1997/98 to 2007/08. M.L. Stevenson, S.M. Hanchet and A. Dunn (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, m.stevenson@niwa.co.nz), 21 pp. (English, unpublished).

The exploratory fishery for Antarctic toothfish (*D. mawsoni*) has been operating for eleven years in Subarea 88.1 and for six 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 2008 *D. mawsoni* catch was the fourth highest on record with a total of 2 666 tonnes against a combined catch limit of 3 207 tonnes. The management of the SSRUs within the two subareas was changed for the 2006 season as part of a 3-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, two catch limits in the 2007 season, and none in the 2008 season. The catch limit was under caught in both Subareas 88.1 and 88.2 during the 2008 season, primarily as a result of the ice conditions.

The length frequency data from the Ross Sea fishery have been very consistent over the past 3–4 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-08/23

Preliminary analysis of *Dissostichus mawsoni* by-catch during bottom and krill fishing (Statistical Division 58.4.2). L.K. Pshenichnov (YugNIRO, 2 Sverdlov Street, Kerch, 98300, Ukraine, lkp@bikent.net), 5 pp. (English, unpublished).

Preliminary analysed data obtained from bottom fishing in 1987, 1989 from Cosmonaut and Cooperation Seas. Presented frequency of occurrence of immature *Dissostichus mawsoni* in catches of bottom trawls and juvenile *Dissostichus mawsoni* in catches of mid-water trawls during krill fishing in the same regions. Some grounds of these seas are permanent feeding places of *Dissostichus mawsoni*.

WG-FSA-08/24

Beach debris survey – Main Bay, Bird Island, South Georgia 2006/07. F. Le Bouard (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom), 17 pp. (English, unpublished).

During the seventeenth year of standardised beach surveys of man-made debris at Bird Island, South Georgia (covering the period 1 October 2006 to 30 September 2007) a total of 365 items were collected. This represents a reduction by 33% on the 544 items recorded in 2005/06 and a decrease in mass of 1.72 kg (32%). The distribution of debris between the summer and winter was similar to the five previous years: 73% during summer (265 items) and 27% during winter (100 items). After three consecutive years in which no fisheries related debris was observed, one nylon fishing line and one snood were found on the survey beach during the summer, plus another snood in winter (August). Both snoods were clearly identified as being the end of a multifilament line where a hook would have been attached. Five multifilament fishing lines (from longliners) were found on the beach, all during the winter fishing season. Six plastic packaging bands were recovered, suggesting that measures introduced by CCAMLR to control their use onboard fishing vessels have yet to prove entirely effective. Fifty-six pieces of trawl web were recovered, mainly during the summer period. Miscellaneous debris such as plastic sheeting, styrofoam packaging and other plastic items comprised the greatest proportion of items removed from the study beach (96% of the total).

WG-FSA-08/25

Fishing equipment, marine debris and hydrocarbon soiling associated with seabirds at Bird Island, South Georgia, 2007/08. D. Fox (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 hydrocarbons associated with seabirds at Bird Island, South Georgia for the period 1 April 2007 to 31 March 2008. It is the fifteenth such annual report. As in previous years, the majority of items (84%) of marine debris and fishing gear (mostly hooks and lines from longline fisheries) were found in association with wandering albatrosses *Diomedea exulans*, and very few in association with grey-headed *Thalassarche chrysostoma* and black-browed albatrosses *T. melanophrys*. Despite increased observer effort, a slight decrease was observed in the total number of items encountered (n = 116) compared with the previous season. Two non-fatal entanglements involving a wandering albatross and a northern giant petrel

Macronectes halli were observed, and in both cases the fishing gear was typical of that used in longline fisheries. There were no incidences of hydrocarbon soiling of seabirds during the reporting period.

WG-FSA-08/26

Beach debris survey and incidence of entanglement of Antarctic fur seals (*Arctocephalus gazella*) at Signy Island, South Orkney Islands, 2007/08. M.J. Dunn and C.M. Waluda (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom), 19 pp. (English, unpublished).

This report details the twelfth annual survey of the incidence of entanglements of Antarctic fur seals *Arctocephalus gazella* and eighteenth beach survey of man-made debris at Signy Island, South Orkney Islands. Data are reported for the period 14 November 2007 to 13 March 2008. Three seals were observed with neck collars formed from fisheries related debris. Beach surveys recovered a total of 56 items weighing 11 kg, representing an increase from 2006/07 of 11% (by number) and 33% (by mass). There was a decrease in the number of plastic packaging bands with only two found in the current season (both of which had been cut open), marking a break in the otherwise continued rise in packaging bands observed. Styrofoam and other plastic waste was predominant, making up 64% of all items recorded. Fishing related debris contributed 11% of all items (9% rope and 2% trawl net webbing). These results 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.

WG-FSA-08/27

Entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at Bird Island, South Georgia, during the 2007 winter and 2007/08 breeding season. E.W.J. Edwards (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge, CB3 0ET, United Kingdom), 17 pp. (English, unpublished).

Results of the survey of entanglements of Antarctic fur seals *Arctocephalus gazella* at Bird Island, South Georgia for the 18th consecutive winter (April to October 2007) and 20th consecutive summer (November 2007 to March 2008) are reported here. During the reporting period of 1 April 2007 to 31 March 2008 a total of 36 entangled seals were observed. Sixteen and 20 entanglements were observed in the winter and summer periods respectively. Entanglements classed as Severe or Very Severe accounted for 25% of winter and 10% of summer entanglements. During winter, synthetic string/longline material was the most commonly found item forming neck collars (44%), whereas during summer the largest proportion of entanglements were in sections of fishing net (40%). Packing bands were the second most abundant entangling material in both summer (38%) and winter (25%). The majority of entanglements (78%) involved juveniles (including pups and sub-adults), comprising 88% in winter and 65% in summer. Data for the winter period showed a decrease in the number of entanglements compared to the high levels during the previous season, but levels were still above the long term winter median (1990–2006). Data for the summer period showed a small rise in the number of entanglements compared with the previous season, but levels were slightly below the long term summer median (1989–2007).

WG-FSA-08/28

Groundfish survey in CCAMLR Subarea 48.3 in April 2008 with preliminary assessment of mackerel icefish. M.A. Collins, R.E. Mitchell, C.E. Main, J. Lawson,

J. Watts, J. Slakowski, L. Featherstone and O. Rzewuski (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, macol@bas.ac.uk), 37 pp. *Polar Biol.*, submitted (English).

In April 2008 the UK undertook a bottom trawl survey of CCAMLR Subarea 48.3 on the FV *Sil*, with 70 bottom trawls undertaken giving good geographic coverage. Using 10 strata and the updated sea-floor areas and adjusting this for the low headline height of the UK trawl (see CCAMLR WG-FSA (2003), the biomass of mackerel icefish was estimated to be 80 426 tonnes, with a lower one-sided 95% CI of 30 050. Catch-weighted length frequencies indicated that icefish population was dominated by 2+ and 3+ fish, with differences in the size between Shag Rocks and South Georgia and with few small fish in the NW South Georgia area. A preliminary short-term projection of the mackerel icefish stock was run using standard CCAMLR parameters in the GYM. Two scenarios were tested, both assumed that all the 2007/08 catch that remained after the survey (1 709 tonnes) will be taken. Scenario 1, which included the 1+ fish produced yield of 3 445 tonnes in Year 1 (2008/09) and 2 318 tonnes in Year 2 (2009/10). In Scenario 2, in which the 1+ fish were excluded and biomass adjusted accordingly, yields were 3 372 and 2 248 tonnes in Years 1 and 2 respectively. The Patagonian toothfish population was dominated by the same cohort that has been detected by surveys since 2003, with no evidence of new recruitment since. Biomass estimates and length frequencies are reported for other non-target species. Conducing the survey in April was successful. The icefish appeared to be dispersed, which is amenable to a random trawl survey. There was evidence that the September 2007 survey under sampled the 2+ fish, meaning that September is not an ideal time for a survey.

WG-FSA-08/29

Identifying patterns in diet of mackerel icefish (*Champsocephalus gunnari*) at South Georgia using bootstrapped confidence intervals of a dietary index. C.E. Main, M.A. Collins, R. Mitchell and M. Belchier (British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom, Current address: Fisheries Research Services, Marine Laboratory, Aberdeen, Scotland, AB24 5AX, c.main@marlab.ac.uk), 40 pp. *Polar Biol.*, submitted (English),

Ontogenetic, inter-annual and regional variations in diet were investigated in mackerel icefish, *Champsocephalus gunnari*, in three successive summer seasons around South Georgia. Stomachs from 2 239 icefish (130–560 mm total length) were examined. A bootstrapping technique was used to calculate confidence intervals for an index of relative importance (% IRIDC) of prey categories. Diet varied significantly between years and age classes but there was little regional difference in diet. In general diet was dominated by krill, *Euphausia superba* and by the amphipod *Themisto gaudichaudii*. Smaller (younger) fish tended to prey on a higher proportion of *T. gaudichaudii* and small euphausids such as *Thysanoessa* sp. and took smaller quantities of *E. superba*. In a season of poor krill availability (summer of 2003–2004) the proportion of krill in the diet, stomach fullness and fish condition (indicated by length-weight relationships) were significantly lower than in the other summer seasons. The poor krill season was followed by a large reduction (> 80%) in the estimated annual biomass of *C. gunnari* the following year (2005). This may have been a result of mortality of age 2+ and 3+ fish, which were more krill dependent than 1+ fish. Younger fish appear to have survived, leading to an increase in the estimated population biomass in 2006.

WG-FSA-08/30

A review of the methods used to release skates (rajiids), with or without tags, in Antarctic exploratory fisheries. J.M. Fenaughty (Silvifish Resources Ltd, PO Box 17-058, Karori, Wellington, New Zealand, jmfenaughty@clear.net.nz), 22 pp. (English, unpublished).

An ongoing mark and recapture experiment for skates was commenced by New Zealand fishing vessels in the Ross Sea (CCAMLR Subareas 88.1 and 88.2) in 1999/2000. Based on preliminary results from this programme showing an unquantifiable degree of the survivorship of returned skates, the CCAMLR Scientific Committee gave approval in 2004 for licensed vessels to cut live skates from the line (while in the water) as an alternative to either retaining all aboard or discarding dead skates, as a skate mortality mitigation measure.

Initial opinion when the skate tag and recapture programme was first implemented was that some form of in-water release would be the ideal to improve survival chances. Subsequently a number of problems have become evident with this method. The Working Group on Fish Stock Assessment (WG-FSA) noted in 2004, when recommending skate release as an option to the Scientific Committee, that it might be difficult to detect tagged rays skates if they are cut off at the sea surface rather than being brought on board. WG-FSA recommended that should the tag identification rate be low, a relaxation of the requirement to cut all rajids from the line on specified vessels and/or for specified time periods be adopted. Consistent with this recommendation, commencing in the 2006/07 season, New Zealand fishing vessels were given permission by the New Zealand government as part of the national research plan, to trial an alternative technique. The new method (for simplicity in this paper called Method 2), required the crew to bring the skate aboard carefully, remove the hook and snood, take and record biological (and potentially other meristic data) from a sub-sample when possible, and release live skates in a timely fashion in a manner most likely to ensure survival. The advantages of this method have been the more effective scanning of the captured skate for existing tags, greater accuracy in the assessment of ideal candidates for live release, the capability to collect supporting meristic and biological data for release candidates, correct species and sex identification, and the ability to more accurately place tags on the skate body – improving the quality of skate tagging. Following favourable results aboard by New Zealand vessels using Method 2 during the 2006/07 season and following a discussion and recommendation from WG-FSA 2007 an amendment to Conservation Measure 33-03 (2007) was made stating that: 'Unless otherwise requested by scientific observers, vessels, where possible, should release skates and rays alive from the line by cutting snoods, and when practical, removing the hooks'.

This paper documents the evolution of skate release methods both for tagging and for live release for New Zealand autoline vessels. It describes the current Method 2 systems in use for two New Zealand vessels. A brief analysis based on data collected from the skates treated in this manner during the 2007/08 fishery in the Ross Sea is included in the document to highlight the additional advantages in data collection possible using Method 2.

This paper is intended to inform WG-FSA with additional information collected over the last two fishing seasons in preparation for the 'Year of the Skate' prior to a final decision on skate release protocols. A proposal is made for a comparative experiment using two tag types to inform a final decision on a standardised CCAMLR tag type for rajid mark and recapture programs carried out within CCAMLR *Dissostichus* spp. exploratory fisheries.

WG-FSA-08/31

Biomass estimates and size distributions of demersal finfish on the Ross Sea shelf and slope from the New Zealand IPY-CAML survey, February–March 2008. S.M. Hanchet, M.L. Stevenson, C. Jones, P.M. Marriott, P.J. McMillan, R.L. O'Driscoll, D. Stevens, A.L.

Stewart and B.A. Wood (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, s.hanchet@niwa.co.nz), 23 pp. (English, unpublished).

A survey using the NIWA research vessel *Tangaroa* was carried out in the Ross Sea during February and March 2008 as part of the International Polar Year. The main aim of the survey was to carry out a Census of Antarctic Marine Life in this region focussing on sampling the pelagic and benthic habitats on the shelf, slope, abyss, and seamounts in the Ross Sea region (CCAMLR Subarea 88.1). The shelf and slope were stratified by depth and at least three random trawls completed in each stratum. The trawl survey of the shelf area focused mainly on icefishes, notothens, Antarctic silverfish, and glacial squid whilst the survey of the slope area was designed to target the macrourid *M. whitsoni* as it is the main species taken as bycatch in the toothfish fishery, and the most important prey item in the toothfish diet.

Biomass estimates and catch rates by station are presented for the eight most abundant teleost species along with scaled length frequencies of those species.

WG-FSA-08/32

Indicative estimates of biomass and yield of Whitson's grenadier (*M. whitsoni*) on the continental slope of the Ross Sea in Subareas 88.1 and 88.2. S.M. Hanchet, D. Fu and A. Dunn (National Institute of Water and Atmospheric Research (NIWA) Ltd, PO Box 893, Nelson, New Zealand, s.hanchet@niwa.co.nz), 12 pp. (English, unpublished).

Catch limits currently in place for macrourids in Subareas 88.1 and 88.2 are defined as being equal to 16% of the catch limit of *Dissostichus* spp. in these subareas. The 16% was based on the ratio of the by-catch limit for macrourids to the catch limit for *Dissostichus* spp. in Division 58.5.2 in 2002/03 (CCAMLR-XXI, paragraph 11.53). The by-catch limit for macrourids in Division 58.5.2 had in turn been based on the extrapolation of catch rates from a trawl survey of *M. carinatus* on BANZARE Bank.

Two bottom trawl surveys (IPY_CAML and BioRoss) have recently been carried out by New Zealand on parts of the continental slope of the Ross Sea in SSRU 88.1H. Whitson's grenadier (*M. whitsoni*) was the most abundant species caught during both surveys, with mean catch rates in some strata being considerably higher than those recorded for *M. carinatus* on BANZARE Bank. Because the strata covered by the New Zealand surveys represented only 25% of the continental slope of the Ross Sea, the data could not be used to calculate a biomass estimate for the entire slope directly. Instead, indicative biomass estimates for the rest of the area were made by extrapolating the more recent IPY-CAML survey catch rates across the entire slope. The extrapolations were carried out in two ways: (i) assuming *M. whitsoni* densities were constant across the entire slope and (ii) assuming *M. whitsoni* densities were proportional to the commercial macrourid CPUE from the fishery. The uncertainty of the extrapolated biomass was estimated through a bootstrap procedure.

Indicative estimates of *M. whitsoni* biomass for the Ross Sea slope ranged from 26 892 tonnes (CV = 29%) to 41 823 tonnes (CV = 28%) depending on assumptions. Applying estimates of gamma (γ) = 0.01439 and 0.01814 gave indicative estimates of yield in range 386–602 tonnes and 487–759 tonnes respectively. These indicative yield estimates provide tentative support for the by-catch limit of 374 tonnes currently in place for *M. whitsoni* on the Ross Sea slope (SSRUs 881H–L and 882A–B).

WG-FSA-08/33

Age and growth of spiny icefish (*Chaenodraco wilsoni* Regan, 1914) off Joinville-D'Urville Islands (Antarctic Peninsula). M. La Mesa, A. De Felice, C.D. Jones and

K.-H. Kock (ISMAR-CNR, Istituto di Scienze Marine, Sezione Pesca Marittima di Ancona, Largo Fiera della Pesca, 60125 Ancona, Italy, m.lamesa@ismar.cnr.it), 20 pp. *CCAMLR Science*, submitted (English).

Age and growth of spiny icefish (*Chaenodraco wilsoni*) were investigated using counts of annual growth increments from sagittal otoliths. Samples were collected during research surveys by benthic trawl carried out off Joinville-D'Urville Islands (Antarctic Peninsula) in February–March 2006 and January 2007. A total of 218 specimens were selected for the study, consisting of 120 females and 98 males. The age of fish was estimated by counting annuli on transverse sections obtained by grinding and polishing whole otoliths embedded in epoxy resin in moulds. The precision of age estimates between readings was tested applying both the average percent error (APE) and the coefficient of variation (CV). The estimated age range was 1–5 for males and 1–4 for females of *C. wilsoni*. Applying the von Bertalanffy growth function to the age-length data, a growth curve was obtained for each sex. The estimated values of VB growth parameters L_∞ and k were respectively 32.7 cm and 0.81 for females and 32.7 cm and 0.68 for males. Age at sexual maturity was estimated to be about 2 years for females and 2.5 years for males. Compared to other channichthyids, the spiny icefish exhibited a high growth rate until they reached sexual maturity and a considerable short life span. The fish population of *C. wilsoni* caught in the studied area consisted mainly of adult specimens between 1 and 3 years of age, with very few older fish.

WG-FSA-08/34

Feeding and food interrelationships of Antarctic toothfish (*D. mawsoni* Norman, 1937) (Perciformes, Nototheniidae) in near-continental waters of the Indian Ocean Antarctic area and on the BANZARE Bank. A.F. Petrov and I.G. Istomin (VNIRO, 17 V. Krasnoselskaya, Moscow 107140, Russia, antarctica@vniro.ru), 21 pp. (English, unpublished).

The paper is based on materials on *D. mawsoni* feeding collected by authors in the four near-continental seas of the Indian Ocean Antarctic area (Dupont D'Urville, Mawson, Davis, and Cosmonaut Seas) and on the BANZARE Bank during 2004–2008. The food relationships are considered. The qualitative and quantitative composition of diet for young and adult Antarctic toothfish is studied. The predominant food objects are identified.

WG-FSA-08/35

On the study of fecundity and eggs size of Antarctic toothfish (*Dissostichus mawsoni* Norman 1937). S.V. Piyanova. A.F. Petrov and N.V. Kokorin (VNIRO, 17 V. Krasnoselskaya, Moscow 107140, Russia, pjanova@vniro.ru), 5 pp. (English, unpublished).

The results of the microscopic analyses of the Antarctic toothfish (*Dissostichus mawsoni*) fecundity and eggs size, caught in December–March the Pacific and Indian Ocean area of the Antarctica are presented. We analysed the main reproductive characteristics which determinate the individual fecundity of the Antarctic toothfish: individual absolute fecundity by the largest oocytes, share of largest trophoplasmic oocytes and their diameter.

The frequency of Antarctic toothfish females with the ovaries on IV stages of maturity was 1.2–10% in the different regions. It was revealed that maximum level of fecundity characteristics had pre-spawning females from the Ross Sea, and minimum – toothfish females from the Indian Ocean area of Antarctica. The individual absolute fecundity is varied from 0.03 to 0.61 million eggs, and relative fecundity – from 11.48 to 42.53. The diameter of largest trophoplasmic oocytes is varied from 2.8 to 3.15 mm.

WG-FSA-08/36

Proposal to vary the requirement to test sink rates for integrated weight longline (IWL) gear prior to entering the Convention Area. I. Hay (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, ian.hay@aad.gov.au), 3 pp. (English, unpublished).

This paper proposes that, for fishers whose vessels comply with certain conditions, the requirement in Protocol C1 of Conservation Measure 24-02 to test the sink rate of integrated weight longlines (IWL) before entering the Convention Area is an impost on fishers that is no longer warranted. Testing could instead be conducted in the first week of fishing inside the Convention Area, potentially reducing compliance costs to fishers while appearing to pose little likelihood of increased seabird by-catch.

The conditions to be satisfied include that the vessel used IWL gear in the immediate previous season that fully complied with the required sink rate and that there have been no changes since then to the IWL, other vessel gear and equipment, and operating procedures used for line setting. Other requirements of Conservation Measure 24-02, including for regular sink rate testing of IWL gear during fishing in the Convention Area and reporting of sink rate test results, would remain unchanged, as would the requirements applicable to fishers using other types of longlines.

WG-FSA-08/37 Rev. 1

Report on Australian fishing effort and seabird by-catch in fisheries outside the Convention Area. T. Hewitt and I. Hay (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, tara.hewitt@aad.gov.au), 5 pp. (English, unpublished).

This paper provides a summary of longline and trawl fishing effort, seabird by-catch, and seabird by-catch mitigation measures in Australian fisheries outside the Convention Area. Mandatory seabird by-catch mitigation measures are in place in all longline fisheries within Australia's national jurisdiction. Seabird by-catch is generally low and typically below 0.05 birds per 1000 hooks.

Seabird by-catch is thought to be low in Australian trawl fisheries but, as yet, there are insufficient observer data to fully assess each trawl fishery. As part of efforts to better assess seabird by-catch in Australian trawl fisheries, a pilot study has commenced to undertake an initial appraisal of seabird by-catch in the largest Australian trawl fishery. Depending on the findings; the need for further assessments and implementation of mitigation measures will be considered.

WG-FSA-08/38

Effect of stern-setting tunnel on the sink rate of integrated weight longline (IWL). I. Hay and G. Robertson (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, ian.hay@aad.gov.au), 3 pp. (English, unpublished).

This paper describes a new vessel modification to allow setting of longlines via a stern-setting tunnel, and the proposed experimentation to evaluate this method's effect on the sink rate of demersal integrated weight longline (IWL). The stern setting tunnel consists of an elongated steel tube, built in to the longliner during a dry-dock refit. The tube angles downwards from where the line exits the baiting machine, which is positioned in the aft section of the stern setting deck, to the exit point at the water line on the vessel's transom. The exit point of the tube is understood to be slightly off-centre towards the downward-swing side of the propeller. The sink rate of IWL longlines, conforming to the CCAMLR standard

specified in Conservation Measure 24-02, is planned to be tested in a series of sets using time-depth recorders during current sea-trials and approximately three weeks of fishing in the New Zealand ling fishery. To evaluate the effects of the stern-tunnel method, the sink rates will be compared to similar vessels using IWL and the same setting machinery but setting conventionally over the stern. The sink rate tests are not expected to be completed until just before the WG-IMAF meeting and it is intended that the results will be tabled separately at the meeting commencement.

WG-FSA-08/39

Research plan for toothfish by *Shinsei Maru No. 3* in 2008/09. Delegation of Japan, 9 pp. (English, unpublished).

A proposal to undertake scientific research in CCAMLR Subarea 58.4.4 over the 2008–2009 seasons is introduced. The first survey has been undertaken by a commercial fishing vessel, *Shinsei Maru No. 3*, in 2007/08 season covering the whole SSRUs (Small Scale Research Units). In the course of this first year survey, important information, including information on distribution of toothfish, size composition of toothfish, and by-catch species, has been obtained. However, the information obtained by just the single year survey is not be sufficient in order to quantitatively assess the stock abundance and consider possibility of re-opening the area for new and/or exploratory fishery. Therefore, it is essential to continue the scientific research to accumulate scientific information on toothfish in this area. Furthermore, the presence of legal operators in this area could contribute to monitor and deter the activity of IUU vessels. In addition, tagging and sampling activities during the survey will particularly contribute to the future study on the distribution and population structure of *Dissostichus* spp.

WG-FSA-08/40

Proposal for revising Conservation Measure 41-04 (2007): Limits on the exploratory fishery for *Dissostichus* spp. in Statistical Subarea 48.6 in the 2008/09 season. Delegation of Japan, 3 pp. (English, unpublished).

Japan proposes the revision of the Conservation Measure 41-04 (2007): Limits on the exploratory fishery for *Dissostichus* spp. in Statistical Subarea 48.6 in the 2008/09 season.

WG-FSA-08/41

The analysis of feeding activity and diet composition of Antarctic toothfish (*D. mawsoni*) in the Ross and Amundsen Seas in the fishing season 2006/07. N.V. Kokorin (VNIRO, 17 V. Krasnoselskaya, Moscow 107140, Russia, antarctica@vniro.ru), 31 pp. (English, unpublished).

The results of analysis of stomachs of Antarctic toothfish *D. mawsoni* caught by the Spanish longline from the longliner *Yantar* in the Ross and Amundsen Seas during the period from 29 December, 2006 to 3 March, 2007 are presented. The comparative analysis of diet composition of Antarctic toothfish in different small-scale research units (SSRU) of Subareas 88.1 and 88.2 is given. The graphs of size composition of food objects of Antarctic toothfish and the same by-caught objects are shown.

WG-FSA-08/42

The role of fish as predators of krill (*Euphausia superba*) and other pelagic resources in the Southern Ocean. K.-H. Kock, D.J. Agnew, E. Barrera-Oro, M. Belchier, M.A. Collins, S. Hanchet, L. Pshenichnov, K.V. Shust, D. Welsford and R. Williams (Institut für Seefischerei, Johann Heinrich von Thünen Institut, Palmaille 9, D-22767 Hamburg, Germany, karl-hermann.kock@vti.bund.de), 92 pp. (English, unpublished).

First attempts were made in the early 1980's to estimate the krill and pelagic food consumption by Antarctic demersal fish based on few biomass estimates and mostly qualitative and a few quantitative food studies. These estimates were extended to the mesopelagic realm and the high-Antarctic Zone in the late 1980s and early 1990s when these areas were exploited commercially and a larger number of food studies were conducted concomitant to the fishery. Currently, the best estimates of krill consumption by fish are $23–29 \cdot 10^6$ tonnes of krill and other pelagic prey taken annually by demersal fish and $7–44 \cdot 10^6$ tonnes taken by mesopelagic fish in the Atlantic Ocean sector only. No estimates of food consumption by mesopelagic fish can yet be provided for the Indian and Pacific Ocean sectors. Due to the commercial fishery reducing largely abundant krill predators such as *Notothenia rossii* and *Champsocephalus gunnari* the importance of demersal fish as predators of krill has been substantially reduced in the last 3 decades.

Estimates if pelagic prey consumption still have wide confidence limits. Major shortcomings of the consumption estimated for mesopelagic fish are the validity of hydro-acoustic biomass estimates conducted in the late 1980s and the scarcity of quantitative food consumption data in some abundant myctophid species. Major shortcomings of the consumption estimates of demersal fish are the inaccuracy of biomass estimates for most abundant fish species, the shortness of most food studies which do not adequately grasp the opportunistic feeding habits of many demersal fish and the scarcity of quantitative food studies during winter. There is evident from this review that the importance of krill in fish diets varies substantially with time and location on various scales, and with the suite of prey types available in the different regions in the Southern Ocean.

The imprecise nature of abundance estimates coupled with a wide range of estimates for daily food consumption in summer and a scarcity of such data for the winter season provides little incentive for fish to become an important component in ecosystem and food web models in the Southern Ocean in the near future. As a first step to start a modelling approach including fish we suggest to include *C. gunnari* in considerations and modelling attempts within the CCAMLR Ecosystem Monitoring Program. *C. gunnari* plays an important role as predator of krill and as prey for seals and birds in the seasonal pack-ice zone for which, at least at South Georgia, sufficiently precise parameter estimates could be created as input parameters for models. Furthermore, the effects of large changes in abundance and community structure of fishes brought about by industrial fishing needs to be considered when evaluating changes which have occurred in Southern Ocean ecosystems in the course of the 20th century.

WG-FSA-08/43

Revised assessment of toothfish stocks in Divisions 58.4.1 and 58.4.2. D.J. Agnew, C. Edwards, R. Hillary, R. Mitchell and L.J. López Abellán (Fisheries Group, Division of Biology, Imperial College London, Prince Consort Road, London SW7 2BP, United Kingdom, d.agnew@imperial.ac.uk), 34 pp. *CCAMLR Science*, submitted (English).

Exploratory fisheries for *Dissostichus* spp. have been operating in these regions for a number of consecutive years with the tagging of toothfish a prerequisite for the legal fishery. This paper presents a detailed study of the catch and effort trends in Divisions 58.4.1 and 58.4.2 and examines four assessment methods based on comparative CPUE trends, local depletions, a constant recruitment model and mark recapture data.

WG-FSA-08/44

Preliminary results of trials testing modified longline gear 'trotlines' in presence of cetaceans in Subarea 48.3. R.E. Mitchell, J. Clark, P. Reyes, L. Jones, J. Pearce, C.E. Edwards and D. Agnew (MRAG Ltd., 18 Queen St, London W1J 5PN, United Kingdom, r.mitchell@mrag.co.uk), 12 pp. (English, unpublished).

1. Paired trials were undertaken to compare toothfish catch rates and by-catch composition on Spanish system longlines with those on 'trotlines' fitted with cetacean exclusion devices (cachalotera nets).
2. CPUE (kg/1 000 hooks and kg/set) was greater for trotlines than Spanish system lines when cetaceans were present. This difference increased with increasing abundance of cetaceans highlighting the potential of this gear to reduce cetacean depredation.
3. By-catch to catch ratio was greater by number for Spanish system lines when cetaceans were present during hauling.
4. A large percentage of skates caught on trotlines fitted with cachalotera nets were dead or suffered life-threatening injuries. Toothfish were also in much poorer condition to the extent that they were unsuitable for tagging and releasing.
5. Consequences of a move to trotlines would therefore lead to:
    i. Some positive benefits by reducing cetacean depredation.
    ii. Significant problems in understanding the meaning of CPUE for trotlines, and consequently in understanding CPUE trends unless there is an extended period of overlap between Spanish system, autoline and trotline use.
    iii. Potential increases in skate and toothfish injury, leading to problems with skate discard survivorship and achievement of tagging goals.

WG-FSA-08/45

Proposal for revising Conservation Measures 24-02 (2005) and 41-03 (2006) in relation to Subarea 48.4. Delegation of the United Kingdom, 5 pp. (English, unpublished).

The provisions for fishing season and mitigation measures in Conservation Measure 24-02 (2005) regulating fishing in Subarea 48.4 do not currently conform to the IMAF risk assessment advice given in CCAMLR-XXIV/BG/26. The UK proposes text that should be added to Conservation Measure 24-02 to bring the measure into line with the Risk Assessment, which would allow fishing outside season April–September if it is conducted in accordance with Conservation Measure 24-02. A small change, to recognise Subarea 48.4, is required to the first paragraph of Conservation Measure 24-02.

WG-FSA-08/46

Proposal for an extension to the mark–recapture experiment to estimate toothfish population size in Subarea 48.4. J. Roberts and D. J. Agnew (Imperial College London, South Kensington Campus, London SW7 2AZ, United Kingdom, james.o.roberts@imperial.ac.uk), 30 pp. (English, unpublished).

1. So far a total of 929 *D. eleginoides* have been tagged and released at Subarea 48.4 and 25 tagged fish have been recaptured, including 23 during the latest season.
2. A preliminary assessment of *D. eleginoides* stock size in the Northern Area of 48.4 estimates a vulnerable biomass of between 1 000 to 2 000 tonnes.
3. The UK proposes to continue the mark-recapture experiment in Subarea 48.4 in the 2008/09 fishing season so as to allow for a full assessment of *D. eleginoides* stock size in the Northern in 2009.

4. Additionally, the UK proposes to commence a mark-recapture experiment in the southern area of Subarea 48.4. This has the aims of providing the data required for assessments of the population structure, size, movement and growth of both *Dissostichus eleginoides* and *Dissostichus mawsoni* in the southern area of 48.4.
5. A catch limit of 75 tonnes is proposed for *D. eleginoides* the northern area, where *D. mawsoni* will remain a by-catch species. A combined catch limit of 75 tonnes is proposed for *D. eleginoides* and *D. mawsoni* in the southern area.
6. It is proposed that catch limits are introduced for by-catch species in the Northern Area of 48.4, set at 16% *Macrourus* spp. and 5% Rajid spp of the catch limit for *Dissostichus* species. In the Southern Area, catches taken at these proportions would trigger a move-on rule.
7. The UK has submitted a complementary proposal to IMAF to amend Conservation Measure 24-02, to bring the mitigation requirements for 48.4 into line with the IMAF risk assessment, such that daytime setting would be permitted if bottle tests are undertaken, and the fishing season is extended to run from 1 December to 30 November.

WG-FSA-08/47

Update on items of interest to WG-IMAF. N. Walker (Ministry of Fisheries, 101–103 The Terrace, Wellington, New Zealand, nathan.walker@fish.govt.nz), 11 pp. (English, unpublished).

This paper documents recent and ongoing developments in New Zealand's Exclusive Economic Zone that are relevant to the work of WG-IMAF. These developments include refinement of the requirement of fishing practices to reduce seabird by-catch by surface longline vessels and the introduction of regulations to reduce seabird by-catch by bottom longline vessels.

The by-catch of seabirds by fisheries within New Zealand's EEZ in recent years that either breed or forage within the CCAMLR Convention Area (Convention seabirds) is detailed. This paper includes a tabulation of observed captures by species and by-catch estimations by fishery for all seabirds.

This paper also contains description of the recent and ongoing seabird mitigation trials that are underway in New Zealand. These include trawl offal management techniques, such as batching and mincing, and the blue dyed bait trial for surface longline fishing.

We also discuss a new version of the Productivity-Susceptibility Assessment technique for risk assessment and its potential for use in the CCAMLR context.

WG-FSA-08/48

Investigating length at maturity of Antarctic toothfish (*Dissostichus mawsoni*) based on scientific observers' data. S. Mormede, S. Parker and P. Grimes (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Wellington, New Zealand, s.mormede@niwa.co.nz), 26 pp. *CCAMLR Science*, submitted (English).

Through generalised linear models, the gonadosomatic index of Antarctic toothfish in the Ross Sea region was shown to vary with latitude, length and month. Limitations of the scientific observers' staging data were highlighted and GSI is recommended as a better indicator of maturity status in Antarctic toothfish.

Reports of histological analyses of a small number of Antarctic toothfish showed vitellogenic fish with low GSI values, in some cases below 1%. In most studies there was

little if any difference in the GSI values of fish at different maturity stages. However these studies were carried out on a limited number of fish, most of which were from the southern area, therefore not on obviously spawning fish.

Histological analysis using a hindcasting assessment of 683 samples collected in December to February showed most fish on the shelf had not spawned that year, most fish in the north had spawned and the shelf contained a mixture of fish that had spawned or not, with length at 50% maturity of about 137 cm. The equivalent GSI at 50% maturity was in the range of 1.1 to 1.4%. These results were used to estimate GSI thresholds for fish that had spawned in the previous season; which were set at 1% and 1.5% GSI, but are limited to only female fish in the sampled areas for December through February.

Based on both histology and GSI data, most fish found in the northern areas, about a third of those found in the slope areas and very few of those found in the southern areas had spawned. As the GSI values of fish caught in the northern area were never very low, it is expected that all the fish in the northern areas spawn every year when in that area. If they were resting in the north it is expected residual GSI would be lower. Conversely, as the GSI values of fish caught in the south were very low, fish caught there are not expected to spawn in the current year, nor are they expected to have migrated back from the north; or their residual GSI would be higher, in the order of 1% or more. Therefore any movement would have to be between the north and the slope areas, with only a proportion of fish coming back to the slope since only a third there are mature. Any other movements would have to be outside of the fishing season, for example a yearly northern migration during spawning season only.

Lengths at 50% maturity of Antarctic toothfish were calculated for each SSRU or area in the Ross Sea region; they varied from about from 89 to 150cm for females and 36 to 184 cm for males, from north to south respectively. Length at 50% maturity was also calculated for female fish from the slope, which was similar to the value calculated from GSI of 137 cm. Uncertainty in the oocyte development cycle may create biases in different histological assessment methods which may influence estimates of length at maturity or GSI thresholds. Length distributions are also known to be spatially heterogeneous. A population-wide length at 50% maturity can therefore not be determined without the help of a spatially-explicit population model and any length at maturity value should be treated with caution.

Gonadosomatic index has shown promise as a potential index of Antarctic toothfish maturity. However, further work is recommended in order to improve the current knowledge of toothfish maturity. It is recommended that:

- GSI continues to be routinely measured and used an indicator of maturity.
- Further histological studies be carried out, in particular targeting spawning fish and fish caught in the northern areas at the end of the fishing season; and that GSI be measured on all fish sampled for histology.
- A histologically based maturity index is developed, from those further samples, which is linked to a GSI threshold, potentially with prescriptive oocyte size ranges for each stage.
- A comparison of hindcasted maturity assessment and forecasted maturity assessment should be conducted to evaluate potential benefits and biases of each approach relative to the reproductive cycle.
- Once a histological assessment method is finalised and in agreement with other maturity information, further histology samples must be analysed from the various regions throughout the fishery to obtain a more complete spatial and temporal picture of the maturation process of toothfish, and infer month and area-specific GSI indicators of maturity.

- The scientific observers' maturity scale be improved, possibly including photos of fish at each stage.
- A spatially explicit model be developed, GSI included in the model and calculations of L_{m50} be carried out both within the outside of the model.
- L_{m50} only be quoted as area-specific unless derived from a spatially-explicit model.

WG-FSA-08/49

Year of the Skate sampling protocol: learning from the 2007/08 season sampling protocol on NZ vessels. S. Mormede (National Institute of Water and Atmospheric Research (NIWA) Ltd, Private Bag 14901, Wellington, New Zealand, s.mormede@niwa.co.nz), 14 pp. (English, unpublished).

Skates are an important bycatch of the toothfish fishery in the CCAMLR area and have been identified as priority taxa for which assessments of status are required (e.g. SC-CCAMLR-XXIII, 2004, 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 (CCAMLR-XXVI, WG-SAM, 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. We propose options for the appropriate collection of such data from the fishery and a revised skate tagging protocol. These changes were piloted in the 2007–08 season by a subset of vessels fishing in the Ross Sea. The results from the pilot study are useful to inform modifications to data collection systems that are required in 2008–09, for the 'Year of the Skate'. Note that we do not consider other information requirements such as determining biological parameters.

WG-FSA-08/50

The Ross Sea Antarctic toothfish fishery: review of the 3-year experiment and development of medium-term research objectives and an operational framework for the fishery. Delegation of New Zealand, 25 pp. (English, unpublished).

The aim of this paper is to review the recent management of the Ross Sea toothfish fishery (including the 3-year experiment), to identify key operational and research objectives for the fishery over the next 5–7 years in relation to Article II of the Convention, and to develop an operational framework to achieve those objectives. The paper focuses primarily on Antarctic toothfish, as catches of Patagonian toothfish are negligible, and covers Subareas 88.1 and 88.2.

We begin by summarising the operational management and conduct of the fishery up to the 2004–05 fishing year (prior to the start of the 3-year experiment). This includes the reasons why the 3-year experiment was initiated and the key objectives of the experiment. We then go on to summarise the operational changes which formed the framework of the 3-year experiment, and to review the success and/or any problems associated with each of those changes.

Next we identify key operational and research objectives for the fishery over the next 5–7 years in relation to Article II of the Convention. As part of this process we identify uncertainties in our current knowledge which need to be addressed to fulfil the requirements of Article II. These include, for example, uncertainty in the biological parameters and stock

assessment of Antarctic toothfish, uncertainty in its ecological relationships with predators and prey, and uncertainty over other ecosystem effects of fishing. Finally, we provide recommendations on the development of an operational framework for the fishery.

WG-FSA-08/51

Updated preliminary results of an ecological risk assessment for seabirds and marine mammals with risk of fisheries interactions. S. Waugh, D. Filippi, N. Walker and D.S. Kirby (Sextant Technology, 116 Wilton Road, Wellington 6012, New Zealand, s.waugh@sextant-technology.net), 82 pp. (English, unpublished).

We examined a methodology for assessing potential risk of interactions between fisheries and species of special interest (seabirds and marine mammals) by applying a Productivity-Susceptibility Analysis to a data set of species distribution, biological information and fishing effort. This type of Level Two Ecological Risk Assessment (ERA) has been used across fishery management regimes to identify areas or species requiring additional management or monitoring.

Our study indicated that the risk of species interactions is clustered with greatest likelihood in a few species, where there is particularly strong overlap between fishing effort and species ranges. We tested the sensitivity of the analysis to changes in weighting of distributional density, fishing data type (area or point data), and to adding a factor of population. We found the outcomes of the PSA analyses were robust to these effects. However, adult survival rates did influence the rankings, and were identified as a key parameter requiring careful estimation.

Relative risk rankings within the longline, trawl, troll and set net fisheries examined indicated that Procellaria petrels, the coastal Hector's dolphins (*Cephalorhynchus* spp.), giant petrels (*Macronectes* spp.), *Pterodroma* petrels, and some albatrosses carried the highest relative risk. For setnet fishing, dolphins and shags were also ranked relatively highly. We examined the small statistical areas where most risk across all species applied cumulatively. We identified areas where there is greatest potential for non-target take to be occurring and which are therefore candidate areas for intensified observer monitoring and mitigation of risks.

WG-FSA-08/52

An assessment of artificial bait (Norbait™) as a means of reducing the incidental catch of *Macrourus* and other by-catch species in high-latitude toothfish fisheries. J.M. Fenaughty (Silvifish Resources Ltd, PO Box 17-058, Karori, Wellington, New Zealand, jmfenaughty@clear.net.nz), 18 pp. (English, unpublished).

The New Zealand fishing company Sanford Limited has initiated a research project to assess the effectiveness of artificial bait as a means of reducing the incidental catch of Macrouridae (rattails) and other by-catch species in the toothfish autoline longline fishery. A company vessel carried out some initial experimental work in the western Ross Sea (CCAMLR Statistical Subarea 88.1) in 2007 to assess basic requirements such as ease of use, bait longevity on the hook, and catchability (defined here as a measure of a baited hook to attract and catch a given species of fish) of target and incidental species. This is a preliminary report based on subsequent trials carried out aboard the vessel *San Aspiring* operating in the waters of South Georgia and the South Sandwich Islands (CCAMLR Statistical Subareas 48.3 and 48.4) during early 2008.

During the period 12 April and 14 May 2008 seventeen trial lines were set in both subareas; a total of 137 000 experimental hooks. The evaluation was based on alternating

sections (magazines or mags – there are approximately 1 024 hooks per magazine on *San Aspiring*) of line with control mags baited with squid, the vessel's preferred bait for toothfish and alternating mags using an artificial or reconstituted bait (Norbait 800C™).

Results from Subarea 48.4 indicated that catches of both the target Patagonian toothfish and by-catch of *Macrourus whitsoni* were reduced using Norbait when compared to the conventionally used squid bait. The reduction in rattail catches however was proportionally much greater than that of the toothfish and points to a potentially useful means of limiting macrourid by-catch. This is similar to results obtained by another Sanford vessel *San Aotea II* in the Ross Sea in early 2007. This was not the case in Subarea 48.3, the other area where trials were carried out. In this area although Norbait reduced the incidental by-catch of *Macrourus*, an overall virtually identical reduction in the target catch of Patagonian toothfish negated any benefit. These reductions effectively meant an increase in fishing effort and time to achieve the same target catch result.

Other than the obvious geographical differences between the two trial subareas there were differences in both the Macrourus species caught and the size of toothfish caught in each. These factors may individually or in combination provide some explanation for the observed dissimilarities.

There are a large numbers of variables involved in such comparative trials making definitive analysis difficult and precluding clearly defensible results. In such cases the collection of large amounts of base data in all circumstances and environments is the only way of reducing uncertainty and understanding the variability. For this reason it is necessary to stress that these results are preliminary and further work is indicated. Although increased and continuing data collection is an ideal, it must be highlighted that there are both clear and concealed costs involved in undertaking such trials. Obvious expenses are incurred in the purchase and transport of the trial bait. There are however hidden costs incurred in the additional time on the grounds and additional gear deployed to catch the same amount of fish when the bait used is less effective than the current standard.

WG-FSA-08/53

Methods for implementing Conservation Measure 22-06: an impact assessment framework for bottom-impacting fishing methods in the CCAMLR Convention Area. B. Sharp, S. Parker and N. Smith (Ministry of Fisheries, PO Box 1020, Wellington, New Zealand, ben.sharp@fish.govt.nz), 13 pp. *CCAMLR Science*, submitted (English).

This paper presents a framework to assess and quantify the likely cumulative impact on potential VMEs from bottom fishing activity. The approach has been designed to facilitate standardized application across gear types and areas to allow comparisons between fisheries employing different bottom impacting fishing methods. Details of the New Zealand preliminary assessment using this framework are available in document CCAMLR-XXVII/26. This paper illustrates the utility of the standardised approach and provides a methodological template for possible wider adoption within CCAMLR or elsewhere. Specific examples from the New Zealand assessment are provided for illustrative purposes.

WG-FSA-08/54

A non-hierarchical taxonomic key for seabird identification in the Heard Island and McDonald Islands and Kerguelen Island fisheries. J. Fielding, T. Lamb*, B. Wienecke and N. Gasco (*Australian Antarctic Division, Department of Environment,Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, tim.lamb@aad.gov.au), 13 pp. (English, unpublished).

A non-hierarchical seabird identification key has been produced to improve the identification of seabirds that come into contact with or are seen in the vicinity of fishing operations in the Heard and McDonald Islands region. This paper provides the background and reasoning behind the development of this key.

WG-FSA-08/55

The Australian skate tagging program at Heard Island and McDonald Islands, CCAMLR Division 58.5.2. G.B. Nowara and T. Lamb (Australian Antarctic Division, Department of Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, gabrielle.nowara@aad.gov.au), 10 pp. (English, unpublished).

Tagging of the three species of skates taken as by-catch in the Heard Island and McDonald Islands toothfish fishery, *Bathyraja eatonii*, *B. irrasa* and *B. murrayi* has taken place over the last eight years with nearly 6 000 skates tagged. The recapture rate has been low, less than one percent. Movement after tagging shows that these fish are recaptured only short distances from where they were released. The mean distance between release and recapture was 4.8 n miles, even though the majority had been at liberty for several years. In order to enhance the ease of identification of skates and to ensure good quality of the data, one page identification sheets were developed for each species which will be used by observers on board fishing vessels.

WG-FSA-08/56

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 2008, using the generalised yield model. D.C. Welsford (Australian Antarctic Division, Department of Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, 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 2008 to provide the information for an assessment of short-term annual yield in the 2008/2009 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. The strong year class detected in last year's survey is now fully recruited as the 2+ cohort, and dominates the population.

WG-FSA-08/57

Report on a longline survey conducted by the FV *Janas* in May 2008 on BANZARE Bank, and an assessment of the status of *Dissostichus* spp. in Division 58.4.3b. D. Welsford, T. Robertson and G. Nowara (Australian Antarctic Division, Department of Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, dirk.welsford@aad.gov.au), 22 pp. (English, unpublished).

In May 2008, a randomised longline survey, consisting of 15 standardised sets over 2 strata covering areas of commercial fishing activity was conducted from aboard the Australian flagged longliner FV *Janas* BANZARE Bank within CCAMLR Statistical Division 58.4.3b. Catch rates were very low, ranging between 0 and 225 kg.1000 hooks^{-1}, consistent with toothfish being depleted to low densities across the majority of the surveyed area. Catches of toothfish consisted of both species of *Dissostichus*, with *D. mawsoni* found across the entire survey area while *D. eleginoides* was mainly found on the shallow areas on the western part of the bank. Data on size distribution and size at maturity indicate that the *D. mawsoni* population is almost entirely large mature fish with a bias towards males, which are shown to mature at a smaller size than females. As the population does not contain juvenile lifestages, we hypothesise that the fish encountered originate from nearby

populations in East Antarctica where juveniles of both sexes are caught. The *D. eleginoides* population consisted of approximately equal proportion of males and females, and few mature individuals were detected. Contrasts in the population characteristics of the two species of *Dissostichus* indicate that species specific management should be considered for this area. Data on major by-catch species *Macrourus carinatus* and *Raja taaf*, including size distribution, sex ratio and size at maturity, are also presented.

WG-FSA-08/58

Estimating the swept area of demersal longlines based on *in situ* video footage. D. Welsford and R. Kilpatrick (Australian Antarctic Division, Department of Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, dirk.welsford@aad.gov.au), 14 pp. (English, unpublished).

During a longline survey on BANZARE Bank (Division 58.4.3b) in May 2008, an in-line video camera recorded the interactions between the main line and the benthos during setting and hauling. Footage revealed that after setting the line moved very little, despite cross currents. During hauling, the section of line visible to the camera swept sideways, interacting with sessile benthic organisms before leaving the seafloor. Based on an estimate of the rate of sideways movement, the total time sideways movement occurred before the line lifted off the seafloor, the total length of the line and the total time to retrieve the line, we estimate that up to 0.122 km^2 of seafloor was swept by the line while it was being retrieved. Consequently the area of seafloor affected by demersal longlines is shown to be comparable with that of demersal trawls. We also provide evidence that benthic fauna that are vulnerable to longline gear may not be retained at the surface, but can fall off the longline hooks before reaching the surface. Hence surface observations of some benthic by-catch are likely to underestimate of the actual level of interaction.

WG-FSA-08/59

Field identification guide to Heard Island and McDonald Island (HIMI) benthic invertebrates. T. Hibberd and K. Moore (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, ty.hibberd@aad.gov.au), 130 pp. (English, unpublished).

At CCAMLR-XXVI the Working Group on Fish Stock Assessment (WG-FSA) noted a lack of specific reference material for the identification of benthic invertebrates in areas specific to which observers carry out their activities (SC-CAMLR-XXVI, Annex 5, paragraph 6.32). To improve the standard of observer identifications and also to assist in the identification of vulnerable areas, the Scientific Committee requested that guides be prepared for the identification of benthic organisms (SC-CAMLR-XXVI, paragraph 4.190). In response to this recommendation Australia has developed the '*Field identification guide to Heard Island and McDonald Island (HIMI) benthic invertebrates*'. This Fisheries Research and Development Commission (FRDC), Australian Fisheries Management Authority (AFMA) and industry funded production is first of its kind for the region, and is intended to be used as both a training tool prior to deployment at-sea, as well as for use by trained observers to make accurate identifications of invertebrate by-catch when operating in the HIMI region. Based on available data, this publication will include instructions to observers for collection of benthic organisms at sea, quick-reference pictorial guides to invertebrate phyla, common species and CCAMLR identification codes, and detailed identification notes for each phylum including representative images for more than 400 benthic organisms identified from the HIMI region thus far. This guide will enable observers to gather invertebrate by-catch data at higher taxonomic resolutions. We encourage the development of

similar guides for training purposes and at-sea use by observers in other CCAMLR designated fisheries and that CCAMLR consider adopting the numerical *Integrated Taxonomic Information System* (ITIS) as an interim coding system to improve the resolution of benthic by-catch data.

WG-FSA-08/60

The autoline system – an updated descriptive review of the method with recommendations to clarify CCAMLR conservation measures regulating longline fisheries within the Convention Area. J.M. Fenaughty (Silvifish Resources Ltd, PO Box 17-058, Karori, Wellington, New Zealand, jmfenaughty@clear.net.nz), 27 pp. (English, unpublished).

The paper updates Fenaughty and Bennett (2005), Longlining Operations on New Zealand Autoline Vessels Fishing for Toothfish in CCAMLR Waters. Additional information is included listing and discussing circumstances and scenarios occurring with the method.

A definition of the fundamental unit of gear (a 'line') for longlines is proposed for the purposes of regulation and management. Current conservation measures dealing with longline fisheries carried out within the Convention Area are reviewed and changes are suggested clarify understanding of these measures.

The paper includes a recommendation for a review of Annex 41-01/B (2007) governing research within exploratory fisheries by WG-FSA with a view to assessing the option of simplifying this measure in a similar manner to that successfully implemented in the exploratory fisheries in Subareas 88.1 and 88.2.

WG-FSA-08/61

Report of the Second Meeting of the Seabird Bycatch Working Group (Hermanus, South Africa, 17–18 August 2008). ACAP Seabird Bycatch Working Group, 48 pp. (English, unpublished).

The Fouth Meeting of the ACAP's Advisory Committee was held in Cape Town, South Africa from 22–25 August 2008. It was preceded by a meeting of the Seabird Bycatch Working Group (SBWG) on 17–18 August 2008. This paper provides a report on the SBWG meeting.

The Working Group reviewed methods to reduce seabird by-catch in trawl fisheries, and noted that the body of work investigating and documenting mitigation measures in trawl fisheries is significantly less advanced than for longline fisheries. Consequently, new developments in this field in recent years are few. Seabird interactions with trawl vessels fell into two broad categories: those focused on the trawl warps, and those focused around trawl nets. For reducing seabird strikes on trawl warps, the use of bird-scaring lines has been proven to be the most effective mitigation device in the trawl fisheries in which comparative studies have been undertaken. However, the retention or strategic management of fish waste (offal and discards) was recommended as the most effective primary measure for by-catch reduction, and should be viewed as the best long-term solution to reducing seabird by-catch in trawl fisheries. Coincident with effective fish waste management, operational measures such as cleaning the net prior to shooting and reducing the time the net is on the surface at shooting and hauling should be viewed as best practice measures and incorporated into routine fishing activities. While a number of methods have been trialed to reduce the incidence of warp strikes, there continues to be the need for more work on effective measures for reducing seabird interactions with trawl nets.

The SBWG also reviewed demersal longline mitigation methods. Two tables were developed that summarised by-catch mitigation measures for demersal longline fishing, and

identified knowledge gaps and research priorities for this gear type. These tables were subsequently endorsed by the ACAP Advisory Committee as representing the current best scientific advice of the SBWG.

The SBWG engaged in extensive discussion regarding the Advisory Committee's collection of seabird by-catch data from the Parties. Dr Keith Reid from CCAMLR described the CCAMLR data submission and management system, and the fine scale analysis at the level of the fishery, by area, gear type and by vessel, that is carried out by CCAMLR on both target and by-catch species. The Working Group noted the comprehensive nature of the data collection and assessment process that has been developed by CCAMLR and agreed that it formed a useful model for ACAP, noting that an observer program with high levels of coverage had been critical to understanding by-catch problems and had been key to CCAMLR's success in reducing by-catch in its fisheries. The model was entirely relevant to other RFMOs but could also be adopted by ACAP for assessment of summary by-catch information provided by ACAP Parties.

WG-FSA-08/62

Application to undertake winter scientific research in CCAMLR Subarea 88.1 (SSRUs 881B, 881C and 881G) in the 2008/09 season. Delegation of New Zealand, 17 pp. (English, unpublished).

New Zealand proposes to conduct a scientific research survey during the austral winter in CCAMLR SSRUs 88.1B, 88.1C and, ice permitting, 88.1G in 2008/09, as the first in a three year time series. The proposal is for a targeted longline survey designed to cover critical gaps in the knowledge of the life cycle of *D. mawsoni* in the Ross Sea by collecting biological samples from a broad spread of locations across the northern Ross Sea during the austral winter. The survey is designed to collect information that should assist in the understanding of the early life history and reproduction of *Dissostichus mawsoni* in the Ross Sea region. In addition, tag data collected will give additional information on the spawning movements of mature *D. mawsoni*. The results of the research will lead to improved estimates of length/age of maturity, proportion mature that spawn, and contribute to an improved understanding of the Ross Sea *D. mawsoni* stock structure. Data collected during the survey will provide information that is likely to directly influence future assessments of *D. mawsoni*. The proposed research is in accordance with Conservation Measures 24-01, 33-03, 41-01 and 41-09.

WG-FSA-08/63

Expected tag–recapture rates from new and exploratory fisheries for *Dissostichus* spp. J.P. McKinlay and D.C. Welsford (Australian Antarctic Division, Department of Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston 7050, Australia, john.mckinlay@aad.gov.au), 20 pp. (English, unpublished).

Tag recapture rates in new and exploratory *Dissostichus* spp. fisheries in the southern Indian Ocean sector of the CCAMLR area are examined. In particular, the potential for tagging programs in new and exploratory fisheries to yield sufficient data to be of use in determining TAC's in the early stages of fishery development is considered. Scenarios are developed using a range of tag release rates, tag detection rates, natural mortality, fish movement out of the fishery, and IUU removals in order to estimate the expected numbers of tag returns. Even under 'worst case' assumptions, tag recaptures are still expected to be considerably higher than currently observed in Divisions 58.4.1 and 58.4.2. If current tag

recapture rates continue, tag-based assessments of stock status 58.4.1 and 58.4.2 are likely to remain uncertain in the short to medium term, and fishing should remain focussed in areas where tag releases have been concentrated until these uncertainties can be addressed.

WG-FSA-08/64

A risk management framework for avoiding significant adverse impacts of bottom fishing gear on Vulnerable Marine Ecosystems. K. Martin-Smith (Australian Antarctic Division, Department of the Environment, Water, Heritage and the Arts, 203 Channel Highway, Kingston, Tasmania 7050, Australia, keith.martin-smith@aad.gov.au), 24 pp. *CCAMLR Science*, submitted (English).

CCAMLR adopted a new conservation measure in 2007 (CM 22-06) to ensure that significant adverse impacts of bottom fishing gear on Vulnerable Marine Ecosystems (VMEs) are avoided. Due to the high levels of uncertainty surrounding both the evidence of VME presence and the consequences of interaction with different types of gear, a risk management framework is proposed, similar to that which has been used successfully by IMAF to minimise the effects of longline fishing mortality on seabirds. The aim of this risk management is to avoid significant adverse impacts on VMEs from bottom fishing activities. The framework consists of four steps: (1) Risk analysis of current and proposed fishing activities; evidence of potential VMEs; scale of interactions between fishing activities and VMEs; impact of interactions on VMEs; and recovery potential of VMEs. (2) Risk evaluation. Combine information on likelihood and consequences of interactions of bottom fishing gear with VMEs and associated uncertainties from risk analysis to produce risk metrics. (3) Risk elimination or mitigation. Unacceptable levels of risk from bottom fishing activities to VMEs must be eliminated or reduced to acceptable levels through the use of management measures including, *inter alia*, closed areas around identified VMEs, open and closed management areas, by-catch limits for VME-forming organisms, gear modification or spatial distribution of fishing effort. (4) Review. All of the above steps should be reviewed regularly to ensure that all relevant or new information has been included, appropriate scientific research and data collection plans are in plan and that risk mitigation measures are successful in their implementation.

WG-FSA-08/65

Conveners' Report of the WG-IMAF workshop. K. Rivera and N. Smith (Co-conveners of ad hoc WG-IMAF), 16 pp. (English, unpublished).

This paper reports on the one-day workshop held at the CCAMLR Headquarters, Hobart, Australia on 10 October 2008 to review the future of the ad hoc WG-IMAF.

The workshop briefly reviewed the history of ad hoc WG-IMAF and considered the current work programme of CCAMLR with respect to the current and future role of ad hoc WG-IMAF. The workshop briefly considered future scenarios under which it might operate and the implications for its work.

The workshop agreed that in future ad hoc WG-IMAF should continue to focus on the direct impacts of fishing and marine debris on seabirds and marine mammals as well as developing, an effective relationship between CCAMLR and ACAP. The workshop noted that this scope was a part of the broader contribution of CCAMLR to the conservation of these taxa.

The key recommendations from the workshop to be considered by WG-IMAF are:

- revised terms of reference for WG-IMAF to reflect a purpose and revised scope of the group;

- in the short-medium term WG-IMAF should place a particular focus on a reduction in incidental mortality of seabirds associated with fishing in those areas of the Convention Area where this still occurs;
- that the current timing and duration of meetings are appropriate but should be kept under annual review; and
- medium term functions for WG-IMAF to address as possible.

WG-FSA-08/P1

Population subdivision in the Antarctic toothfish (*Dissostichus mawsoni*) revealed by mitochondrial and nuclear single nucleotide polymorphisms (SNPs). K. Kuhn and P.M. Gaffney. 2008. *Ant. Sci*., 20 (4): 327–338, doi:10.1017/S0954102008000965.

The Antarctic toothfish (*Dissostichus mawsoni*) exhibits a circumpolar distribution in coastal waters south of the Antarctic Polar Front. For a preliminary evaluation of global population structure in this species, we examined four mitochondrial regions and 13 nuclear gene fragments in samples from four CCAMLR subareas in the Southern Ocean (Australian Antarctic Territory (Subarea 58.4.2), Ross Dependency (Subareas 88.1 and 88.2) and the South Shetland Islands (Subarea 48.1). Significant genetic differentiation within and among locations was observed for both mitochondrial and nuclear loci. The single nucleotide polymorphism (SNP) markers developed here will be useful for more extensive analyses of population structure in this species.

WG-FSA-08/P2

Recruitment and body size in relation to temperature in juvenile Patagonian toothfish (*Dissostichus eleginoides*) at South Georgia. M. Belchier and M.A. Collins. 2008. *Mar. Biol.,* 155 (5): 493–503, 10.1007/s00227-008-1047-3.

Recruitment variability in juvenile Patagonian toothfish (*Dissostichus eleginoides*), a commercially important, deepwater nototheniid fish, was examined at the sub-Antarctic island of South Georgia, South Atlantic. Data from 13 demersal trawl surveys conducted over a 20-year period were analysed. Abundance of the 1+ juvenile fish cohort (13 to 15 month old dependent on survey date) was found to vary inter-annually and was found to be inversely correlated with the sea surface temperature (SST) conditions experienced by adults prior to spawning. Environmental temperatures experienced by toothfish eggs and larvae were not significantly correlated with juvenile density. The mean length of 1+ fish attained after 13-15 months was higher in years of high juvenile abundance and was significantly inversely correlated with SST in the summer prior to adult spawning. Trends in toothfish recruitment variability mirrored those previously observed in a range of krill-dependent land-based predators at South Georgia for whom non-seasonal, large-scale climatic events such as El Niño Southern Oscillation (ENSO) are considered the most likely underlying drivers of variability in breeding success. The drivers of recruitment variability in toothfish are not fully understood but a range of possible mechanisms are considered. A better understanding of recruitment variability holds great interest for fisheries managers and could be used refine forecasts of years of good or poor recruitment for the toothfish fishery at South Georgia

WG-FSA-08/P3

Oxygen and carbon stable isotopes in otoliths record spatial isolation of Patagonian toothfish (*Dissostichus eleginoides*). J.R. Ashford and C.M. Jones. 2007. *Geochimica et Cosmochimica Acta,* 71: 87–94, doi:10.1016/j.gca.2006.08.030.

Strong contrasts in ambient isotope ratios and in diet suggest stable isotopes in the otoliths of oceanic fish can resolve water masses and geographic areas, promising a powerful multivariate approach for examining population structure and provenance. To test this, whole

otoliths were taken from Patagonian toothfish (*Dissostichus eleginoides*) sampled off the Patagonian Shelf and South Georgia, on either side of a population boundary, and otolith $\delta^{18}O$ and $\delta^{13}C$ values were measured to see if they could distinguish South American-caught fish from those taken in the Antarctic. Values of $\delta^{18}O$ and $\delta^{13}C$ predicted capture area with 100% success, validating their use for distinguishing provenance and corroborating the prior evidence of population isolation. Values of $\delta^{18}O$ in the otoliths reflected ambient values as well as seawater temperature: low values in Patagonian Shelf fish were consistent with exposure to Antarctic Intermediate Water (AAIW), and high values in South Georgia fish were consistent with exposure to Circumpolar Deep Water (CDW). In contrast, differences in otolith $\delta^{13}C$ appeared to reflect diet: relative depletion of $\delta^{13}C$ at South Georgia compared to the Patagonian Shelf were most likely linked to differences in sources of metabolic carbon, as well as $\delta^{13}C$ in dissolved inorganic carbon (DIC) of seawater. These contrasting properties strongly suggest that stable isotopes can resolve the provenance of toothfish from Antarctic sampling areas that hitherto have been difficult to separate. These results show that, by using the chemistry recorded in otoliths, researchers can exploit biogeochemical variation in fully marine environments to examine the spatial ecology of oceanic fish.

WG-FSA-08/P4

Otolith chemistry reflects frontal systems in the Antarctic Circumpolar Current. J.R. Ashford, A.I. Arkhipkin and C.M. Jones. 2007. *Mar. Ecol. Progr. Ser.,* 351: 249–260, doi: 10.3354/meps07153.

Pronounced environmental trends across fronts suggest that the otolith chemistry of oceanic fish can resolve zones on either side, promoting application to population questions at similar spatial scales. Trace and minor elements laid down immediately prior to capture – along the edges of otoliths from Patagonian toothfish *Dissostichus eleginoides* – discriminated frontal zones in the Antarctic Circumpolar Current in the Southwestern Atlantic Ocean. Mean values differentiated sampling areas by up to 2.6 standard deviations, suggesting: 1) otolith Mg/Ca enrichment related to fish activity around the Burdwood Bank; 2) Mn/Ca enrichment associated with South America; 3) Sr/Ca linked to the presence of Circumpolar Deep Water; and 4) Ba/Ca to nutrient production and mixing. In the Polar Frontal Zone, meanders or eddies may account for affinities with neighbouring sampling areas, bringing water from the Subantarctic and Antarctic Zones onto the North Scotia Ridge. Moreover, fish age showed a significant relationship with depth and improved cross-validation by 14%, giving 85% classification rates to South American and Antarctic regions, and 57 to 83% to areas along the Patagonian Shelf. These results indicate that otolith chemistry reflects hydrography, detecting oceanic gradients across the slope of continental shelves and between zones separated by strong trends like fronts.

WG-FSA-08/P5

Otolith chemistry indicates population structuring by the Antarctic Circumpolar Current. J.R. Ashford, C.M. Jones, E.E. Hofmann, I. Everson, C.A. Moreno, G. Duhamel and R. Williams. 2008. *Can. J. Fish. Aquat. Sci*., 65: 135–146 (2008), doi:10.1139/F07-158.

Large-scale transport of seawater in ocean currents may generate spatially complex population structure through the advection of life stages of marine fish species. To test this, we compared the chemistry of otolith nuclei from Patagonian toothfish (*Dissostichus eleginoides*), presently managed as spatially discrete populations corresponding to fishery management areas along the Antarctic Circumpolar Current (ACC), which transports water eastward around the Southern Ocean. The chemistry of otolith nuclei, laid down during early life, differed significantly between fishing areas off South America and the Antarctic and

between some Antarctic areas. We also found evidence of four groups of fish with different early life chemistry: one associated with South America and three Antarctic groups showing mixing consistent with advective transport along the ACC. These results suggest that toothfish populations are structured by their physical environment; population abundance and persistence may rely on a restricted number of breeding members with access to spawning grounds, whereas fisheries may rely substantially on nonbreeding vagrants transported from fishing areas upstream.

WG-FSA-08/P6

Slope currents around the Kerguelen Islands from demersal longline fishing records. Y.-H. Park, N. Gasco and G. Duhamel. 2008. *Geophys. Res. Lett.*, 35 L09604, doi:10.1029/2008GL033660.

The Kerguelen Plateau constitutes a natural obstacle for the eastward progress of the Antarctic Circumpolar Current (ACC), especially around the Kerguelen Islands. However, there is little quantitative knowledge of the current field around the islands due to lack of long-term current measurements. We performed a systematic analysis of a total of 28 917 points of fishing gear drifts from setting and recovery positions of demersal longlines deployed between 2002 and 2007 for Patagonian toothfish (*Dissostichus eleginoides*) fisheries in Kerguelen waters. This enabled the construction of a realistic field of depth-averaged time-mean slope currents along the 1 000 m isobath all around the Kerguelen Islands. Sevral branches of the ACC are clearly identified, with the strongest depth-mean velocities of 25 cm s^{-1} east of the islands being associated with the Polar Folar rounding the islands from the south and flowing northward along the inner continental slope immediately east of the islands. These results demonstrate the potential for hitherto unexploited historic longline drift data from demersal fishing grounds to provide valuable quantitative information on the regional circulation.